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SIKKIM

FOUNDATION COURSE IN SCIENCE AND TECHNOLOGY

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Subject: FOUNDATION COURSE IN SCIENCE AND TECHNOLOGY **Credits: 4**

SYLLABUS

Towards Scientific Path
Science as a Human Endeavour, Science in the Ancient world, Iron Age, The Golden Age of Science in India

Science: Medieval and Modern Time
Science in the Medieval Times, Renaissance, the Industrial Revolution and After, Science in Colonial and modern India, The Method of Science and the Nature of Scientific Knowledge

Know about Universe
Universe as a System, Exploring the Universe, the Solar System

Origin and Evolution of Life
Origin and Evolution of Life, Evolution of Man

Environment and Natural Resources
Ecosystem, Components of Environment, the Changing Environment, Natural Resources, Resources Utilization, Planning and Management, Food and Agriculture

Human Life
Scientific Possibilities and Social Realities, Food and Nutrition, Health and Disease, Mind and Body, Psychological Aspects of Behaviour

Wonder of Science and Technology
Information and Communication, Modes of Communication, Science and Technology in Industry, Technology and Economic Development, Modern Development Science and Technology-I, Modern Development in Science and Technology-II, Perceptions and Aspirations, Science-The Road to Development

Suggested Readings:

1. Encyclopedia of Science and Technology; McGraw - Hill Publication;

2. J B S Haldane; Science and Everyday Life; Macmillan. Penguin, Ayer Co.
reprint: ISBN 0-405-06595-7

3. Kleinman Daniel Lee; Science and Technology in Society; John Wiley and Sons.

CHAPTER 1

Towards Scientific Path

STRUCTURE

- Learning objectives
- Science as a human endeavour
- Science in the ancient world
- Iron age
- The golden age of science in India
- Review questions

LEARNING OBJECTIVES

After reading this chapter, you should be able to:

- Explain why one should be aware of the history of science.
- Outline the social changes that led to stagnation in science in the Bronze Age.
- Describe, in an objective manner, the major developments in science and technology in India and Greece in the Iron Age.
- Outline the factors that led to the decline of science in India by the seventh century A.D.

SCIENCE AS A HUMAN ENDEAVOUR

Linking Past with Present

The history of human civilization shows that the progress of science has not always been steady. There were tremendous advances in mathematics in India in relation to the 2000 years ago, and in medicine in relation to the 2500 years ago. But, no comparable growths have taken lay here in the last 2000 years. When sophisticated calculations and observations were being made in India in ancient times, Europe usually was in the primitive stage. On the other hand, while India was being ruled and exploited by the British, there was a flowering of the Industrial Revolution in Europe. The picture is intricate, but we cannot deny that science and human affairs are closely linked and jointly they provide rise to, what we call, human civilization.

Today, several questions related to life and happiness, like the following, worry us.

- How is it that, in spite of the development of science and technology in our country, the vast majority of our people do not even have clean drinking water, vital health care, or the simplest facilities for education? Why is it that only a tiny minority enjoys the fruits of science and technology? While the latest techniques of surgery are accessible to a tiny minority, mainly people do not get even vital medical care. Why are essential medicines so expensive in our country?
- How is it that our science and technology is not as advanced as that in the West or in the socialist countries? In spite of glorious beginnings thousands of years ago, why have we fallen so distant behind?
- How is it that a group of countries in the West have advanced and sophisticated machines, excellent health care, and good standards of livelihood, while we do not have these?
- Is it true, as some in our country now say, and some of the colonizers have said in the past, that science and India have nothing to do with each other? Our culture, they say, is purely spiritual: science brings misery and spirit solace. Hence, we should concern ourselves mainly with scriptures and not with test tubes. Does this correspond with reality? Can we really do without science?
- While science has brought enormous benefits to human beings, it has also been used as a means of destruction. For instance, today a significant question facing us is how to manage and eliminate the threat of total destruction which a nuclear war may cause.

How to set up a world where the dealings flanked by nations and people will be peaceful? You could think of many more such questions. All such questions arise because, consciously or unconsciously, we have come to accept science as a part of our lives, and cherish the hope that it will bring us a better life. While we cherish the hope, we discover impediments which either distort the true purpose of science, or divert the fruits of science for a small minority of our people.

Why Search the Past

How do we answer these questions which are of vital interest to us? ne approach is that characterized by the well-known statement of Henry Ford, "History is bunk". All the earlier knowledge that is useful is absorbed in the present state of knowledge. But this approach does not answer the vital questions. To understand why science is being misused to produce more and more deadly weapons, it is not good enough to blame the scientists who are at present occupied in defense research. Instead, we have to seem at history in order to see how knowledge, including scientific knowledge, has been used to further the narrow interests of dominating groups. Whether in tribal life, or in agricultural societies, or in industrialized countries, competition for economic power has led to destructive use of science. Although new discoveries enriched science, they too were employed, in course of time, for expanding empires, winning markets and controlling natural possessions. And this has always benefited very small sections of people or only a few countries.

It can be easily seen that none of the questions which arise out of the intimate interaction of science with our lives or with society in common, can be answered without due reference to history of science. Thus, in order to draw full benefits from science, we have to understand how science is related to social and economic factors.

Science is the means by which the whole of our civilization is rapidly being transformed. In the past, science grew steadily and imperceptibly. But now science is progressing by leaps and bounds, for all to see. The fabric of our civilization has changed enormously in our own life times and is changing more and more rapidly from year to year. To understand how this is taking lay, it is not enough to know what science is doing now. It is also essential to be aware of how it came to be what it is; how it has responded in the past to the successive shapes of society, and how, in its turn, it has served to mould them. In science, more than in any other human institution, it is necessary to search the past in order to understand the present and to manage the future. In other words, we have to know the history of science.' But then, what is the history of science? We will shortly answer this question.

What is History of Science

The history of science is not a chronological account of events of scientific detection. It is a story of an ongoing procedure of the interaction of science and society. It begins in the primitive human society and threads its method through dissimilar ages which have seen dissimilar shapes of society, upto the contemporary times (Fig. 1.1). It is a story of how social and economic pressures arising out of a given form of society necessitate scrupulous History of inventions and innovations. These innovations are slowly used and absorbed by dominant social forces to stabilize their power. The stability eventually leads to social stagnation. In the era of stability, new thoughts in science and technology do arise. These thoughts may be ahead of their times, and it may not be possible to put all of them into practice, in the prevailing socio-economic circumstances. Later on, new social groups and forces take form, often out of the frustrated and exploited sections of the society. These new groups press for full utilization of the new thoughts, inventions, and discoveries. Out of such demands and struggles arises a new society, with new forces as the dominant part. The procedure is not an endless circle, as with each stage science takes society to a qualitatively higher stage. Each higher stage has more intricate troubles and social dealings, creating even more intricate and hard troubles for science to solve.

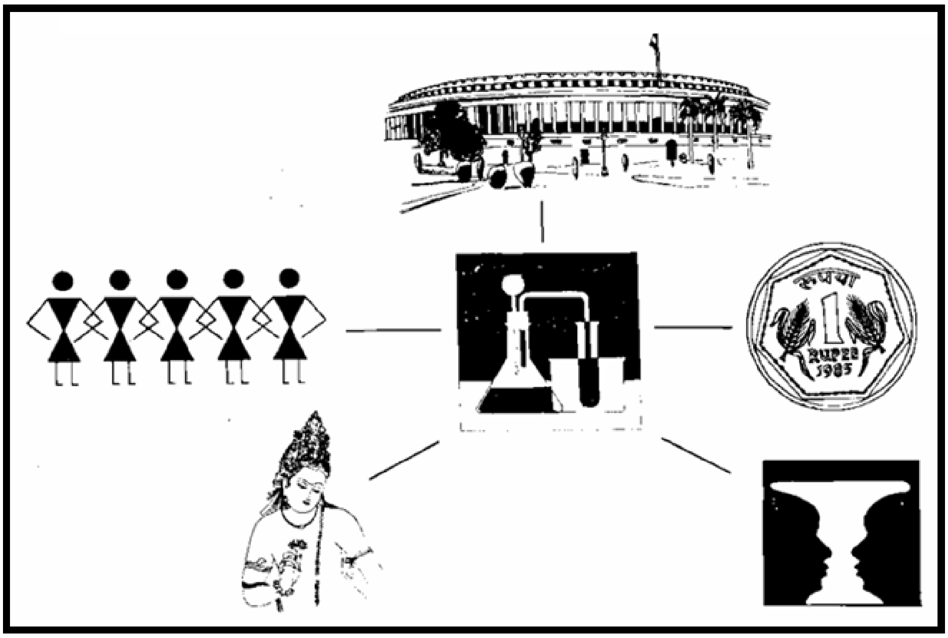
(a) (b) (c)

Fig. 1.1: Three societies belonging to different epochs—the Stone Age, the Bronze Age and the Iron Age.
(a) Primitive human beings depended on food gathering and hunting for their survival and mainly used stone tools: some Stone Age tools; primitive human beings; (b) the Bronze Age is marked by the practice of agriculture and the use of bronze tools: sowing of crops using ox-drawn plough and reaping with a sickle; an Egyptian Pharaoh Tutenkhamen, fourteenth century B.C.; (c) the Iron Age is marked by the discovery of iron and its widespread use for making tools and implements. It was also a period of constant war between societies: a slave working in a black-smith's shop; a hoplite—an infantryman of the warring Greek states.

While the above picture has a rough universal validity, the actual story has motivating variations. New thoughts are sometimes transmitted through human interaction, due to deal and other means of communication, to other geographical locations. There, the society may be more conducive to a rapid change. Again, in a given society, successive changes may be rapid in a scrupulous epoch (era of time). In a dissimilar epoch, in the similar locality, changes may be very slow. You may wonder why it is so. To understand this, we have to understand the specific social, cultural, and economic circumstances of a given society. We also have to understand the world situation in which such a society functions.

It is in this perspective that we are going to study the history of science. Science, as it is today, is not a product of disinterested search for truth by a few gifted individuals. Nor is it a monument where one brick is basically placed on top of the other to gain magnificence. The history of science is a story of human life. It is a story of human striving in all its failings, frailties, and strengths. It is a story of the interaction of science with other forces in society such as economics, politics, psychology, culture, and social organisation (Fig. 1.2). Only through such a study of the past can we understand the present so as to manage the future for the welfare of mankind.

Fig. 1.2 Science Interacts with Politics, Economics, Psychology, Culture, and Social Organizations



Some Characteristics of Science

When we seem at science today, it appears as an organized and specialized human action. This character of science is, though, not more than 300 years old. Before that, science was a part of the common culture, often indistinguishable from other regions of knowledge. In the olden days, a philosopher, an artisan, a priest, or a magician could at the similar time be a scientist. Though, today, science is a multifaceted action. It has its own body of knowledge, organisation, experts, tasks, and ways. It is significant that we talk about these characteristics before briefly going into the history of science.

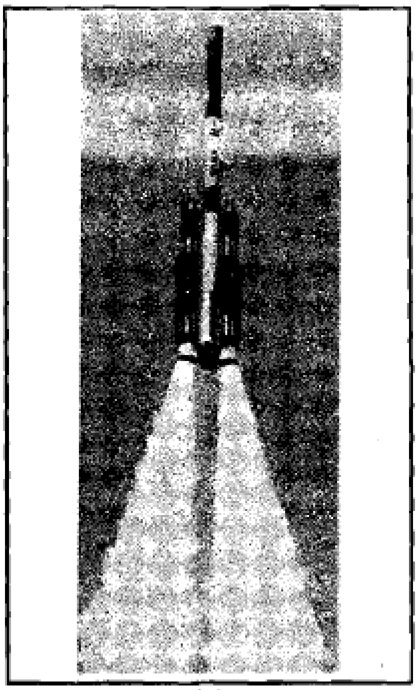
The Institution of Science

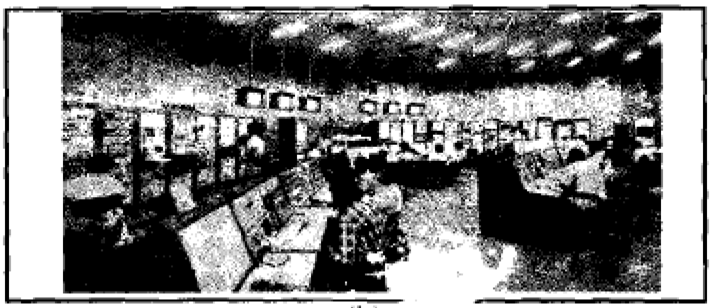
Science, in the modem times, is a communal and organized action, in which hundreds of thousands of men and women are actively involved. They work with tools, which appears strange and even mysterious to a layman. They perform intricate calculations and speak a language which the general people discover hard to understand. Scientists are usually thought of as a set separately in society. The big and diverse scientific action, which is well organized, provides science the nature of an “institution”. In Fig. 1.3, we illustrate you some of the behaviors in which scientists are involved.

While the power of science on our daily lives has grown, it has not become easily understandable to mainly of us. These days, scientists limit themselves more and more to narrow regions of specialized action. What is more, the specialization is so narrow that often one part of the scientific society fails to understand the other. For instance, scientists specializing in the study of insects may not know much in relation to the other regions of life sciences, such as the study of worms, snakes, or monkeys.

Specialization in science means a deep study of a limited range of questions or phenomena. Thus, it may help in rapid solution of some troubles. Though, too narrow a specialization often leads to loss of broad scientific understanding. It inhibits the scientist’s skill to see the relation of one set of questions to another set, thus hampering the growth of knowledge. Specialization also leads to the use of special conditions and phrases or what may be described jargon. This prevents general people from understanding science and using it for their benefit in everyday life. Very often it leads to stagnation and decay of scientific action.

When we think of science as a social institution, then the objectives of science are, in a common sense, social objectives. The common economic and ideological atmosphere of society determines the broad motivation for scientific action. And the specific regions of social life, such as deal or “markets”, industrial development, agriculture, natural possessions, health etc., set definite troubles for science to solve. Unluckily, military action has also been one of the major social goals for science throughout history. Such goals do not lead to human welfare and, in information, pervert scientific action. Mainly scientists in modem time have taken a location against such a perversion of their work. The stand taken by scientists all in excess of the world against using legroom to install deadly weapons is an instance of this.


(a)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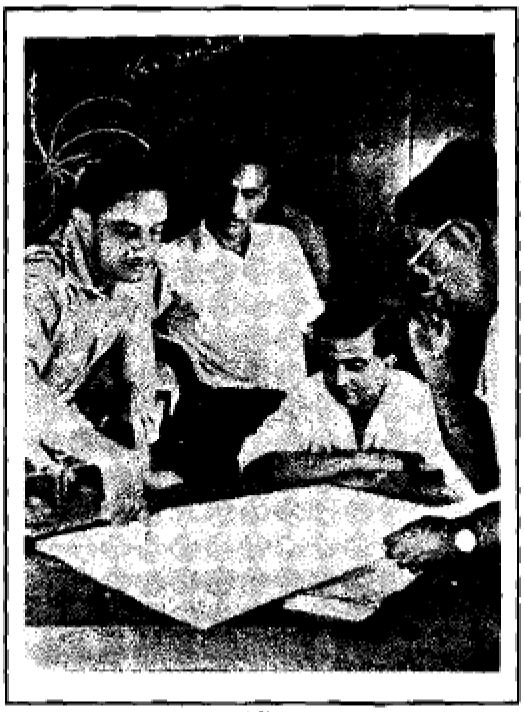

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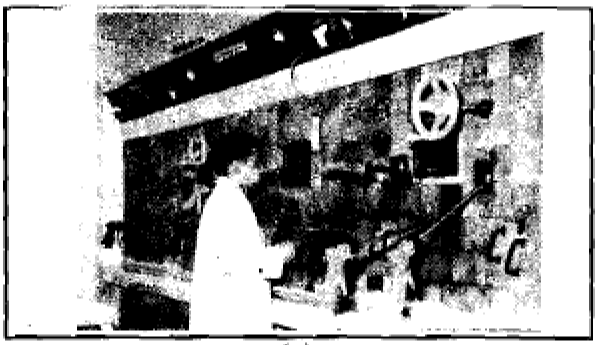


(e)

(f)

Fig. 1.3: The institution of science may be used to solve the problems of a society or to satisfy individual curiosity. (a) Blast off of rocket ASLV (Augmented Satellite Launch Vehicle); (b) control room to monitor the launching of ASLV; (c) an agricultural scientist explaining the advantages of a new wheat variety to farmers; (d) late Vikram Sarabhai, former head of the Indian Space Research Organisation (ISRO), inspecting plans with fellow scientists; (e) scientist handling sophisticated apparatus at Bhabha Atomic Research Centre, Trombay, Bombay; (f) tiny electronic devices being assembled.

Thus, science, as an institution, is used to solve specific troubles in dissimilar regions, within the broad framework of existing social circumstances. The fruits of scientific labour can be use' for human good or they may be misused. It depends upon the historical epoch and the interests of dominant groups in a scrupulous society. For instance, science, in a society based on private profit, would lead to manufacture of goods which can be sold for profit rather than those which are really needed. And if weapons can be a source of profit, in such a society weapons will be produced rather than medicine for the ailing.

In the final analysis, it is we, the general people, who are the ultimate judges of the meaning and value of science. Therefore, science should not be kept as a mystery in the hands of a few. The scope of science and its working as an institution has to be understood by all of us. Only then will we be able to demand that science be connected with our needs and be used for general welfare. Tick the correct ones and cross the wrong ones :

- Science is a social institution. This means that,
- Scientific action is accepted out in a big number of vast structures throughout the world.
- Scientific action is accepted out by a big number of people bound jointly in an organized method.
- Narrow specialization in science implies,
- An in-depth study of a specific problem in a given region.
- That the specialist is able to acquire a broad understanding of many interrelated questions from dissimilar regions.
- Using a readily understandable language to express scientific thoughts.
- That the ordinary people are unable to understand and use scientific knowledge for their betterment.

The Way of Science

In which a big number of people, all in excess of the world, are involved in an organized method. They carry out sure tasks in society, such as extending the frontiers of knowledge or applying science to solve practical troubles. The ways and the practices that they follow can be broadly described as the “way of science”. The ways of exploring and enlarging scientific knowledge are continuously evolving through an intricate interplay of mental and practical action. Science cannot be given a purely intellectual character. For, removing it from the din and dust of practical life, and from physical and manual work, distorts science in the extensive run.

The way of science is made up of a number of operations, some mental, some manual, Observation and experiment are essential for science. Now, everyone, whether a scientist or not, observes things and phenomena. But, to a scientist, the significant question is what to observe and how to observe it. Scientists also have to create sure that observations are, as distant as possible, independent of their sentiments and wishes.

Though, systematic observation alone does not tell us "why things are as they are". Based on previous knowledge or observations, a speculative framework or a hypothesis is usually built to answer the question 'why'. Experiments are set up to prove the first hypothesis, or to discover under what circumstances the thought is valid. This leads to formulation of more reliable laws and theories which, of course, are not measured unchangeable. Each law is valid within sure boundaries or circumstances. Application of laws to real life brings out these limitations, and leads to new hypotheses, further experiments, and better laws.

Strategy of Science

So distant we have talked of using the way of science to solve troubles and to ensure that the solutions are satisfactory. But, how do troubles arise? Why should a problem be solved? In a broad sense, economic and social necessities pose troubles to be solved. For instance, the need to cure general diseases, or to produce food for all in a given climate and soil are some such troubles. In a capitalist society, the desire to sell a product may also pose troubles. For an individual scientist, though, the problem he solves is often a logical extension of the work of an earlier scientific worker. It is also to be noted that significant advances in science are made by people who are just curious and who want to resolve the so described mysteries of nature. Some of the great scientists of the past like Newton, Darwin, and Einstein belong to this category.

The Custom of Science

One aspect of scientific endeavour creates it dissimilar from all other characteristics of social attainment. This is that scientific endeavour, at any point of time, depends on the subsistence of previous knowledge. Without the stock of previous knowledge, the ways of the scientist would not be able to achieve much. Further, to be described scientists, scientific workers have to add to previous knowledge. Scientists constantly strive to change the accepted truth. In this sense, they uniquely differ from other professionals such as lawyers, priests, and officers who mainly interpret and use previous knowledge.

Science is cumulative, that is, science at any time is the total result of all that science has been up to that date. Further, an individual scientist's contribution, howsoever great, is absorbed into the body of scientific knowledge. The individual character of a scientist's work is lost in the common history of science and knowledge. In art and music, the works of past masters are always appreciated and sought after. In science, it is only the current state of knowledge which is of the utmost importance as the past is fused into the present. For instance, we still listen to and appreciate the music of great maestros like Ustad Bade Ghulam Ali Khan or Ustad Fayyaz Khan. Prints and reproductions of Leonardo da Vinci's well-known painting, 'Mona Lisa', are bought by art lovers all in excess of the world. The works of Shakespeare and Kalidasa are read even today. But, not several people feel the need to read Newton's Principia Mathematica or Einstein's well-known papers in original. What is significant, in science, is the form in which those thoughts are used today.

Art and religion appeal to personal faith and sentiment. In contrast, scientific action always strives to reduce the personal or subjective component and build as objective a foundation as possible. Results of science can always be checked, verified, and repeated by anybody anywhere. This provides science a "universal" character. The truth of science lies in its application. The final test of validity lies in testing scientific knowledge in real life, in controlling nature towards some chosen ends.

The Social Function of Science

All the characteristics discussed so distant describe the character of science—as an institution, as a way and as a rising and ever-changing body of knowledge. By themselves they do not answer several questions. For instance, what is the major function of science today? How does science power the method a society develops? What social factors help or impede the growth of science in any society? We will now look at these questions.

Science and the Means of Manufacture

Science has always played a crucial role in manufacture. The history of humankind, is principally, the history of how human beings have attempted to manage and change nature for their own use. In this, dissimilar apparatus and means of manufacture have played a crucial role (Fig. 1.4). We call the major historical epochs by the corresponding principal means of manufacture: Stone Age, Bronze Age, and Iron Age. In the last few centuries, the means of manufacture have become very intricate and, therefore, one now refers to the Industrial Age, Atomic, or Legroom Age etc. on a very dissimilar foundation.

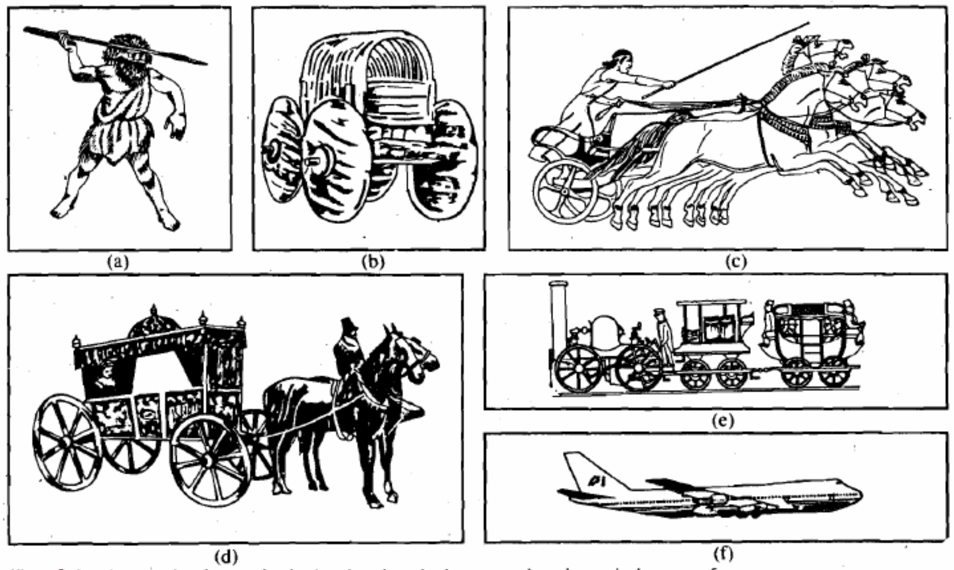


Fig. 1.4: Developments in science and technology have brought about tremendous changes in the means of production, that is, in the land, transport, resources, and the tools, machines and methods for making goods of use. Here we show the changes in transport from primitive to modern times.

Early man strived to extract and fashion materials so that they could be used as apparatus to satisfy his prime needs.

Science flowered in dissimilar countries at dissimilar times. Usually, science thrived whenever a society had organized itself to augment the manufacture of goods and to make a degree of satisfaction in its members. The development of science led to a further augment in manufacture. Though, in a given form of social organisation, the range and stage of manufacture have a limit, both in excellence and quantity. Therefore, in this procedure, whenever saturation in manufacture was reached, science stagnated. The unequal sharing of the produce led to the emergence of a dominant class who wanted to stay things as they were. This was another impediment in the growth of science.

Though, societies which were more receptive to new thoughts forged ahead, and science flourished there. And, the mainly fruitful eras of scientific advance were also those in which practice and theory could be combined, either in individual scientists, or in groups where practitioners of medicine, artisans, and technicians mixed on equal conditions with learned men.

The growth of science not only increases manufacture but also leads to an improvement in the ways of manufacture. And when ways of manufacture evolve and develop to a new stage, societies change. For instance, when agriculture was the prime means of manufacture, human habitations were scattered in excess of big rural regions with their own lifestyles. But, when factory-based manufacture became general, industrial cities grew up, because a big number of people were working in one lay, with a life very dissimilar from the rural life.

In this procedure of change, societies may even break up. Social classes come into disagreement in this procedure and make new social organisations. In Europe, at a sure stage of development, the big landlords who jealously guarded their territories, and the merchants and tradesmen who wanted free passage through such territories, as also general laws for big geographical regions, came into disagreement. A few centuries ago, science and industry urbanized jointly so that the growth of science and the improvement in the ways of manufacture were intimately related. In the present stage, science has grown to such a point that it leads to the development of industry.

The practical application of science leads to its growth. But, the advance of science depends on something more than just the practical aspect. An equally essential part of science is theory and concepts, which have played a significant role in its advance. The theoretical framework links jointly the practical achievements in science and provides them an intellectual unity. Major advances in science occurred when a scrupulous theory was proved or disproved. Though, in science, theory is intimately connected with practice. It has often happened that a significant theory became very formal and came to be used mechanically, without any fresh thoughts or new approaches. Then a new get in touch with practical experience brought forth its limitations. And it had to be customized or rejected, leading to another major advance in science.

We have also seen that the stage of practical application of science in a society depends on the prevailing social circumstances. For instance, there are scientific ways to prevent births and manage population, but social circumstances in several countries do not allow such an application of science. Or, in agriculture, mechanization could augment productivity. But, in the regions where farmers have small pieces of land, mechanization is not possible.

Likewise, the theories of science are also influenced by the common intellectual atmosphere in the society in which scientists work. It often happens that a theory which fits into the common intellectual atmosphere and so is accepted universally, impedes further scientific advance. New theories based on newly exposed facts may be radically dissimilar from the existing ones. Therefore, they come into disagreement with the prevailing thoughts and social thought. This disagreement has, in the past, even resulted in the persecution of scientists. For instance, in the seventeenth century, Galileo used a telescope to see and to illustrate others that the moons of the planet Jupiter, revolved approximately it. This was very much like what he was proposing: that the earth revolved approximately the sun. He could also illustrate that there were hills and valleys on the surface of the moon. But these thoughts were against the prevailing concepts that the sun revolved approximately the earth and that God had created the perfectly spherical moon. This new theory when published, led to the trial of Galileo. Nevertheless, history shows us that barring a few exceptions, new thoughts in science overcame opposition and came to be accepted in due course of time. This not only led to great leaps in science but also molded the intellectual thinking in common.

SCIENCE IN THE ANCIENT WORLD

Primitive Human Society

And now, we begin the story. To discover the origins of science, we necessity seem into the very origin of human society. In its earliest stages, the human subsistence revolved approximately food gathering and hunting. (Fig.1.5).

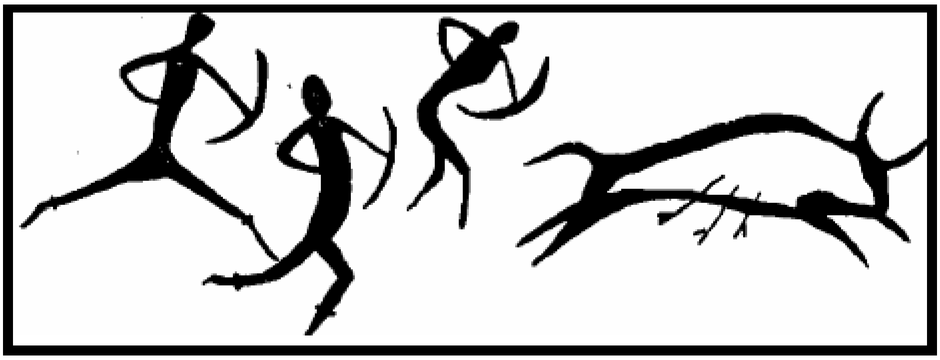


Fig. 1.5 : Hunting was a group activity. Cave painting by prehistoric man.

Food Gathering and Hunting

In order to live, man needed to eat and to protect himself from the weather and animals. For both purposes he establishes it better to be in groups. Wherever human beings existed, they looked for food in plants and trees and also dug the earth for roots. In this method they came to know what the right type of food was, and where they could get it from. They also establish out which animals were dangerous and which were not, and how to protect themselves. This knowledge had to be passed on from one generation to the after that, so that the group could survive.

A casually picked up branch or stone aided their efforts to reach the fruit in trees or to dig for roots, strike down animals or give better protection. As time passed, the primitive apparatus and weapons were improved upon and regular ways for creation them were recognized. This specialized knowledge was passed on in the shapes of apparatus and techniques from one generation to another. Under hard circumstances of livelihood, food gathering and hunting became a group action. Since food could not be preserved, it had to be eaten fairly soon. This meant that the surplus food had to be shared.

Sharing eventually became a social obligation. Especially, when it became general experience that if more people hunted jointly, or looked for food jointly, they got more and better food, and also had better protection. Out of this practice, small societies started to form, with their own distinctions, symbolized by the kind of food they specialized in eating, described ‘totems’. The size of each society was restricted by the environment and the total availability of food. In the Indian sub-continent, the stone age population density did not, almost certainly, exceed one per twenty five square kilometers.

These groups met each other as they moved approximately in search of food. “Exchanges” flanked by these groups or societies started as gifts. The exchange of gifts, flanked by highly specialized food gathering groups, led to a better diet, wider range of food, improved ways of tool creation and tool using. The act of sharing food and also the act of exchange flanked by groups, were at first festive and formal occasions. Such occasions gave rise to art, dance and music as well as social customs and rituals. It was but natural that such sharing and exchange required verbal communication and mutually agreed conditions of expression and events of quantity. Language, thus, arose out of necessity. Language helped in knitting the society jointly and handing down of the accumulated culture to the after that generation.

So distant, we have painted a very common picture of the primitive human society. We will go into specific regions, like the type of 'apparatus and clothes that primitive people used, how fire came to be used for cooking etc. All these characteristics form the material foundation of primitive life.

The Material Foundation of Primitive Life

In the primitive society, human beings invented apparatus for catching animals, and for collecting, transporting, and even preparing food. They looked for protection against the elements of nature in the form of clothing and shelter in the caves. The material foundation of primitive life is reflected in the apparatus and other artifacts that have been establish in archaeological surveys. The apparatus are all made up of stones. This is why that era has been named as the Stone Age.

Implements and Apparatus

Stones were shaped to suit a specific purpose like digging, throwing or scraping. Their forms and sizes became standardized in excess of an era of time in dissimilar geographical regions. These forms and sizes became so stable that they continue in some tribal societies even today. You may like to compare the apparatus used today for hunting, digging or shaping materials with those of the Stone Age shown in Fig 1.6.

Fig. 1.6 Some stone tools used by the primitive people. 1) Chopper about 7,00,000 years old; 2) cleavers for cutting trees about 3,00,000 years old; 3) blade; 4) arrowhead; and 5) awl about 60,000 to 25,000 years old; 6) polished stone celts used for cutting trees about 4000 years old.

A motivating aspect of tool creation is that the “thought ” of an implement grew in the mind of. the maker before the actual shaping of the stone was done. Archaeological proof shows that the apparatus were first shaped out of superior chunks of stone just like an engineer would effort to fabricate a part of a machine. You should study Fig.1.7 to understand this better.

This procedure of conscious foresight was to become an integral part of designing and scheduling, which are the features of science, particularly of the experimental way. This comes from trying out several ways of creation a substance. Likewise, these days, we discover that models or drawings of the desired substance are made first, rather than always relying on its straight manufacture. The substance can then be improved by trial and error.

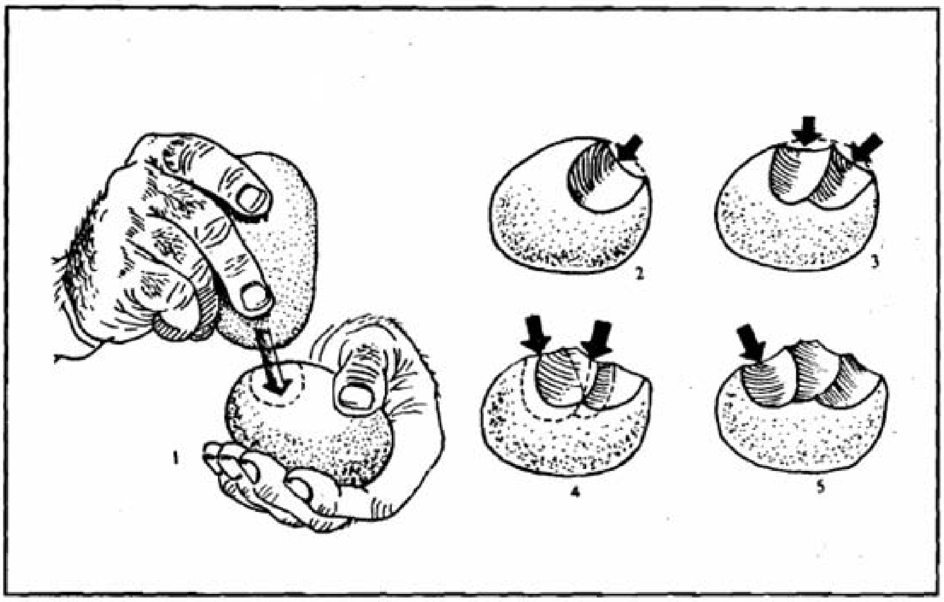


Fig. 1.7 Idea of a tool grew in the mind of the tool-maker before he actually shaped the tool. A chopping tool with a short, irregular sharp edge is being made from a round pebble: (1) Tool-maker strikes a sharp blow at the edge of the pebble with a hammer stone, (see dotted line and the arrow); (2 and 3) two flakes are first struck off; (4) tool is turned over and the process is repeated; (5) when another flake is struck off, the tool gets a short, irregular sharp edge.

The major development at this stage, though, was the invention of master apparatus: the implements to create implements. This created the possibility of producing several dissimilar kinds of implements than could be basically selected or picked up from nature.

The procedure of creation apparatus laid the base for our modem ways of casting, hammering etc. When men made apparatus and used them for dissimilar tasks, they also became aware of the mechanical properties of several substances. For instance, they establish out which materials were strong, which could be molded easily, and which were brittle. This laid the foundation of the physical sciences.

The apparatus were used not only for hunting, but also provided a means of shaping and preparing softer materials such as wood, bone and skin for decoration and art, or for protection from cold weather. Food gathering became much more efficient with the introduction of containers, baskets, and bins. Sure refinement of apparatus used for creation hunting implements and the knowledge of how to handle soft materials led to pinning, sewing, tying, twisting, twining, and weaving (Fig. 1.8). These are the techniques needed for creation clothes, rugs, tents etc.

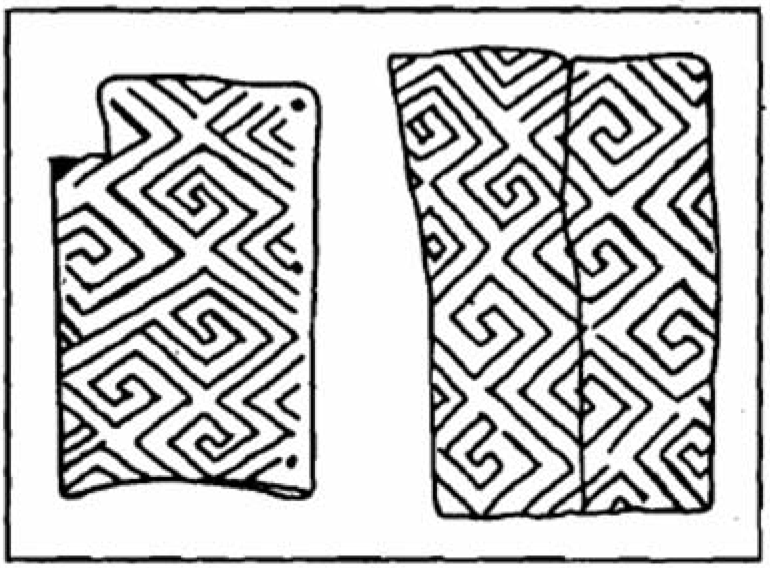


Fig. 1.8 **: Weaving patterns of the Stone Age from near Kiev, USSR. Note the mistakes and distortions.**

Small stone apparatus or microfiches are established at several sites in India. These apparatus are dated at 3000 B.C. or earlier. The apparatus are mostly establish close to minor streams with fishing pools in ancient times, though the pools are now usually silted up. Some valuable stones, like, agate or onyx, sharpened by chipping or cutting fine teeth in the edge, have also been establish. From a comparison with the current practice of African Bushmen, we may infer that these could be parts of compound apparatus. These chips were set in handles of wood, horn, or bone by means of tree gum or some such adhesive, and were used for creation javelins, barbed harpoons, arrows, knives, sickles, etc. (see Fig. 1.9).

Fig. 1.9 Small stone tools or microliths dated about 3000 B.C. found in Langhnaj, Gujarat. Microliths were hafted in a bone or a wooden piece to make a compound tool, like a sickle.

The stone apparatus were used for several purposes like chopping wood, digging, skinning animals, scraping off the flesh, and breaking the fibers under the skin, as well as for splitting canes for weaving baskets or preparing fish for the fire. A good number of narrow, sharp pointed flakes could be needles or awls (like the tool used by shoemakers) for stitching the hides, presumably with gut.

Clothes

The concept of clothes might have started even before weaving, as an extension of the practice of carrying food and implements in relation to the. Attachments with a convenient hold in the hair, approximately the neck, waist, wrist, and ankles might have been used. Feathers, bones, and skins were often added to these attachments. The crucial detection, though, was that furry skin helped to stay people warm. The use of such clothing, jointly with domestication of animals and their killing when food was needed, helped human beings enormously. It increased their mobility in excess of wider regions, and enabled them to survive cold weather.

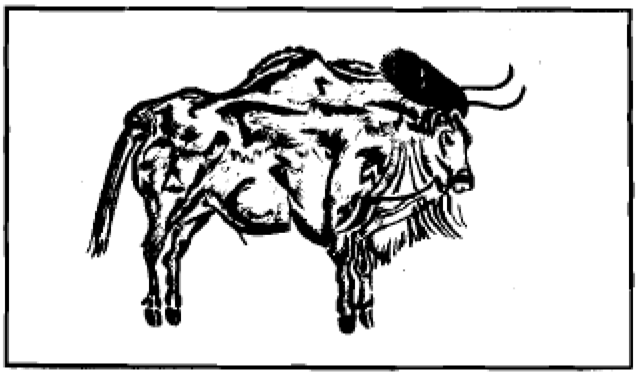


Fig. 2.7: Early human beings had a fair knowledge of animal anatomy. Painting of a bison in Altamira caves, Spain.

Fire and Cookery

Exactly where and when fire came to be used is not recognized. Fire, to start with, necessity have been a frightening thing, giving rise to several myths and legends. Though, as man slowly learned to manage it, he establishes it very useful to stay himself warm and to frighten absent wild animals. It is easy to imagine that chance eating of burnt or charred flesh necessity have led to the thought of cooking, which then made even tough meat edible and tastier. Thus, it necessity have tremendously increased the number of things one could eat. It was, perhaps, from the use of fire for cooking that fired clay pottery and melting of metals for creation apparatus arose.

Boiling gave rise to sure difficulties. At first, water was heated by dropping hot stones into water in leather buckets. We discover such stones, cracked by heating and chilling, approximately prehistoric sites. The crucial detection, though, was that by coating a basket with thick clay it could be put on the fire. Eventually, towards the end of the Stone Age, it was exposed that coated baskets crack while heating, whereas pots made of heat-treated clay do not crack. Fired pottery was, therefore, a very important detection. Finally, as the problem of storing liquids for extensive eras in clay pots was tackled, the slower chemical changes of fermentation could be noted and later used for brewing wine. From the use of dyes, paints and tanning as establish in this epoch, we can infer that the use of rudimentary chemistry for transforming materials was also in progress in the later part of the Stone Age.

Social Foundation of Primitive Life

We gave you a glimpse of how the primitive human beings faced the troubles of day to day subsistence and establish some solutions. As their material life became organized by the invention of apparatus, the detection of fire, and some protection against natural elements, their social life also evolved. Language, customs, and rituals appeared as the social foundation of primitive life. We will now briefly describe some characteristics of their social life.

Language

Language necessity have originated as many individuals in a group cooperated in hunting and other behaviors related to food gathering. There necessity has been highly specialized sounds specific to each group. As the groups started the procedure of exchanging surplus food, sure standardization of spoken word became necessary to ensure better communication. The specialization meant special conditions for specific animals and plants accessible in the vicinity. The common conceptual conditions, such as 'animal' for all kinds of animals, and 'tree' for all kinds of trees came much later. We can easily surmise this by learning the complicated grammar and words of tribal languages spoken even to this day. This characteristic is also shared by Sanskrit, Greek and Finnish languages. The word 'color', for instance, originally meant 'red', the color of blood. It was only later that yellow, blue, green etc. also came to be described 'colors'. The transition from specialized to common language also meant a trend towards abstraction. This led to the use of symbols. Very soon man had to let one word stand for several dissimilar things.

Social Life and Rituals

The social life of the earliest human groups or tribes revolved approximately food gathering. To begin with, they necessity have composed anything they could eat—seeds, nuts, fruits, roots, honey and any small animals that could be caught with bare hands. The main food sharing unit tended to concentrate upon a sure kind of food which was easily accessible to them in plenty. Thus, human groups eating one kind of food came to consider themselves as 'kins' or fellow beings of the similar society or clan. Other human groups who ate dissimilar foods were not in the kinship, and at first were not even measured human. As we have told you earlier, this special food thing is described "totem".

The act of gathering the totem was associated with special rituals (Fig. 1.10). The rituals sometimes involved sacrifices (including human sacrifice) to secure increased food supply. The food gathering tribes were entirely dependent oh nature for their survival. Therefore, in order to avoid scarcity, they also urbanized sure "taboos". For instance, taboos were enforced on sexual intercourse in order to manage their population for the limited supply of food. Attempts were also made to manage the group population by a taboo on cohabitation within the totem clan, and by the practice of marriage outside the clan.

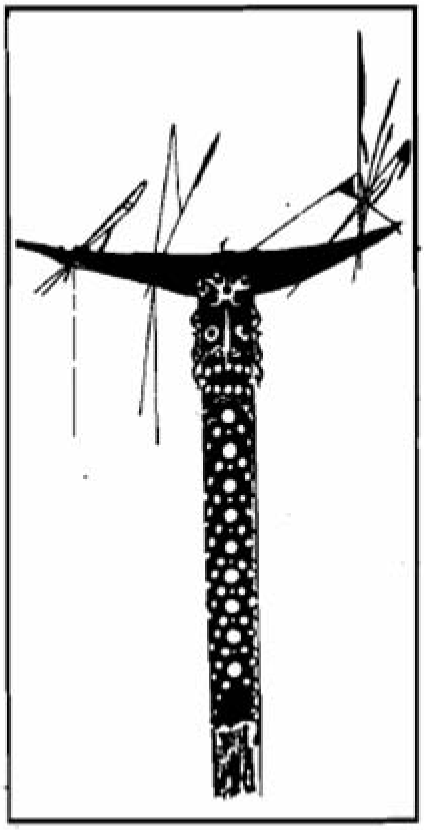


Fig. 1.10 A primitive totem pole, from Borneo, an island near Indonesia. Primitive people probably performed some rituals with their totems around such poles.

Magic, Religion and Caste

You necessity have realized that the food gathering stage was an era of extreme hardship for primitive tribesmen. They tried desperately to manage and manipulate nature for their survival. Though, the techniques for this were few. Therefore, they evolved magic to fill in the gaps left by the limitations of technique. By the use of images, symbols, and imitative dances, they whispered that the animals or plants could be encouraged to flourish and multiply. Objects were often given inherent powers. Sometimes these were realistic, as in the case of some stones which had the 'inherent' power to draw iron. Mainly often, these attributes were imaginary. For instance, gold was supposed to protect from evil or danger.

Magic of the Stone Age, in a method, helped the growth of science, as it was an effort to extend the existing techniques. This signified man's quest for further manage of his environment. Though, magical thoughts did not change with changing circumstances of life. Rather, often the later generations could not even understand what these thoughts meant. Eventually, these thoughts turned into superstitions and myths without any meaning.

Fig. 2.9: Australian aborigines dancing around the picture of an animal before hunting.

Another aspect of primitive thought was in relation to the power of "spirits", may be of dead people, or of gods and demons, on the real world. Therefore, a need was felt to manage or to please them. The concept may have originally arisen out of man's inability to accept the information of death. There were also occurrences which he did not understand and in excess of which he did not have any manage. For instance, a drought or a flood, an earthquake or a forest fire or even an infectious disease, which could wipe out mainly of the population? All these may also have contributed to the thought of 'spirits'.

The origin and development of religion is intimately linked with man's effort at creation a livelihood out of nature, his utter helplessness in several circumstances and the totem oriented food gathering life. Several deities in India are basically bits of stone, colored with red pigment, the color being a substitute for blood. Primitive religion can also be thought of as man's effort to come to conditions with nature, his first effort to explain what was happening approximately him and why. When agriculture became prevalent and settled life became possible, smaller groups merged into superior groups. Their totems, taboos, and cults also got merged and the new system of beliefs became a 'religion'.

The people who were absorbed into these cults supervised to retain some of their identity and to an extent sustained their previous totemic separateness. This connection became codified in India, in conditions of castes. Caste system in India has evolved in excess of an extensive era and has imprints of several epochs and several stages of manufacture. Totemic characteristics are reflected in caste names such as crocodile (Magar), horse (Vaji), and peacock (More), peepul tree (Pimple). Mores do not eat peacock flesh, the Pimples do not eat off the leaves of their totem tree etc. Other stages of manufacture such as agriculture with its specialized professions are also reflected in the caste grouping, such as herb-vendors (Vaidu), diggers (Vaddars) etc.

The Origins of Science

We have seen that the primitive human beings acquired dissimilar types of knowledge from the use of implements and apparatus, from cooking on fire, from hunting animals and gathering fruits or seeds of plants for food. All this knowledge blended into one general pool and jointly with the rituals and myths of society shaped their culture. What we now have to discover is the origin of science in the womb of this culture.

Rational Mechanics

By creation and using apparatus, man was transforming nature according to his deliberate will. This laid the foundation for mechanics of rigid bodies, motion, and properties of materials. The handling of bow and arrow, the javelin or the boomerang is some examples (Fig. 1.11). Again, in the use of lever, it was possible to know before hand what would happen to one end when the other end was pressed. In the use of such devices, the useful results of interaction with nature could be 'seen' or 'felt'. Thus, understanding and confidence urbanized. At least, in one sphere, human beings were realizing how things worked.

Fig. 1.11: (a) Different types of boomerangs: 1) for fighting; 2) for hunting; 3) and 4) boomerangs that return on throwing; (b) an Australian aborigine throwing a boomerang.

Observation and Account

Even without such an understanding, human beings could take advantage of nature whenever they detected regularity. It was enough for them to know what to expect, and when to expect it for taking advantage of a situation. For instance, they observed that earth's fertility changed with seasons. The growth of plants arid movement of animals was also affected by the changing seasons. Fruits and nuts were ready to be picked up at sure times but not at others. The migration of birds, buffaloes, dears etc. changed with seasons. All these observations of the Stone Age people arose from their need for survival. This was especially true in land masses such as India and Egypt with their sharp seasons and varied geography. These laid the foundation for bringing in relation to the discipline of observation and careful account of nature and environment.

Unlike in the case of mechanics, in the case of cooking or brewing, it was not possible to predict easily what would happen as the consequence of a scrupulous action. For instance, if a stone was thrown up, one could be sure that it would come down. One could also aim a stone at a fruit or an animal and be sure of hitting it. Though, in cooking the result would depend on the food being cooked, the amount of moisture in it, and how strong the fire on which it was cooked was. Brewing was even more intricate. Thus, there were several uncertainties in these procedures.

Though, it was possible to know what would happen, if one tried a scrupulous procedure, observed the results, and remembered them, so that at the second trial one was better informed. In this field, and even more in that of animal behaviour, knowledge was essentially traditional, handed down by word of mouth from generation to generation. Though, the reasons for the phenomena observed or noted were often sought in mythical explanations, by involving totem ancestors or spirits.

Classification

There were several similarities flanked by things or phenomena which led to their classification. The first classifications were in conditions of beings (the livelihood), things and passions or actions. Here arose a type of descriptive reasoning; if one of a class behaved in a scrupulous method, it was likely that the other in the similar class also behaved in the similar method. Thus, the accumulation of knowledge and sifting of experiences had major impact on primitive biology and chemistry.

End of Stone Age

The essential characteristic of the hunting and food gathering society was its dependence on nature. It could eat off nature but could not manage nature to augment the food supply when its population grew. Nor could it breed animals for the similar purpose. Therefore, whenever the food supply ran out, the population had to move or they would perish. The movement of tribes became hard as their population grew. Due to their lack of manage in excess of natural disasters, at times, mainly of the population of a tribe was wiped out.

The end of the Stone Age was also brought in relation to the by climatic changes. In Europe and in the northern hemisphere, with the onset of very cold circumstances (also spoken of as the Ice Age), food gathering and hunting behaviors became restricted and hard. The society had to thrash about for its survival by developing a dissimilar kind of manufacture.

It necessity be mentioned at this stage that the Ice Age in the Indian subcontinent (including parts of Pakistan, Afghanistan and Burma) was neither so harsh nor as extensive as in Europe. Therefore, food gathering was much easier here in conditions of quantity and diversity than in Europe. Whereas only half a dozen cereals, peas and beans made up approximately the whole diversity of European staple food, even a region of average fertility such as Maharashtra had in excess of forty types of indigenous staples.' This had a profound power on subsequent growths in these two locations.

This fortunate event, though, also meant that the Stone Age mode of manufacture sustained in this subcontinent in excess of a much longer era and in excess of a wider region than in Europe. People could and did survive in the food gathering stage when their immediate neighbors had been forced to move on to agriculture for food manufacture. This meant that, unlike in Europe, the old culture with its elementary thoughts of science and techniques survived here for centuries, well into the new epoch. There was also some get in touch with flanked by the two parallel cultures and manners of manufacture, which sometimes turned into a disagreement flanked by them. For instance, the search for cultivable land often led to disagreement flanked by the Aryans and primitive tribals. The tribal's were pushed into the interior regions. In turn, the old beliefs and customs influenced the practices which were feature of the new mode of manufacture.

Agriculture and Civilization

The after that era in the development of human society is recognized as the Bronze Age, named after the new alloy which replaced stone throughout this era. This era was, in information, the beginning of a new kind of productive action, namely, agriculture. We will now study how the practice of agriculture changed the society. We will also see how the rise of municipalities and the changing socio-economic needs led to the birth of science. The growth of municipalities brought in relation to the change in the social organisation which later affected the growth of science in Bronze Age cultures.

The Origin of Agriculture and Civilization

There is no historical proof to tell us exactly how agriculture arose. We can only imagine what may have happened. Farming of grain may have arisen without any violent break from food gathering. In regions well stocked with wild granules, enough seeds would get scattered approximately to produce crops worth reaping. Agriculture, almost certainly, resulted from the understanding that plants could be grown from seeds and that the crops had some relation to the seasons. And, almost certainly, the availability of water helped in this procedure. Farming, though, marked a break from the primitive era, as human beings stopped being dependent on nature and started to manage their livelihood and destiny.

Farming necessarily meant permanent or semi-permanent settlements approximately regions that were climatically and soil-wise appropriate for crop manufacture. These settlements grew into villages, with some society life and leisure. It is but natural that the settlements recognized in regions mainly appropriate for farming, urbanized the fastest. Thus, we see that in this era, from in relation to the 4000 B.C. to 1500 B.C., the four great civilizations of Egypt, Mesopotamia, India, and China came into subsistence in the wide river valleys of the Nile, the Tigris and the Euphrates, the Indus, and the Hwang Ho respectively (Fig. 1.12). The Indus Valley Civilization, of which we are the descendants, is dated flanked by 2700 B.C. to 1750 B.C.

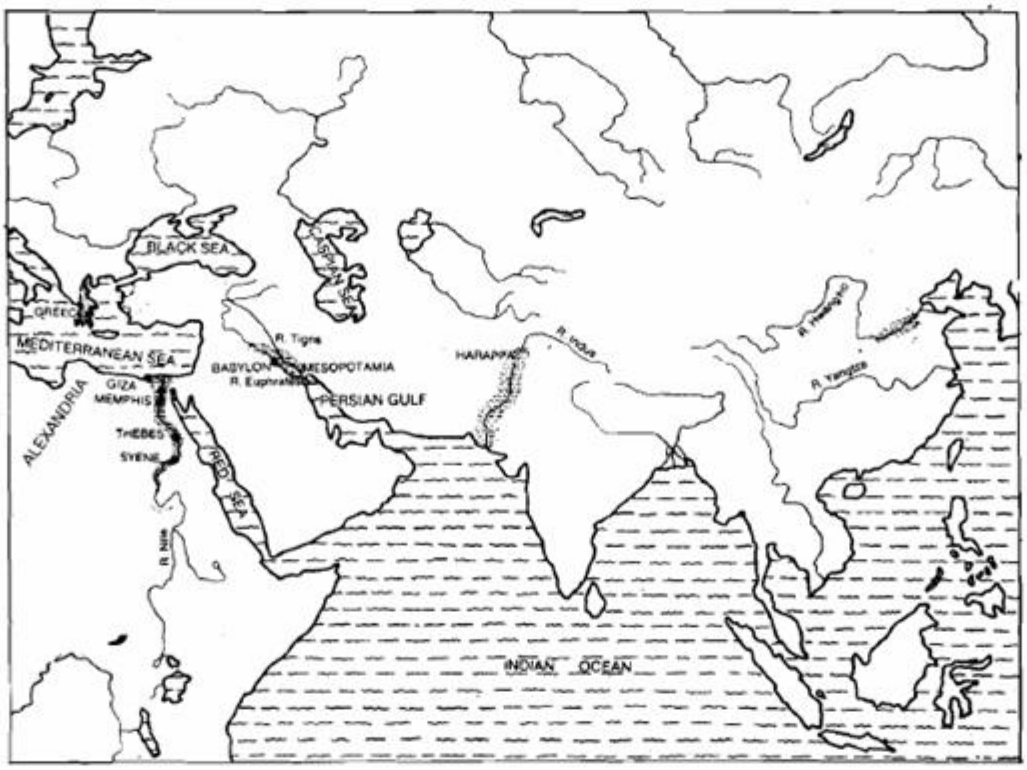


Fig. 1.12 Four major river valley civilisations of Egypt, Mesopotamia (present-day Iraq), India and China. Shaded area shows Greek civilisation of the Iron Age.

Growth of Municipalities

The people of those times came to understand very well the advantage afforded by the river for food manufacture. They also came to realize that if the river could be systematically used through natural and artificial irrigation, food manufacture could be increased manifold, (fig. 1.13).

Fig. 1.13 An Egyptian farmer lifting water by lowering a cone-shaped leather bucket which hangs from a beam, balanced across a pillar. The weight at the other end helps the farmer to lift the filled bucket with less effort. Sketch from a tomb painting about 1500 B.C. In India, even today such a device called 'dhenkli' is used.

Though, this could be achieved best, not by one village alone but by many villages getting jointly. Further, barter deal led to some spaces being recognized as meeting spaces for the exchanges. Convenient sites were chosen for displaying goods and exchanging grain for cloth or spices, or shopping for better apparatus and implements made by expert artisans. Some proof suggests that municipalities were founded by bringing jointly population of many villages. The growth of municipalities led to the rise of an administrative class who could organize and coordinate manufactures and exchange, but did not take part in it directly.

We discover that the growth of municipalities was helped by another characteristic of this new mode of manufacture. Man started producing much more than he could consume in the vicinity. Therefore, all people in agricultural societies did not have to be agriculturists. They could produce other useful goods and even excel in music or dance. The surplus could be used to support craftsmen who made the agricultural implements and storage vessels, masons who built shelters, wheel-wrights who made pottery, and others who made carts. There were still others who worked as officers and priests, and who were not directly involved in the procedure of manufacture. These groups of people came to live in the municipalities.

The population of municipalities used to be supported, as today, by agriculture in the neighboring as well as distant villages. This resulted in a division flanked by villages and municipalities, flanked by those who produced and those who supported manufacture through work of other types; those who worked with their hands, and officers or priests who mainly used their mental skills. This division had a very definite effect on the development of techniques and science. For the first time, specialization of occupations and professions had taken lay.

As there was enough food accessible, society could support even those who did not produce. Such people had leisure to think, to improve their crafts, to make art and beauty, and to develop abilities to lead society through institutions of religion and management.

The surplus also had to be transported by land, river, and sea in exchange for other necessities of life and even luxury goods. This provided tremendous impetus for the development of transport, such as rafts, boats and small ships, which brought in relation to the new dimensions of deal, cultural get in touch with and exchange of techniques and science in the middle of dissimilar societies.

Changes in Social Organisation

We discover that the trend in social organisation led to a tendency which eventually stifled the progress of these civilizations and led to their decay. The surplus, or whatever was left of food manufacture after the consumption needs of the society were met, came to be appropriated by a small group of officers. They eventually became priests and kings and shaped an exclusive group. The successors of the original officers slowly lost touch with agricultural techniques, as well as with knowledge and techniques related to manufacture of other articles of consumption and deal. They gave their time and attention to structure monuments, temples and palaces of leisure to impress the rest of the society or to emphasize their exclusiveness. They raised armies to take in excess of more and more productive land. Their priestly power also grew. They cultivated the thought that they had divine powers and were created by God to illustrate the method to the general people and be their natural leaders. Thus, society got divided into exclusive classes of producers and appropriators.

The tragedy of this procedure was that those who used knowledge and technique in the beginning to augment manufacture became in accessible from the vital manufacture techniques and knowledge which had given them power. Recourse was taken increasingly to magic and spreading of false beliefs instead of scientific observations and use of technology to solve material troubles. The farmers and the craftsmen who used the techniques to produce goods were weighed down with the daily troubles of subsistence. They had very little possessions for innovations. Thus, the practitioners could not improve the techniques to solve the troubles they faced; and the appropriators who had the time, possessions and power to do so were no longer interested in these things. As a result of these growths, the progress of technique was thwarted and science stagnated.

In historic eras, stagnation led to the complete decay of civilizations, as in the case of the Indus Valley Civilization. Sometimes there was readjustment of societies due to their being conquered by others, as in Europe where weak and stagnating cultures and societies were subjected to barbarian invasions. In both cases, the centre of progress shifted geographically, to other locations.

So distant, we have given you a broad overview of the social circumstances prevalent in the Bronze Age civilizations. We will now indicate a few technological and scientific achievements of that age, which came to have profound power on subsequent growths.

Scientific and Technological Achievements of Bronze Age

The major technological advance that accompanied the rise of municipalities was the detection and use of metals, particularly copper and its alloy bronze. Simultaneously, deal flanked by societies flourished and gave rise to better shapes of transport. The wide range of services involved in the operations of a municipality gave rise to a qualitative change which marks the beginning of conscious science. This was possible, because this initial stage of development required that the practitioners of techniques and the priests who did only mental work solve troubles jointly. Recording of numbers or quantities of goods, standardizing their events, counting and calculating, creation of calendars etc. form the foundation of quantitative science in the Bronze Age. We shall now study each of these characteristics, in brief.

The Use of Metals

Human beings were attracted by shiny gold and copper which are establish free in nature and used them originally as ornaments. Bits of metal have been establish in necklaces and other ornaments of Stone Age. Though, copper nuggets beaten to dissimilar forms were not of much practical use as apparatus and weapons, as they were too soft. With the development of fire kilns needed for creation pottery, copper ores which could be easily reduced were used to produce copper metal. Later, an alloy of copper and tin was exposed. It was harder and stronger than copper and could be cast into apparatus and weapons. Casting was done by pouring molten copper and tin mixture into vessels or “moulds”. When the mixture was allowed to cool, it took the form of the pot. Some of the apparatus thus made were establish to be distant superior to stone apparatus and weapons, and were easier to produce.

The use of this new metal meant revolution in several techniques, such as carpentry, masonry, creation apparatus, vessels, vases etc.

In the Bronze Age civilizations in dissimilar parts of the world, the new metal was widely used for creation weapons and apparatus and it became a commodity of distant deal. In India, the copper ore came from Rajasthan and was accessible in enough quantity for export to Babylon. The problem of carrying ores from inaccessible parts to municipalities, and to distant spaces was solved by the development of transport.

Transport

River Valley civilizations were characterized by settlements beside the rivers and growth of municipalities which needed, in the middle of other things, stones, and wood from distant spaces to create homes and monuments. Municipalities also signified that everyone need not depend on land. There was surplus manufacture so that some people could deal or take up other occupations. The surplus had to be traded for goods produced in dissimilar parts of the world. For instance, we have proof that Mesopotamians traded extensively with India through Bahrain. Besides copper, the Indians exported peacocks and apes, ivory and ivory combs, pearls and some textiles. In return, they received silver and other commodities. Deal, as well as the desire to manage big territories, led to the need for efficient transport. Since the rivers were easy flowing, water transport was mainly almost certainly urbanized first (Fig. 1.14).

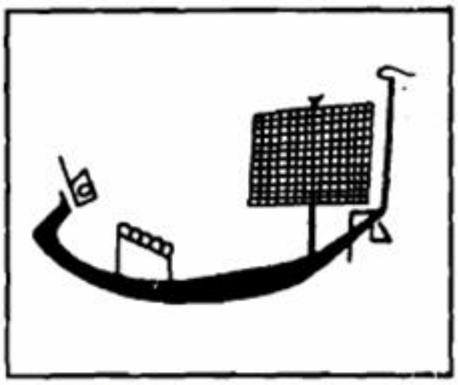


Fig. 1.14 Oldest known depiction of a sail appears in this 5,000 year old Egyptian drawing of a Nile river boat.

We also discover proof to suggest that dugout canoes and rafts made of reed and bamboo were used for carrying goods in bulk. At some early date, the sail was invented marking the first use of inanimate power for locomotion. When river transport was extended to the sea, it posed new troubles of boat construction and navigation. Stronger winds meant stronger fabrics for creation a sail, and construction of heavy frames and structures to hold them. Woodwork had to be very strong and durable, too. The river went in a recognized direction, it was like a road, but one could easily lose one’s method on the high seas. New methods of finding site and direction had to be searched. The mainly primitive way was of the land finding bird. Navigation by sun and stars had also become a general practice.

The rise of municipalities would also have required heavy goods to be transported in excess of short distances by land. This may have been done by the use of sledges to begin with. Heavy sledges could be eased downhill. Though, beside the plains, tree trunks came in handy as rollers. Discover of wheel revolutionized land transport, though it is not possible for us to say, from historic proof , where the wheel was first invented. Its use for creation carts which transported goods and passengers was perhaps one of the mainly important growths of the Bronze Age. The real ingenuity in developing this mode of transport, was in joining the solid roller or wheel to the body of the cart in such a method that it could turn without coming off. In other words, the wheel and the axle were twins from birth. Carts pulled by animals soon urbanized in Mesopotamia, Indus Valley and much later in Egypt where the boat remained the main mode of transport. In early Mesopotamian carts and even in some present-day Indian carts, the axle turns and is held in lay by leather straps (see Fig. 1.15).

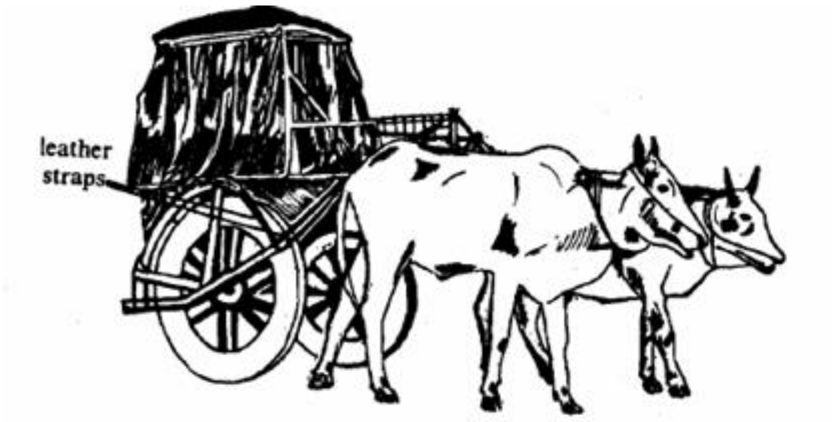


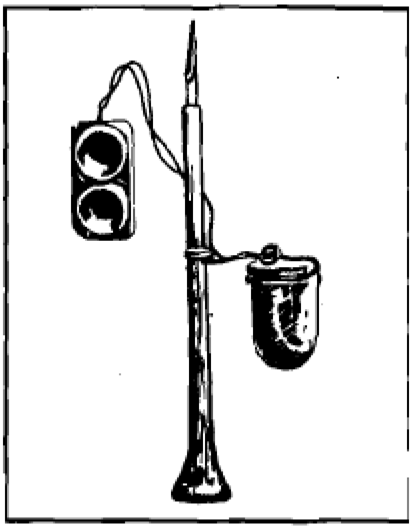
Fig. 1.15 A bullock cart in India. Notice the leather straps holding the wheel supports.

The motion of the wheel, use of the lever to dislodge boulders, use of the inclined plane to push things up or slide them down in the construction of granaries and temples, provided a great impetus for the understanding of mechanics. Mechanics was to have a dramatic impact in rising man's mobility. Today, we can move anywhere on earth at high speeds, span the oceans, fly in the sky and go out into legroom.

Quantitative Science

With the availability of surplus in agriculture and the manufacture of non-agricultural goods by craftsmen, exchange and deal became a part of life. With the passing of time, exchange dealt with increasingly dissimilar kinds of commodities as well as increasingly big quantities of these commodities. Therefore, what should be exchanged, with what, and in what quantity, could no longer be basically memorized. Some standards, such as numbers and measure of amounts of grain etc., and weights, became necessary so that proper quantities of goods could be set separately or marked off for collection and exchange.

For the record, the symbol for measure was followed by a picture or shorthand symbol of the scrupulous substance which was to be traded. Slowly, symbols were introduced to cover actions as well as objects, and so writing appeared. Writing urbanized, either as a sketched symbol standing for a whole thought as in Chinese, or symbols and sounds going jointly as in Mesopotamian cuneiform or the Egyptian hieroglyphics (Figs. 1.16, 1.17).



(a)

(b)

Fig. 1.16**: (a) Writing materials in ancient Egypt: ink-pot, sharpened reed and jar for water; (b) some Egyptian hieroglyphs.**

Fig. 1.17: Mesopotamian cuneiform: the laws of king Hammurabi (about 1800 B.C.) of Mesopotamia, carved on a pillar. The top of the pillar shows the Sun god offering the code of laws to Hammurabi and below is the code. A replica of this pillar is kept at the National Museum, New Delhi.

The standardization of exchange in the form of weight led to the use of balance, a scientific invention of great consequence. Exchange also necessitated easy calculations such as addition and subtraction of numbers, which led to arithmetic.

The use of bricks for structure homes gave rise to the thoughts of right angle, and the straight row, which led to the birth of what we call geometry. A strong school of modem historians and archaeologists, such as Debiprasad Chattopadhyaya of Calcutta and Allchin of Oxford, consider that the base of geometry was also laid at this time in the Indus Valley Civilization. The geometrical thoughts of this civilization were followed by the Greek geometricians of the Iron Age, and thus, these came to profoundly power contemporary geometry. The practice of structure in brick also gave rise to the concept of regions and volumes of figures and solids, which could be calculated from the lengths of their sides. Later, in Egypt, mathematics became sufficiently advanced to create it possible to calculate the volume of a pyramid.

The skill to count and calculate establish immediate use in sure other regions such as creation of calendars and in the consequent development of astronomy (Fig. 1.18).

Fig. 1.18: Early Egyptian ideas about the universe. The star studded figure at top is the sky goddess Nut. Beneath Nut is Shu, the god of air, shown holding symbols of immortality in his hands. Under him lies the earth god Geb, his body covered with leaves. The boats on each side of the drawing carried the sun on its daily journey across the sky.

The sun and the moon were needed for navigation. The need for practical astronomy was also felt in scheduling agriculture on a big level. Crops had to be planted and harvested in the right season. Floods were a recurrent phenomenon in the river valleys, for which it was essential to be prepared beforehand. The observation of sun and stars to fix the length of a year became so precise that already in 2700 B.C., the Egyptians were able to fix it at 365.2422 days!

Sumerians and their successors in Mesopotamia adjusted the solar (sun-based) and lunar (moon-based) calendars through accurate observations. They invented the hexadecimal system of 360 degrees in a circle (close to enough to the days in a year), 60 minutes in an hour, 60 seconds in a minute. The exercises were accepted out using mathematical tables and led to algebra and arithmetic of the later epochs.

Another job that came to be very prestigious with the growth of municipalities was that of medicine. Although the practice of medicine was limited to treating wounds, dislocations, fractures etc., the practitioners could successfully diagnose several diseases. They could compare cases with one another, notice dissimilar diseases, and record them. From such descriptions, orally passed on to later generations, arose the sciences of anatomy and physiology. Practitioners of medicine also had the knowledge of plants and mineral substances to prepare drugs for several diseases. They grew plants and herbs for this purpose. It is from this source that the science of botany arose later.

The foundation for chemistry was laid in the observations and practices of jewellers, metalworkers, and potters. They knew in relation to the at least nine chemical elements—gold, silver, copper, tin, lead, mercury, iron, sulphur and carbon, and also in relation to the diversity of arid and liquid reagents. The procedure of smelting ores, of purifying metals, of coloring them, of adding enamels-—all involve intricate chemical reactions that were learnt by several trials and experiments. Though, chemistry never rose to the rank of a recognized science in the Bronze Age.

To sum up, we have seen that the socio-economic needs of rising municipalities and deal flanked by municipalities gave rise to several broad regions of quantitative science, such as standardization of events, arithmetic, geometry, astronomy, medicine etc. The base for the future development of several other regions such as chemistry, algebra, anatomy and physiology, botany etc. was also laid in this era.

Indus Valley Civilization

The great municipalities of Harappa and Mohenjo-Daro, now in Pakistan, were exposed in the 1920s. They were the first proof of a fairly advanced civilization in the Indus Valley. Subsequent excavations at other sites such as Kalibangan, Ropar, and Lothal have shown that this civilization spread as distant as the present Haryana to the east and as distant as Gujarat to the south. You can see all these sites in the accompanying map (Fig. 1.19).

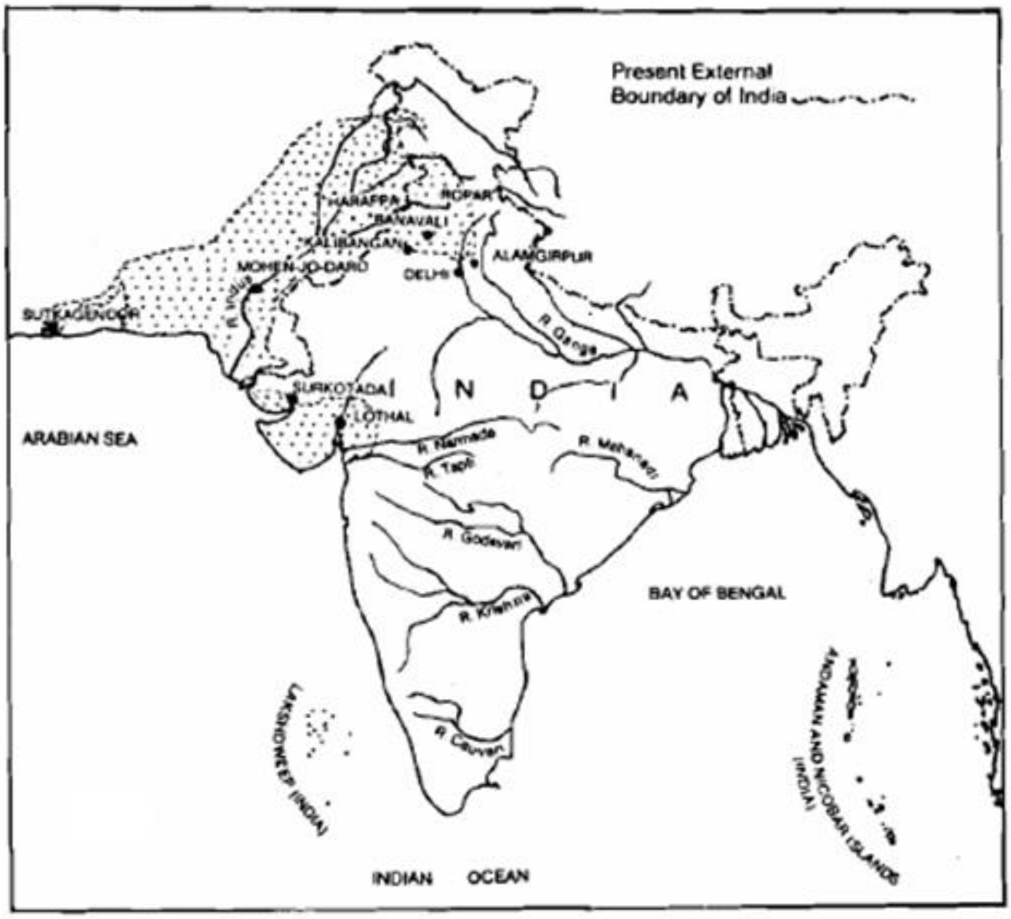
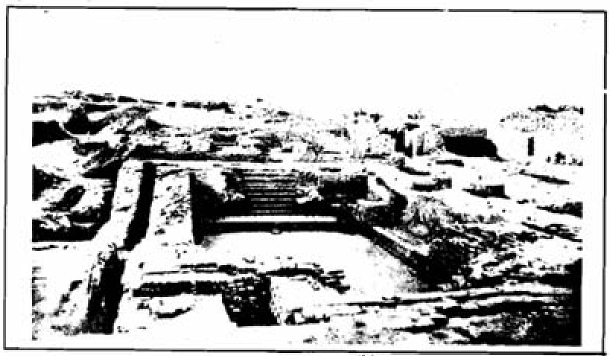


Fig. 1.19: Extent of Indus Valley Civilisation, showing some major cities.

The ancient municipalities in the Indus Valley illustrate city scheduling of a truly amazing nature. Some of the municipality homes are multi-storied and palatial. They are built of well baked burnt bricks and supplied with such amenities as excellent bathrooms and lavatories. These obviously belonged to the rich. The city layout was in rectangular blocks of in relation to the 200 yards x 400 yards, with wide main streets and good minor lanes. The straight streets met at perfect right angles. There was a superb drainage system for carrying out rain water, and cesspools for clearing the sewage. There were enormous well constructed granaries. The small tenement homes in rectangular blocks obviously accommodated workers or slaves. Public baths were a significant characteristic of the Indus Valley municipalities. Several rooms and multi-storied structures were establish approximately an open courtyard, which contained a rectangular tank of in relation to the 23 ft x 30 ft and 8 ft deep. The bricks were well laid in the tank wall, with waterproof intermediate layer of pitch. A finely built drain allowed water to be emptied for cleaning the tank, while filling was done by drawing water from a nearby well (Fig. 1.20).

(a)



(b)

Fig. 1.20 (a) A public drain by the side of houses, Lothal; (b) the water tank, Mohenjo-daro.

The high excellence of construction and layout establish in the Indus Valley implies that the people of these municipalities were good technologists. They had mastered the techniques of construction using a profound knowledge of legroom utilization and geometry. Historians conjecture that the creation of bricks with perfect geometrical precision, fitting them jointly in dissimilar forms and sizes, and maintaining straightness and angles, in roads as well as in big structures, required considerable knowledge of geometry.

It is motivating to discover detailed account of the geometrical theorems and axioms in a text described Sulvasutra which dates approximately 600-300 B.C. These sutras were used for creation intricate devotional fire altars in Vedic times. Fire altars have also been establish in some municipalities of Indus Valley Civilization like Kalibangan. This leads the historians to conjecture that Sulva geometry is the product of the earlier age of Indus Valley Civilization, transmitted through custom to a later age.

We are all well-known with the well-known Pythagoras theorem which says that "the square on the hypotenuse of a right angled triangle is equal to the sum of the squares on the other two sides" (Fig. 1.21).

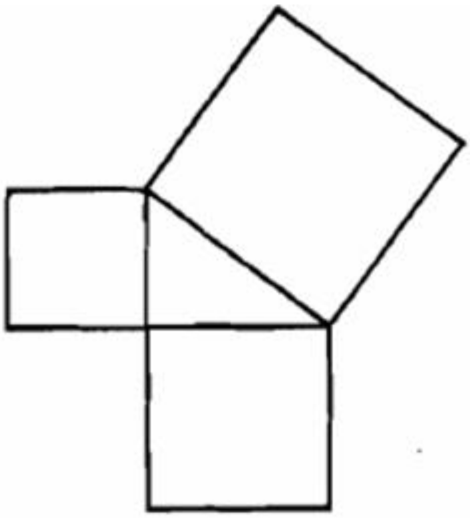


Fig. 1.21: Illustration of the Pythagorean theorem.

Its detection is usually attributed to the Greek thinker Pythagoras (582-500 B.C.). The Sulvasutra also contains an alternate version of this theorem which says that "the diagonal of a rectangle produces regions, which its length and breadth produce separately”. Separately from this, Sulvasutra deals with construction of geometrical figures, combination, and transformation of regions, measurements of regions and volumes, squaring the circles and vice versa, creation of similar figures with dissimilar regions, and a diversity of other related troubles. The value of square root of 2 (i.e. V2) is given in Sulvasutra as 1.4142156.

All this leads us to surmise that the inhabitants of Indus Valley may have possessed considerable knowledge of geometry.

Bronze apparatus, containers, sticks, ornaments, toys etc. establish in the excavations at Mohenjo- daro, Harappa and the other sites indicate that the Indus Valley Civilization had attained a high stage of scientific and technological know-how. We also have proof of deal with Mesopotamia in the artifacts establish in archaeological surveys. Richness of slit deposited by the Indus on its banks made it possible to cultivate without deep ploughing. Hence, the accessible proof does not reveal bronze ploughs but only apparatus to bury the seeds very close to the surface of the soil.

A peculiar characteristic of the Indus Valley Civilization was that bronze was used only for creation apparatus, such as sturdy knives, chisels and saws, but approximately never for instruments of violence. The spears used were thin without a rib and totally ineffective in combat. There were no bronze arrowheads either. The early Indus Valley culture was particularly non-violent.

All these inferences in relation to the Indus Valley Civilization arise from the physical proof , such as apparatus, artifacts like pottery and textiles, architecture, and the total plan of the municipalities including water works and sewage disposal, gathered from these sites. We could have recognized a lot more in relation to the times, if only we were able to decipher the writings on the sticks establish at these sites. So distant, we haven't been able to create out what the several symbols and writings carved on stone sticks, indicate. Thus, in future, new facts may emerge which could shed more light on the Indus Valley culture.

The growth of municipalities created further demands which led to great scientific and technological advances. In turn, these advances improved the ways of manufacture. Much of the equipment that evolved at that time has not changed appreciably in the 5000 years that have gone by. Mainly of us still use the similar type of tables and chairs; live in rooms with walls and ceilings of stone, brick and plaster, eat from the similar type of dishes and wear clothes made of the similar type of cloth such as cotton, wool, or silk. Even the staple cereals that we eat were more or less recognized at that time. Though, the glorious era which gave us so several things, came to an end, by in relation to the 1500 B.C. We will now outline the factors that led to the decline of the Bronze Age Civilization.

Decline of the Bronze Age Civilization

We discover that the great growths in manufacture ways that came with the rise of early municipalities lasted only for a few centuries. The initial burst of technological advance was followed by an extensive era of stagnation. Municipalities arose and fell; one dynasty of priest-kings overthrew another. But there was no change in the pattern of manufacture. It remained based on irrigation agriculture, complemented by deal with other cultures. This, almost certainly, happened because in this procedure the social organisation had also changed.

In the primitive human society no special groups lived, whereas there now came into being dissimilar strata in the society. There arose a division flanked by those who produced and those who appropriated the produce. This also meant a division flanked by the thinkers and the doers, flanked by theory and practice. We have also seen how this led to stagnation in science. Eventually, the social structure became exploitative. Peasants and urban craftsmen became poorer, several of them ending up as slaves later on. The emergence of two separate classes, the haves and the have-nots, in the society, led to conflicts flanked by them. This weakened the municipality states and ultimately put a stop to their intellectual and technological progress.

Rising population and continuous barbarian invasions also brought tremendous pressure on these municipality cultures. They had to expand territorially to inhabit more accessible land, in order to feed the population. They also had to raise armies and fortifications to defend themselves. Even in the Indus Valley, which was a non-violent culture, fortifications were raised in the later days. Fortifications, walls and other instruments of violence such as catapults and moving towers required the application of mechanics. As wars became a part of life, a new group of professionals came into being. They were the persons who invented and made new war machines and built suspicious and offensive structures. They may have been the precursors of the engineers of today.

To end the story of Bronze Age, while civilization stagnated at the centre close to the rivers, its power was spreading wider and wider. An impressive and valuable stock of knowledge was handed on to the succeeding generations. The science and techniques of the after that major historical epoch, the Iron Age, are mainly derived from those of the ancient world. The people of Iron Age themselves did not doubt the greatness of the empires that they had destroyed. We discover an echo of those times in the well-known Greek classics, the Iliad and the Odyssey, written by Homer.

IRON AGE

Science in Iron Age India

In the Indian subcontinent, itinerant Indo-Aryans came from the steppes of what is now- Soviet Central Asia and Iran. They came in waves, the first one being approximately 1500 B.C. They moved south-east, and finally settled in the regions shown in Fig. 1.22 as postoral - agricultural societies and kingdoms. For these people, transformation from rustic to settled agricultural societies took flanked by 1000 to 1500 years, the era lasting until in relation to the 700-600 B.C. We get information in relation to the era from the literature of Vedic times such as the Vedas. Samhitas, Upanisads, Sutras etc., and from the apparatus and artifacts establish in excavations at several sites. Let us now attempt to reconstruct this history.

Fig.1.22: Distribution of the Painted Grey Ware pottery in the Gangetic plain provides evidence of the Aryans' movement towards the east.

Search for Agricultural Land and Minerals

For the Aryans, the era of transition from rustic to agricultural societies was characterized by war and strife against the local population. They were constantly in search of agricultural land, mineral deposits, and ores, and they cleared thick forests for these purposes. This is described the Rigvedic era.

Rigvedic Era (1500 B.C.–700 B.C.)

In the Rigvedic era, the Aryan groups were always on the move and in constant strife with each other or with the local non-Aryans. Therefore, they did not have enough opportunity to develop science and technology. Their technology amounted mostly to the construction of chariots, iron apparatus, and weapons of war. The pottery of those times (1000 B.C. to 600 B.C.) establish in the Gangetic plain is described the 'Painted Grey Ware' pottery. It is not as urbanized as the Harappan pottery. You can see this in Fig. 1.23. Likewise, there was no brick technology of any great note, especially in comparison to that achieved in the Harappan era. Craftsmen such as wood-workers, cabinet and chariot-makers, metalworkers and ship-builders, were free members of the tribe. Weaving and spinning was done only by women.

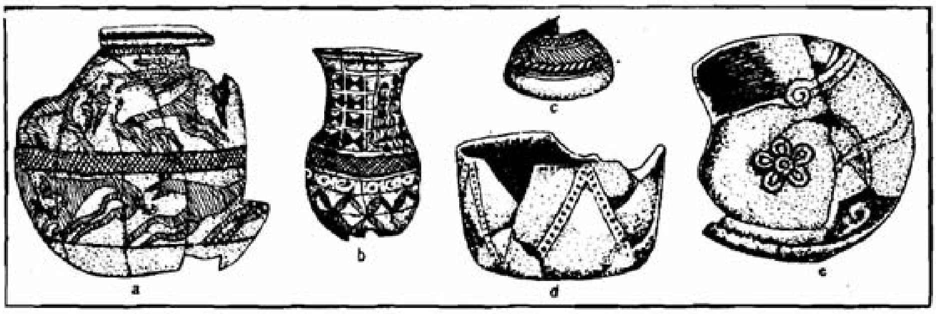


Fig1.23 Sketches of some pottery from the Indus Valley and Painted Grey Ware sites. **Harappan pottery:** a) from Daimabad dated about 2000 B.C., b) from Lothal; c) from Navadatoli, dated about 2000 B.C. **Painted Grey Ware pottery:** d) bowl (Panipat) and e) dish (Ahicchatra). Considerations of range, type, design, temperature of baking show that Harappan pottery is better than the Painted Grey Ware.

As for their knowledge in other regions of science, we discover a reference to the division of the universe into three regions - the earth (prithvi), the firmament (antariksh) and the heaven (dyaus) in the Rig Veda. We now know that this is incorrect. The priests needed calendars for performing sacrificial ceremonies, which depended on the location of sun, moon, and the planets. This meant tracking the motion of these heavenly bodies. The calendars they drew up gave the division of time into days, months, and years and also indicated the seasons. Though, these attempts did not go deep into the study of the motion of planets, of stars and constellations. We also discover stray reference to dissimilar plants, their classification, and structure in the hymns and verses of Rig Veda. Interest in medicine is also reflected in some of these hymns.

Yajurvedic Era (700 B.C. - 400 B.C.)

The Rigvedic era was followed by a wave of eastward push in search of agricultural land and metallic possessions. This era, described the Yajurvedic era, lasted for 300 years. Yajurveda speaks of ploughs drawn by teams of twelve oxen. Such ploughs were indispensable for driving deep furrows and turning in excess of heavy soil which would not otherwise yield well or retain its fertility. The strong plough could be made of wood trimmed down by bronze apparatus, but the ploughshare for cultivating strong soil had to be of iron. Where did the iron come from? Copper may have been accessible in Rajasthan, but iron deposits lay much farther absent in the east. India's finest deposits of iron and copper lie at the eastern end of the Gangetic plain in south-east Bihar. We also discover proof of the Aryans' movement for ores from the copper harpoons, shoulder Celts and semi-human figures dated in relation to the 1000 B.C., which are establish all in excess of the Gangetic plain. The apparatus and artifacts lead us to surmise that these were peddled by Aryan traders. These objects imply that Aryans knew copper refining by controlled fire using good kilns.

The demand for high grade iron increased tremendously with time. As a result, Aryans explored new deposits of iron all in excess of the country, going as distant as Andhra and Mysore by in relation to the 200 to 100 B.C. Knowledge of the metallurgy of iron, copper, silver and tin sustained to be urbanized by the Aryans till well into the Maurya era. We discover that in Arthasastra, directions are given for reducing and melting of ores with distinction flanked by several grades.

Emergence of Urban Societies

The writings of this era also provide us a picture of the social circumstances. The social structure was undergoing radical changes at this time, from the tribal to a more structured urban society. By the time the

Aryans started their eastward progress, a new sort of tribal slave, the 'dasa' was being used for extra labour. A highly urbanized priesthood, specializing in sacrificial rites, combining Aryan and pre-Aryan practices, was also coming into being. Mainly importantly, though, commodity manufacture was becoming recognized. This means that craftsmen and laborers were producing, not for direct consumption of the local society, but for deal within the distant flung Aryan and non-Aryan settlements. Deal routes of Uttarapatha, and later Dakshinapatha, were recognized. You can see these routes in Fig. 1.24. Traders recognized as Sanhavahas (Caravaneers) and Vaidehikas started to ply beside the routes, from Taxila to Magadha. From the coins establish in the excavations, we can deduce that regular coinage had come into use by the end of the seventh century B.C.

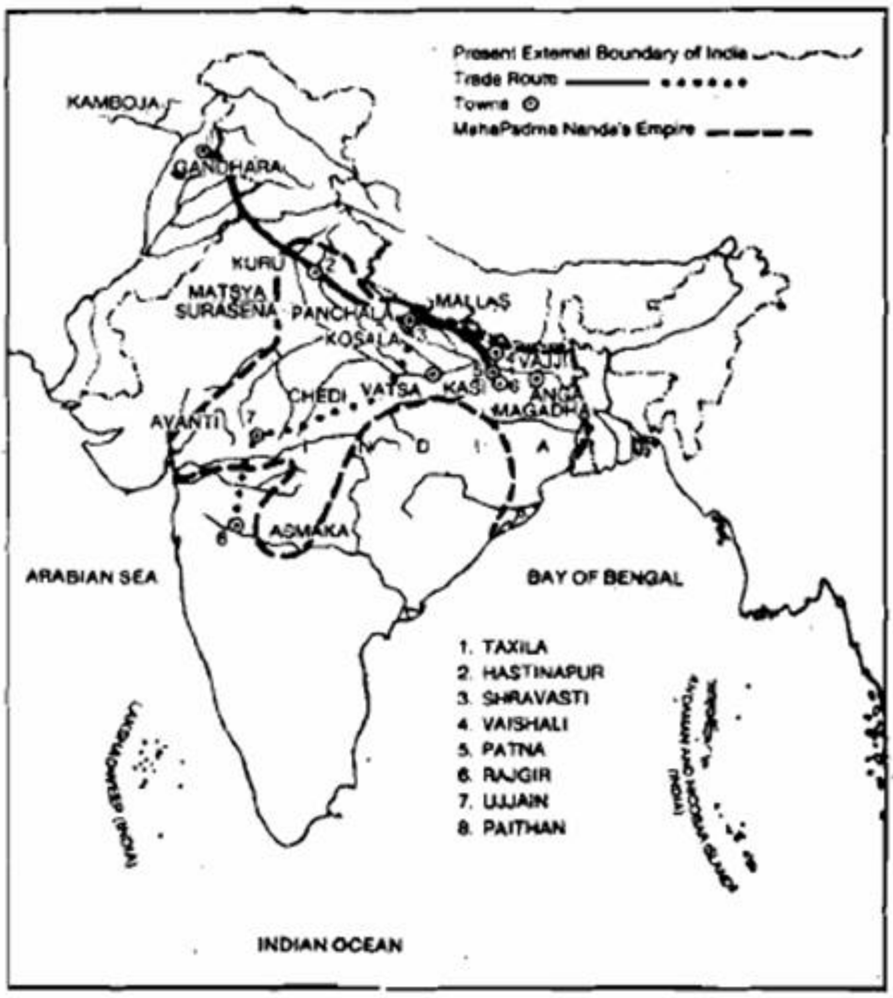


Fig. 1.24: Sixteen principal Janapadas (territories) of the seventh century B.C. Trade routes of Uttarapatha (——) and Dakshinapatha (. . . . .). Magadha empire under Mahapadma Nanda. 4th century B.C.

At in relation to the end of this era, professionals appeared in the meadows of science, medicine, and technology. Students from all beside Uttarapatha started to travel to centers of learning, such as Taxila, for specialized training. The learned grammarian Panini taught in Taxila approximately the fourth century B.C. Atreya taught medicine approximately the sixth century B.C. Atreya's students and successors Jivaka, Kumarabhacha, Bhela, Parasara and others, came to have profound power on the development of medicine and chemistry in India in the after that 1000 years.

A new orderly social life came into being approximately 800 to 600 B.C. This was free from shortages and unending conflicts of the Vedic society. Small states or ‘Janapadas’, headed by kings and governed by codes and laws formulated by state powers, were being shaped.

There were sixteen Janapadas in the seventh century B.C. The state income came from agriculture and deal. These societies had kings, priests, scholars, soldiers, traders, peasants, craftsmen, and lowly civic laborers. For the efficient running of the state and ensuring that power remained firmly with the wealthy, the social hierarchy soon became rigid and got codified into four 'varnas', the Brahmins, the Kshatriyas', the Vaisyas and the Sudras. Divine sanctions were invoked to uphold this hierarchy.

Emergence of Science

We gave you a glimpse of the social structure in India throughout the Iron Age. With the emergence of ordered urban societies, the stage was set for a tremendous development in science and technology. We will now describe, in brief, the advances in several regions of science, such as astronomy, mathematics, chemistry, botany, and zoology.

Astronomy and Mathematics

We have described earlier the stage of knowledge in astronomy in the Rigvedic times. Much of the later work in astronomy in this era is merely a detailed or expanded version of the astronomical knowledge already establish in Rig Veda. We could, perhaps, understand this characteristic if we realize that the growths in astronomy in this era, stem mainly from the astrological practices of sacrificial ceremonies. As a matter of information, astronomy degenerated into astrology in the later years of this era.

They illustrate a fairly high stage of knowledge of geometry. Arithmetic was equally well urbanized. Numbers in multiples of 10 going up to as high powers of 10, as 1012 (one million), were recognized and used. All the arithmetic operations on numbers were also recognized. Sulvasutras contain many instances of addition, subtraction, multiplication, division, and squaring of fractions. Quadratic equations, indeterminate equations, permutations, and combinations also appear in the Sulvasutras.

Chemistry

The stage of chemical knowledge and practices in the new ordered society is reflected in the pottery, iron apparatus and glass objects establish at several Iron Age sites. The iron apparatus that you see in Fig. 1.25, indicate a fairly advanced knowledge of iron smelting. By the fifth or the fourth century B.C., the Indian metalworkers had attained a high degree of perfection in the techniques of producing iron and steel.

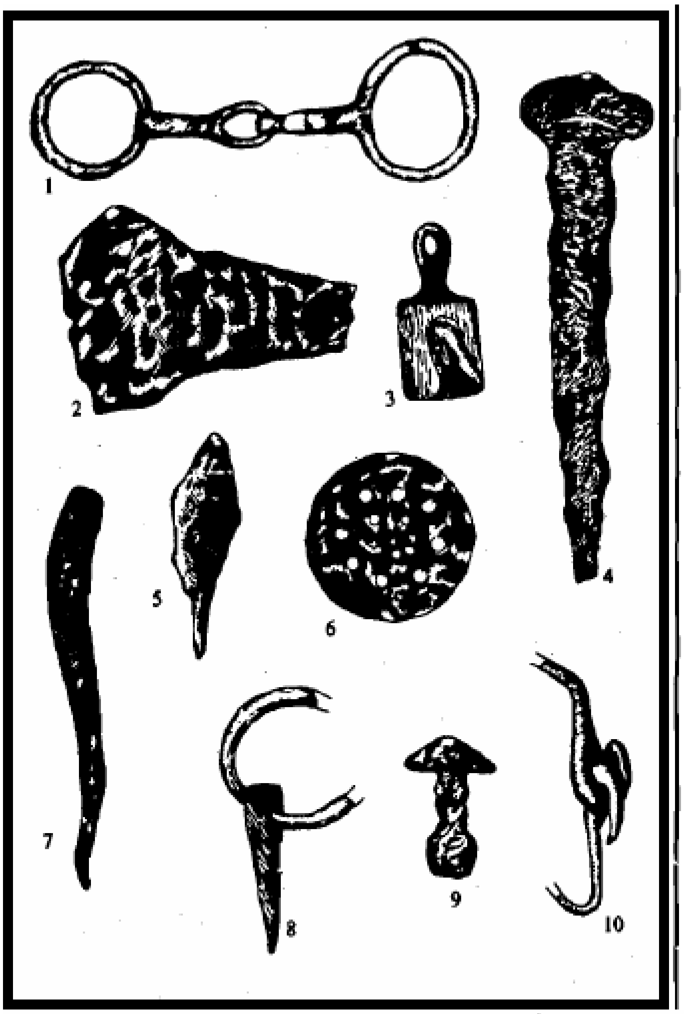


Fig.1.25 Sketches of some ancient iron objects found at various sites such as Taxila, Hastinapur, Ujjain and Sisupalgarh: 1) ringed chain; 2) lower portion of an iron axe; 3) miniature bell; 4) staple from a looped head; 5) spearhead; 6) slightly convex iron disc with perforation; 7) spike of square section; 8) door ring; 9) circular piece of iron with a nail rivetted into it; 10) fragment of a chain.

Glass objects unearthed in excess of 30 sites indicate that manufacture of glass came to be recognized only towards the end of this era (Fig. 1.26). Ceramic bowls, dishes, lids and carinated jars ('handis') dated from in relation to the sixth century B.C. to the second century B.C., were also establish in these sites. Fermentation ways, dyeing techniques, the preparation, and use of a number of chemicals and color pigments were well recognized.

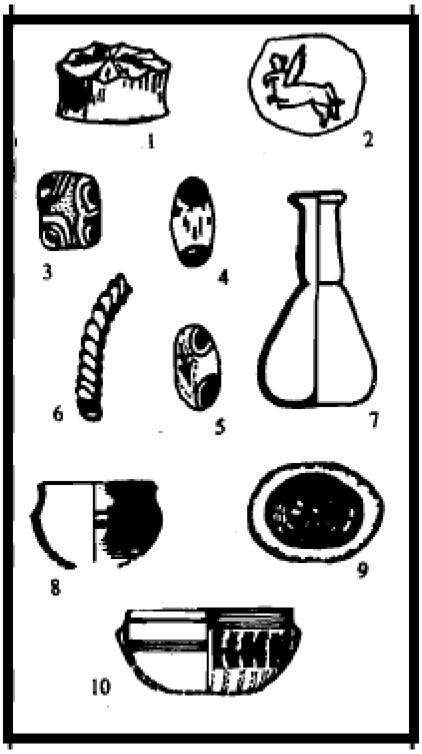


Fig.1.26 Sketches of some ancient glass specimens from a) Taxila (6th century B.C.—1st century A.D.): 1) ear-reel; 2) seal; 3-5 beads; 6) bangle piece; 7) wine flask (the thicker line was the piece that was found); b) Arikamedu (1st century—2nd century A.D.): 8), 10) Roman glass bowls; 9) millefiori glass.

Botany

In the Bronze and the Iron Ages, agriculture became the principal mode of manufacture of man in all lands. It is, thus, not surprising that in India, botany and elementary plant physiology urbanized with the advances made in agriculture. The growths in medicine also helped these sciences. For instance, in Rigvedic hymns, Atharvaveda, Taittiriya Samhita etc., scattered references are made to the following:

Dissimilar parts of the plant such as mula (root), tula (shoot), kanda (stem), valsa (twigs) etc.

- Classification of plants such as *osadhi* (medicinal), *valli* (climber), *guccha* (bushy) etc., according to their morphology and use, and
- Physiology of plants in conditions of what nourishes a plant through addition to the soil, such as cowdung etc.

A systematic study of botany, 'Vrksayurveda' by Parasara, though, came into being by only in relation to the first century B.C. The treatise formalized a lot of the earlier botanical and medicinal knowledge.

Zoology

The domestication of animals like horses and elephants and their use in warfare necessitated the study of their anatomy and physiology. A survey of Vedic literature has revealed that more than 260 animals were recognized at that time. Classification of animals and study of their dietary value had been attempted. Human physiology had also been studied. Post-Vedic literature also contains the names of animals and a vast storehouse of observations on their natural history. These observations may have stimulated the later thoughts and concepts in relation to the classification, heredity, embryology etc.

Though, none of the growths in astronomy, mathematics, chemistry, botany and zoology that we have described so distant, compare with the tremendous advances made in medicine in that era.

Growths in Medicine

Throughout the early Vedic era, healing was thought to be the duty of the priests. Diseases were seen as the results of God's wrath for sins committed, or of being possessed by demons. Interwoven with these thoughts, we discover speculations in relation to the origin of disease, use of healing drugs, beneficial treatment, and surgery in the Vedic texts. The Ayurvedic concept of 'medical knowledge as a science' urbanized only later.

The Ayurvedic System of Medicine

Punarvasu Atreya (in relation to the 6th century B.C.) taught medicine at Taxila. Each of his disciples such as Bhela, Jatukama, Harita, Ksarapani, Parasara wrote treatises on medicine. Atreya himself, Patanjali (in relation to the 2nd century B.C.) and later several others wrote commentaries on what is measured to be the main Indian treatise on medicine, the Caraka-Samhita. Very little of the original samhita survives today. Mainly of what we know of this treatise, comes from some of these commentaries. The origin of Caraka-Samhita, ana the surgical text Susruta-Samhita, is usually estimated to be approximately 600 B.C. There is variation of opinion as to who wrote these samhitas. While some ascribe them to individuals, others describe the authors to be practicing doctors and surgeons belonging to a group of tribes. The main body of the work is a meticulous classification and documentation of symptoms of several ailments, corresponding healing systems, their properties, ways of application and their dosages. The treatises are so significant, because

- They arc scrupulously scientific in their approach and way,
- They have power on the development of other branches of science such as chemistry and botany, and
- They are transmitted through the ages in a form of practice recognized as Ayurveda. Approach and Way

Approach and Way

Their approach and way had the following important characteristics:

- The physician was interested only in one thing and that was the cure of the patient. Towards this, he was allowed to take any steps including subterfuge and lies. For instance, if it was essential for the patient to eat some flesh, the physician had to work out some tactics to overcome the patient's religious or aesthetic revulsion.

- The physician was to direct his attention towards curing the patient. Hence, he was not supposed to cause any injury to the patient even though his own life may be at stake. The physician was to treat the patient as his own son.
- Medical knowledge was to be acquired from previous practitioners as well as through medical discussions.
- Empirical data constituted the first and absolute minimum for science. It was said that of all kinds of evidences, the mainly dependable ones were those that were directly observed by the eyes. A knowledgeable physician was never to attempt to look at, on grounds of pure logic, the efficacy of a medicine which was recognized by direct observation to have a specific medical action.

Diagnosis and Prognosis

The diagnosis and prognosis of disease were done directly by seeing, hearing, smelling and touching all external human organs and human waste and often indirectly by pulse examination. These observations, singly or in combination, were correlated in specific diseases. Thus, in an abscess, the physician heard the bustling sound of air with frothy blood. Likewise, the sounds in entrails, the crack of joint, changes in voice etc., gave other indications. His diagnosis was based not only on direct observation but on knowledge of the patient's house, caste, mode of livelihood, diet and other characteristics of medical history. Prognosis was based on the dictum that a clever physician should not treat an incurable patient.

Curing Ways

The mainly significant curing ways were classified under five heads, namely, inducing vomiting, giving purgative, enema, oily enema and nasal therapy. Specific applications of these were made according to the disease. Possible accidents throughout their application were also listed. There was also extensive classification of diseases.

Healing substances were classified into curative medicines. These were animal, vegetable and mineral substances. This classification was crossed by another consideration, that of grouping according to the effect of medicine, as emetic, purgative etc. These groupings were further so divided into fifty groups of decoctions according to the relief they provided.

Surgery

Susruta-Samhita, a. major treatise on surgery, was derived not only from exhaustive observation of symptoms of diseases and their possible treatments but also a fairly detailed knowledge of human physiology, anatomy, and especially the internal organs. For instance, in treating ulcers or wounds, it is directed that the instruments should be introduced with the precaution of avoiding dangerous spaces, such as veins, bones and the like, until the pus is visible. In the Samhita there is also detailed account of dissimilar kinds of iron instruments, made by local smiths for extraction, cutting etc., in conditions of sharpness, form and size (see Figs. 1.27 and 1.28).

Fig. 1.27 Artist's reconstruction of Susruta's surgical tools as described in Susruta-Samhita.

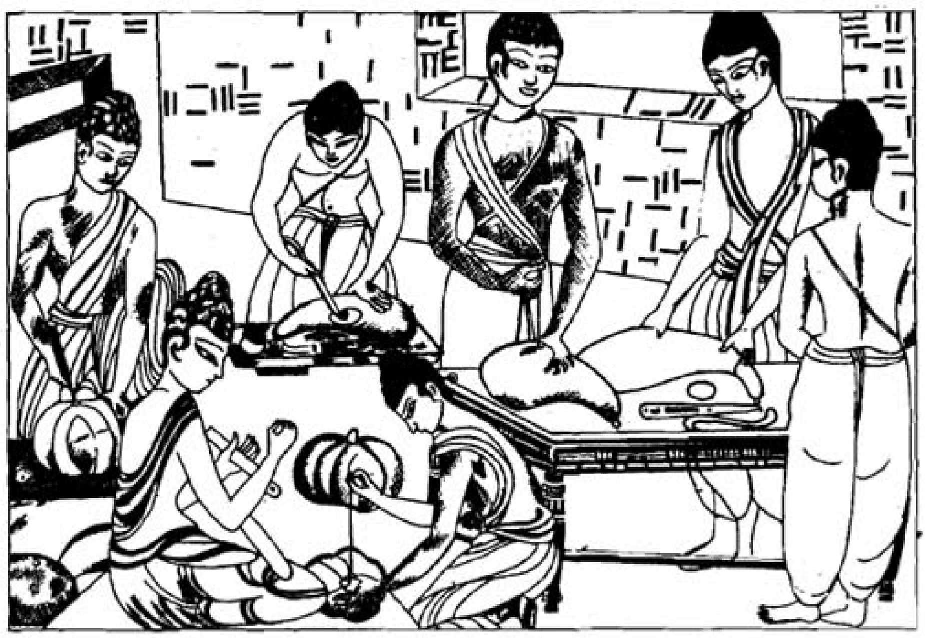


Fig:1.28 An artist's sketch of Susruta's students practising surgery on vegetables, like gourd (*puspaphala*), bottle-gourd (*alavu*) or cucumber (*ervaruka*). The students were given thorough practical training on vegetables, water bags, dead animals and full-sized stuffed dolls before performing surgery on human beings.

Two motivating characteristics of this treatise are:

- Scrupulous attention to pre and post-surgical cleaning of the wound, implying some empirical knowledge of infection, and
- Use of anesthetics. While instructions are given to bind the patient strongly so that he could not move throughout the operation, it is also mentioned that he should be given wine to drink before the operation so that he might not faint and might not feel the knife.

Thus, we discover that in Iron Age India, a scientific approach and way was adopted in the practice of medicine. It is not surprising that the scientific practices of Carakas and Susrutas earned the wrath and displeasure of the priests. This was, perhaps, because their practices often contradicted the prevailing thoughts of priests who earned their livelihood by reciting dictums such as “the gods are fond of the obscure” or "the gods are fond of the obscure, they detest direct observation.” In the practice of medicine, the Indian physicians did not distinguish flanked by the upper and the lower castes in conditions of their medical attention. This was another cause why they were not too popular with the priests.

This is not to say that the practice of medicine was entirely free from the power of the thoughts prevalent in society. Cosmogonic speculations, that is, philosophical thoughts in relation to the origin of universe, earth and livelihood beings, discover a reflection in Ayurveda. For instance, the practice of ascribing the causes of illness to humors or ‘dosas’, such as wind (‘vayu’), bile ('pitta') and phlegm (‘kapha’), reflects this power. So does the practice of relating the qualities of curative substances to the five elements (‘pancabhutas’)—earth (‘prithvi’), fire (‘jyoti’, ‘agni’), water Capas’, ‘jala’), air (‘vayu’) and empty legroom (‘akasa’). According to Ayurveda, the ‘tridosas’, ‘vayu’, ‘pitta’ and ‘kapha’, are supposed to be present in all livelihood creatures. Diseases are said to be caused by their imbalances, paucity or excess in the body. Though, the prevalent philosophical and religious dogmas did not power the physicians while prescribing what they thought was good for the patient.

Science in Iron Age Greece

One of the mainly extra ordinary characteristics of world history of the Iron Age is the parallel of growths of culture in India and in Greece (Fig. 1.29).

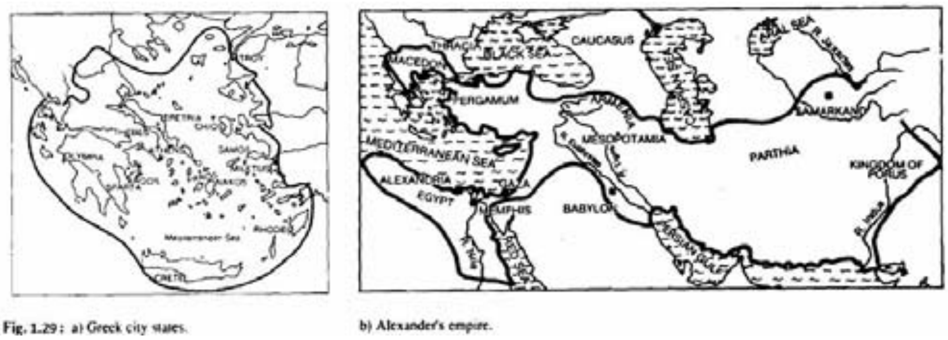


Fig. 1.29 : a) Greek city states. b) Alexander's empire.

We know that there was deal flanked by the two regions. The spread of knowledge may have taken lay through West Asia and finally through direct get in touch with recognized at the time of Alexander’s incursion into north west India in 327 B.C. It is, therefore, easy to see that Indian and Greek cosmogonic speculation, medicine and surgery came to power each other through these contacts.

One of the similarities flanked by the Indian and the Greek civilizations was growth of the similar type of stratified social structure, at in relation to the similar era. While in India, the caste structure was relegating all practical and manual work to the lower castes, manual work was being associated with slaves in Greece. The craftsmen and manual-workers were measured to be definitely inferior beings to brain-workers or contemplative thinkers. Although much craft work was done by free men, they were degraded by competition with slaves, so that their work was also described base and servile. This, as we have observed earlier, led to the separation of contemplative science from technique, both in Greece and in India. It reduced the power of thinkers on practical work, and of practice on thinking.

The patronization by the rulers, of a group of people, whose profession were to contemplate and to teach, led to the peculiar development of science throughout that era. Initially, it led to the flowering of Greek sciences such as geometry, mechanics, medicine and cosmogonic system. But, finally, it made Greek science distant too speculative and abstract. The abstractions were totally removed from life. Though, as they were formulated by leading authorities and philosophers of those times, these abstract thoughts, usually, came to be accepted as “laws of nature". Not much attention was paid to people who challenged such thoughts, on the foundation of observation. As such, these abstractions became a major stumbling block to the growth of science, for the after that 2000 years.

In India, abstractions certainly grew in physics and cosmogonic systems, but medicine, chemistry, botany and agricultural science retained strong links with practice. Medicine, in addition, required the use of proscribed flesh and other substances for healing. The common approach of the medical practitioners to healing and saving of life disregarded Karma and other orthodox tenets. This led to their condemnation by the spiritual and legal authorities, resulting in the stagnation of medical science in India, by in relation to the third to the fourth century A.D.

It is motivating to note a vital variation flanked by Indian and Greek science in conditions of the power of existing ideological and religious systems on science. Indian scientific treatises of this age always started with obeisance to divinity. But the actual text, except for those on cosmogony and. to some extent, those on medicine (containing thoughts of five elements and three dosas), were free from philosophical interlacing and inspirations. Greek science of this era was though, deeply influenced by the prevailing social philosophy and ideologies, with some exceptions, such as the works of Democritus and Hippocrates.

In Greek science, this was the age of questioning. The philosopher-scientists continuously looked for reasons and causes of things. But, in the absence of experimental apparatus, and more importantly, being influenced by the social philosophy of slave society, they sought answers in parallels with the existing order of society.

The early Greek philosophers of the sixth century B.C., such as Thales, Empedocles and Pythagoras were exceptions, in the sense that they speculated on what the world was and how it came to be without the intervention of gods. The theory of four elements—earth, water, air and fire is attributed to these Ionian philosophers. Aristotle (4th century B.C.), who was one of the leading Greek philosophers came to inhabit a central lay in the history of science. He broke absent from the Ionian school by refusing to consider how the world had been made. In his view, the world always had been as it was then, and would always be the similar, because that was the reasonable method for it to be. Aristotle built his physical world in the image of an ideal social world, in which subordination was the natural state. In this world, everything, whether fish in the lower strata of evolutionary tree or slaves in a Greek municipality state, knew their lay, and for the mainly part, kept to it. In this order, inanimate objects moved only when they were out of lay and wanted to return to their original lay in the pre-ordained order. For instance, a stone when thrown up in air always returned to its native earth. Or sparks flew upwards, to join the heavenly fires. Animate objects moved because it was in their nature to do so. Thus, it was in the nature of a bird to fly in the air, of a fish to swim in water. In this method, he tried to explain all motion in nature by ascribing it to a predetermined cause or a final cause.

Aristotle never told anyone anything they did not already consider. He explained that the world as they knew it, was just the world as they knew it. As extensive as the world remained the similar, Aristotle's thoughts would hold. Though, the world did not remain the similar and Aristotle's thoughts were challenged, although it took an extensive era of in relation to the 2000 years for this to happen.

Growths in Some Regions of Science

We shall now describe, in brief, some of the major growths in some regions of Greek science.

Geometry and Astronomy

The need to portray an ideal world of perfect shapes and proportions led to the development of geometry by Pythagoras (582-500 B.C.) and Hippocrates of Chios (in relation to the 450 B.C.) (Fig. 1.30).

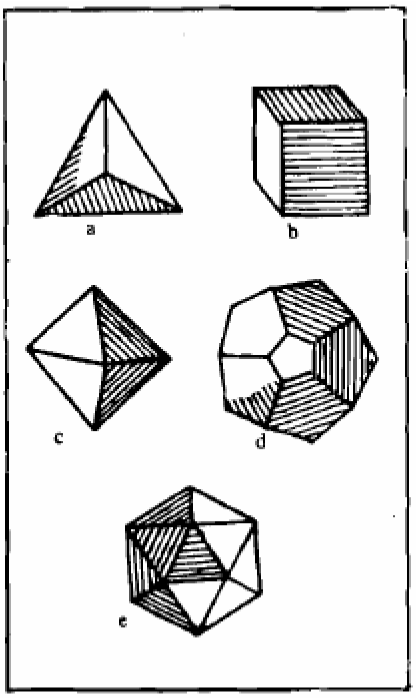


Fig.1.30 Five regular geometrical solids much studied by the Greeks: a) tetrahedron; b) cube; c) octahedron; d) icosahedron and e) dodecahedron. In all these solids, the faces are equal in area and in shape. Pythagoras, the Greek mathematician and philosopher, is credited with their discovery.

The latter occupied him with the solution of troubles which were unanswered for an extensive time, such as squaring the circle and doubling the cube. He failed in both, but opened the method to study the geometry of curves. Eudoxus (408-355 B.C.) was almost certainly the greatest Greek mathematician and he was able to explain the motion of sun, moon and planets by means of sets of concentric spheres, each rotating in relation to the an axis fixed in the one outside it (Fig. 1.31).

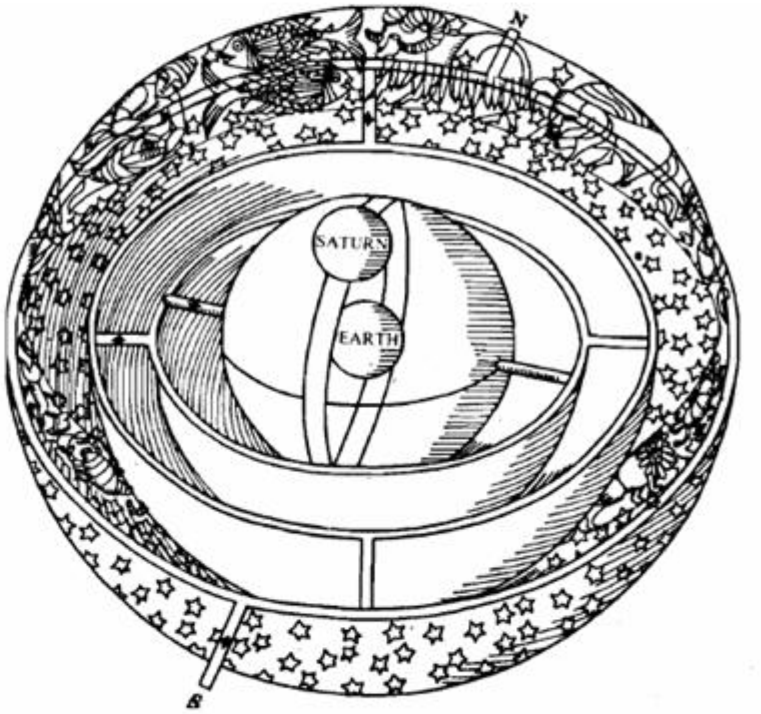


Fig 1.31 Part of Eudoxus' model of spheres within spheres, to explain the motion of the planets. Believing that planets orbited the earth in perfect circles, Eudoxus drew 27 concentric spheres around the earth. Each sphere, with its planet attached, rotated on a different axis. Arrows in the figure show the rotation of spheres.

The model was crude, and too easy to explain observed facts, even as recognized at that time. But the sets of actual metal spheres based on this mode provided the foundation for mainly of the astronomical instruments for an extensive time.

Approximately 300-200 B.C., the custom of geometry which grew up in the scholarly atmosphere of academies, schools and Lyceums of Athens shifted to the Museum of Alexandria. The geometry of Eudoxus was elaborated by Apollonius of Perga (in relation to the 220 B.C.), who worked out the details of conic sections-ellipse, parabola and hyperbola (Fig. 1.32).

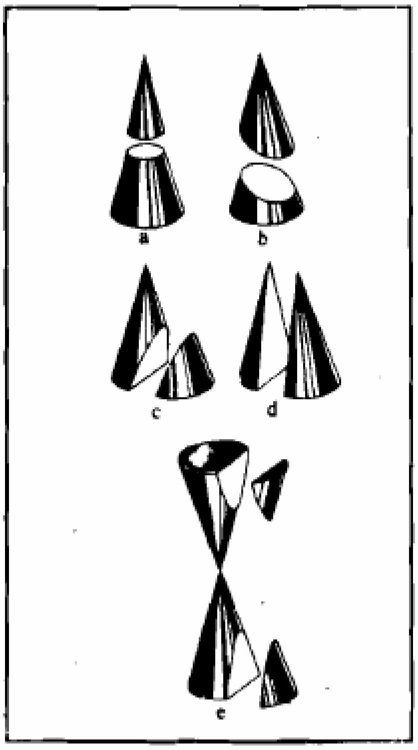


Fig. 1.32 Conic cuts of Apollonius: a) a cut parallel to the cone's base made a circle; b) an oblique cut an ellipse; c) a slice parallel to a straight line on the cone made a parabola; d) a cut down through the top point produced two intersecting lines; e) cutting through the cone and its mirror image on top resulted in a hyperbola or double curve.

A big part of the previous mathematical knowledge was built jointly into a single body of knowledge based on deduction from axioms, by Euclid (in relation to the 300 B.C.). This is the geometry which is still studied in schools today.

The study of astronomy lay flanked by the theoretical and the practical. According to Plato, a noted Greek philosopher and Aristotle's teacher, it was the study of an ideal world in the sky, and the deviations that were observed could be ignored. On the other hand, it was also significant to know the accurate location of stars and planets. As a result, Greek astronomers tried to invent complicated models to fit the observations without violating the image of an ideal, easy and beautiful world. The mathematical foundation of astronomy was the spheres of Eudoxus as shown in Fig. 1.33. But for actually working out the planetary motion Hipparchus (190-120 B.C.) adopted a flat model, that of 'wheels within the wheels'. He also invented mainly of the astronomical instruments used for the after that 2000 years.

In relation to the two hundred years later, Ptolemy (90-168 A.D.) adopted this model in which the earth was at the centre and the rest of the planets, the sun and the stars revolved approximately it (Fig. 1.33). This was to be average astronomy in Europe till the fifteenth century.

Fig. 1.33: Ptolemy's model of the earth-centred universe. The earth is shown in the centre, with the four elements, earth, air, fire and water. Above these elements are the heavenly bodies, the Moon, Mercury, Venus, the Sun, Mars, Jupiter and Saturn. Then comes the sphere of fixed stars; beyond that the ninth and the tenth spheres driven by divinity from which all other spheres derive their motion. Beyond this lay heaven, where 'God and the Elect' lived.

An alternative version, that of the sun at the centre and the earth and other planets moving approximately it, was also presented by Aristarchus of Samos (310-230 B.C.) and others. But it was not accepted because it was thought to be philosophically absurd, and violated everyday experience. It was, though, transmitted by Arabs, revived by Copernicus (1473-1543) and finally justified by Galileo (1564-1642), Kepler (1571-1630) and Newton (1642-1727).

Mechanics

Another branch of science which is, perhaps, the greatest contribution of Greek civilization is mechanics. Mechanics urbanized out of the necessities of irrigation, moving of heavy bodies, ship-structure and creation military equipment with recognized apparatus and ways. As the invading armies of Alexander came in get in touch with the craftsmen of the middle-eastern countries, a number of inventions such as the pulley, windlass and screw came into use and were improved upon (Fig. 1.34).

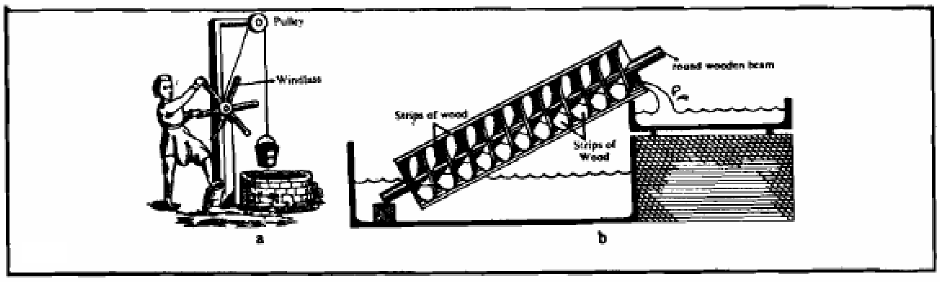


Fig.1.34: Some mechanical devices used in Greece: a) windlass and pulley for drawing water from a well; b) cross-section of a water-raising screw designed by Archimedes, widely used for irrigation. Strips of wood were wrapped in a spiral on the edge of a round wooden beam. This was then encased in boards. When placed in water and spun, it caused the water to climb the spiral and gush out.

Archimedes (287-212 B.C.) aided this procedure of structure machines by his thoughts of forces having to balance each other to stay a body static (at rest). And his contribution to the study of floating bodies and hydrostatics is useful even today.

Medicine

The other region, in which the Greek growths had a parallel in India, was medicine, although encouragement for this development in the two cases came from diametrically dissimilar sources. The Carakas and Susrutas in India were roaming physicians who went in relation to the healing ordinary rural folk and fostered democratic thinking and world views. Greek medicine, on the other hand, could continue its older traditions because of the support it received from the aristocracy. In the era when Greek society was declining from the highest point of its attainment, wealthy citizens could not do without doctors as they led an increasingly unhealthy life of pleasure and abundance. We discover that the Museum of Alexandria encouraged much research in anatomy and physiology.

Hippocrates of Cos is a legendary figure in Greek medicine. His works, almost certainly written sometime flanked by 450 to 350 B.C., contain a clinical explanation of several diseases based on careful observations. Magical or religious causes or cures for diseases are not mentioned. Though, the practice of medicine of the original Hippocratic school was superseded by the doctrine of four humors, firstly put forward by Empedocles, an Ionian philosopher (see Fig. 1.35). His thoughts proved very damaging to the practice and theory of medicine.

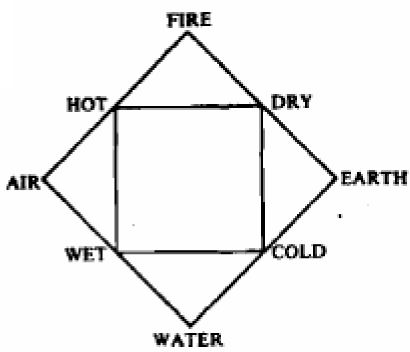


Fig.1.35: The four 'elements' of the Greek thinker, Empedocles. According to Empedocles, the 'primary matter' could change into different substances, depending upon which primary qualities were affecting it. For example, the primary matter could become earth with the pair of primary qualities, cold and dry; water, with cold and wet; fire, with hot and dry; and air, with hot and wet.

A great doctor of those times, Herophilus (in relation to the 300 B.C.) based his work on observation and experiment. He was the first to understand the working of the nerves, distinguish flanked by sensory and motor nerves, and create clinical use of the pulse. Erasistratics (in relation to the 280 B.C.) went further and noted the significance of the peculiar structure of the human brain. Unluckily, mainly of the fine work of this era has been lost in its original form. But the essence of these findings was picked up and further urbanized by Galen (130-200) who was born in Asia Minor but practiced in Rome. Galen became a great founder of Arabic and medieval medicine with power as great as that of Aristotle. He dissected animals and gained much anatomical knowledge. Galenical physiology described the ebbing and flowing of spirits, and blood in arteries and nerves, with the heart as the origin of heat, and the lungs as cooling fans. It provided a comprehensive, though rather unreal, view of human body. In conditions of providing explanation of the phenomena, even Galen could not break out of the old doctrine of three spirits and souls, a doctrine which blocked any substantial advance in man's knowledge of his own body for another 1500 years.

Atomic Theory in Antiquity

The oldest of Indian philosophical systems was Samkhya. The system envisaged that everything except consciousness evolved out of primaeval matter. Consciousness, inert mass and power were three shapes of interdependent and inter-related subsistence. In the procedure of development, matter could be neither created nor destroyed and the sum total of all the three, mass, power and consciousness, remained the similar. The redistribution of mass and power gave rise to all the diversity of the material world, the plants and the animals. Matter was recognizable through its five qualities—smell, taste, touch, color and sound, corresponding to the five senses. There were five shapes of matter—earth, water, fire, air and empty legroom.

A parallel to this theory, but perhaps of a much later origin (in relation to the 600 B.C.), was the materialistic cosmogony of Thales and others in Greece. Thales formulated the thought that everything originally came from water, and then earth, air and livelihood things separated out.

To earth and air, mist and fire were added to be described elements from which other substances were made, like words are made from letters. These elements, as in the case of Samkhya, had to fulfill two incompatible functions. On the one hand, they stood for actual observed phenomenon, such as wind, flood, storm etc., while on the other hand they stood for qualities such as hot, cold, wet, arid, light, heavy etc.

The separate contribution of Samkhya as well as the Greek school of thought was that they had set up a picture of how the universe had come into being and how things happened, without the intervention of gods and a predetermined design. The weakness of these thoughts lay in their vagueness and their purely descriptive character. By themselves, these thoughts could lead nowhere, nothing concrete could be done with them and there was no practical application. Though, with all their shortcomings, these thoughts symbolize man's first stirrings to search for his origins and that of the universe.

A very dissimilar method to understand the nature of matter was to stipulate the subsistence of atoms. Atoms were thought of as the fundamental structure blocks of observed substances. A scrupulous combination of atoms imparted properties and qualities to substances.

The Indian Vaisesika system, the well recognized proponent of which was Kanada (in relation to the 600 B.C.), measured the negligible particles as dimensionless mathematical points. These points possessed potential excellence of the four elements, earth, water, fire and air, on the foundation of which, they were divided into four categories. At least six atoms of the similar category joined jointly, with the legroom in flanked by filled by empty legroom, to form an intricate atom which is analogous to a chemical element.

The problem of dissimilar, heterogeneous atoms joining jointly was overcome by the Jainas. Jainas said that when two heterogeneous atoms joined jointly, the combination gave rise to a new body. The mechanism of joining was by mutual attraction, one positive, the other negative. AH changes in qualities of compounds were explained by the nature of their mutual attraction.

While the shows a high stage of intellectual action, the limitations lay in the abstraction. The philosophers had no hesitation at all in putting jointly obviously contradictory thoughts in their abstractions. For instance, in their cosmogonic system they incorporated things they observed in the material world along with things they did not observe, or things they learned from religious texts, or things which had no material foundation. Thus, the Jainas brought in karma and soul within their otherwise materialistic system; and the Vaisesikas formulated that atoms were set in motion by adrista, i.e. performance in the previous life.

The Greek atomists were, curiously enough, free from these distortions such as thoughts of soul, adrista or karma propounded by Indian atomists. Democritus (in relation to the 420 B.C.) imagined the universe to be made out of small innumerable indivisible particles moving in the void of empty legroom. The atoms were unalterable. They were supposed to be of several geometrical shapes to explain their capability for combining to form all the dissimilar things in the world. Their movement accounted for all visible change.

This atomic theory avoided appeal to pre-ordained harmonies, i.e., it did not say that the universe was static, where things worked according to a predetermined design. Instead, it presented a dynamic universe where things were not static, but were changing. In this sense, it remained a heresy, as it challenged the recognized thoughts of Plato and Aristotle.

We cannot consider the Greek or Indian atomism as a part of scientific thoughts, in spite of its brilliance. No conclusions could be drawn from it which could be practically verified. Though, we cannot deny that Greek atomism, with its inherent materialism and reasonableness did power the atomism of Gassendi (1592-1655), Newton (1642-1727) and through them that of Dalton (1766-1844), 2000 years later.

Decline of European Science

By the middle of the second century B.C., the Greek empires were collapsing in anarchy and under the weight of the more vigorous power of Rome. Italy, in the third century B.C., was a farming country with a good climate and a rising healthy population. By the first century

C., the Romans had organized themselves into a powerful military dictatorship, with popular support. The army went on to conquer the countries of eastern and western Mediterranean as well as Britain, western Germany and Austria (Fig. 1.36).

Fig. 1.36 : Roman Empire in second century A.D.

While the army became all powerful, the land was ruled by slave owners and wealthy merchants. The cementing force of the empire was the army, as it was used by the emperor to collect enough taxes to stay the soldiers from mutinying and choosing another emperor. The best land was cultivated by the slave gangs from the villas of the wealthy, while the poorer regions were left to the pagan natives or to newly settled free slaves from the villas.

Thus, the mainstay of the economy was loot from the empire by military coercion, and agriculture by slaves. In such a situation, it is, perhaps, not surprising that there was very little demand to augment manufacture and to improve the economy through the applications of new techniques. There was, therefore, a very limited contribution to culture in the form of science and arts throughout the era of the Roman Empire which sustained until the second century A.D.

While there was no improvement in techniques and no growth of science in the Roman era, the existing Knowledge was applied to construct structures for civil and military management. Burnt bricks and concrete made from volcanic ash and lime were used to construct roads, harbors, aqueducts, baths and theatres (Fig. 1.37).

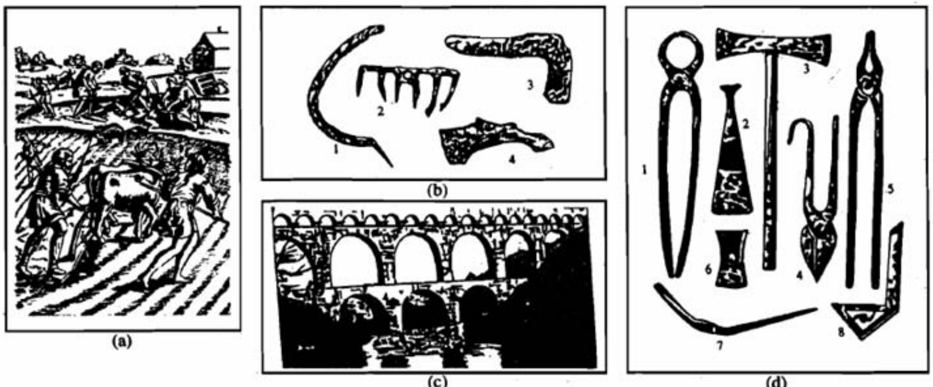


Fig. 1.37 a) Roman agriculture. Notice the ploughing and other activities like sawing wood, making plough, basket weaving. Note also a harrow in the background; b) agricultural implements: 1) sickle; 2) rake; 3) garden knife; 4) axe-hoe; c) the aqueducts built of burnt brick and of concrete made from lime and volcanic ash were used to carry water across hundreds of kilometres in the Roman Empire. Water pipes passed over the bridge; d) tools for constructing Roman buildings: 1, 5) tongs; 2) trowel for spreading mortar; 3, 6) hammer and a hammer head; 4, 7) cutting tools; 8) a mason's square.

Accumulation of power and wealth in the hands of a few rich men, and common brutalization and consequent impoverishment of a population of slaves, lowered the demand for commodities. This depressed the circumstances of merchants and craftsmen still further. With no incentive for science to develop new techniques, science lost its essential excellence of inquiring into nature. As the Roman Empire was followed by the serf-owning feudal economy of Europe, this state of cultured stagnation sustained till the fifteenth century. Europe was engulfed by the Dark Ages and the centre of learning and enlightenment shifted to the East.

You may enjoy reading the following piece from J.D. Bernal's well-known book "Science in History", illustrating how social decline leads to the decline of science.

"Classical civilization was already intrinsically doomed by the third century B.C., if not earlier. The tragedy for science was that it took so extensive to die, because in that era mainly of what had been gained, was lost. Knowledge that is not being used for winning of further knowledge does not even remain—it decays and disappears. At first the volumes (books- Ed.) molder on the shelves because very few need or want to read them; soon no one can understand them, they decay unread, and in the end, as was the legendary fate of the Great Library of Alexandria, the remainder are burnt to heat the public-bath water, or disappear in a hundred obscure methods."

THE GOLDEN AGE OF SCIENCE IN INDIA

Second Urban Civilization in India

Thus, the stage was set for a second urban civilization to flourish in India, after the decay of the Harappan Civilization more than a thousand years ago. This second stage can be dated back to the advent of Chandragupta, the great Maurya king in the fourth century B.C. The last great Mauryan emperor, Asoka, assumed the imperial throne in relation to the 270 B.C. His empire extended crossways the whole of northern India and well into the southern state of present-day Karnataka (Fig. 1.38).

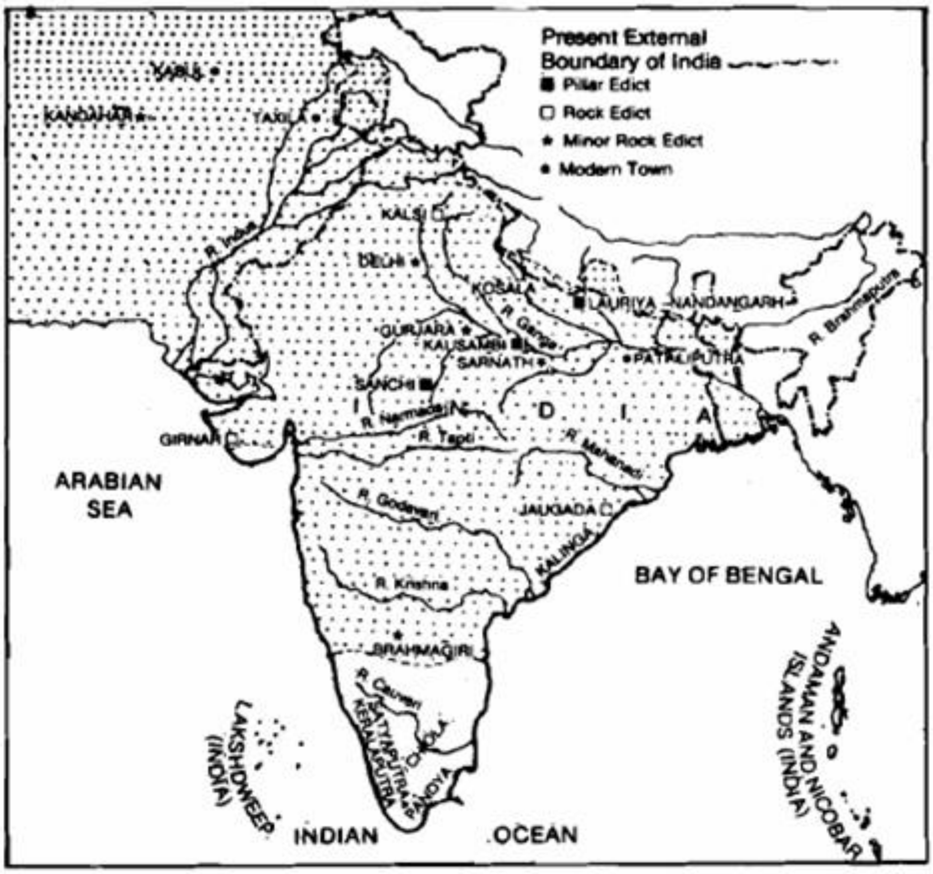


Fig. 1.38 : Empire of Asoka (about 274—236 B.C.).

The imperial state was mainly interested in extending its hold on cultivable land. It acquired tribal land by conquering small kingdoms. The local population of the conquered lands settled down to practice agriculture under the supervision of imperial functionaries who were often Brahmins. They started using new techniques which were introduced at that time. There were two kinds of agricultural land. The first kind, which acquiesced taxes for the state, had a semi-autonomous local management, although a sixth portion of the harvest went to the crown treasury. The second kind, described sita land, came directly under crown supervision and was cultivated by resolution units of 100 to 500 Sudras. They gave a fifth of their produce to the crown. These did not contain a tax for "army rations" and gifts to the king.

The acquisition and maintenance of land on such a big level required a well trained army, an ideological and religious superstructure, good agricultural base and mining industry. It required a centralized state power which could hold jointly and expand such heterogeneous empire. Let us see what the nature of the socio-political organisation of state power in the Mauryan empire was.

The Indian State

Such a state and its policy are described in detail in Arthasastra, written by Kautilya, the great minister of Chandragupta. It was a highly centralized state which was the principal owner of industry as well as the greatest producer of commodities. The commodities produced by the state were bought and sold by traders. The traders traveled crossways the empire, often using navigable rivers, and even went overseas to Burma, Indonesia and Sri Lanka to sell their wares. Deal practices and the prices charged by traders were strictly controlled by the state. Laws regulating revenue collection, and the procedures for collecting them, from the land as well as from the merchants, were exact and precise. This big revenue was used to uphold a huge army, of half a million men, which was used to acquire land, protect the land and the frontiers, and uphold law and order in the vast empire. The revenue was also used to organize welfare events for orphans, the aged, the infirm, widows and pregnant women who had no one else to feed them.

Now the army could conquer land, but, it could not ensure that the conquered people would voluntarily and peacefully serve the empire and create it prosper. We discover that the state used religion in a very intelligent fashion to achieve this. Brahmins, as mediators of the crown, spearheaded the move into the new territories. A procedure was initiated whereby tribal deities were equated with average Aryan gods. New scriptures were written by

Brahmins to bestow respect on tribal gods whom they could not otherwise adopt. New rituals and special dates of the lunar calendar were introduced, which took explanation of the tribal customs. Totemic deities such as primaeval fish, tortoise, monkey, bull etc. were introduced into the traditional Hindu scriptures as companions of major gods like Vishnu, or their reincarnations. Further, thoughts were propagated that tribal chiefs were also twice born (dwija), which gave them special high caste status. A caste structure was, thus, subtly introduced whereby the ruling elite of the tribal's were incorporated into the ruling hierarchy of the empire. All this amounted to assimilation of the tribal hierarchy into the more accentuated caste-class structure of the empire. The Vaisyas and Sudras newly created in the tribes, joined the lower-caste society of the peasants and workers of the empire without an apparent break of their own traditions, culture and religion.

The Brahmins could impose the caste structure quite easily, as they played a significant part in introducing a new mode of agriculture and of commodity manufacture to the tribal people. They brought plough agriculture to replace slash and bum farming or food gathering. New crops and knowledge of distant markets brought by the Brahmins, gave visions of higher productivity and prosperity to the people.

These growths had a profound effect on manufacture from land and united the people culturally for peaceful livelihood. The growths also increased the wealth of the state. Though, the new religion which evolved in excess of an era of time, started to inhibit the growth of culture as well as manufacture. This was because it laid emphasis upon superstitions, which were very much a part of tribal life, and on senseless rituals. The superstitions, which provided the ideology of the lower castes, in effect, kept them in subjugation. Finally, these superstitions came to have an adverse effect on the growth of scientific thoughts.

It is not surprising that Asoka reacted to the development of this superstitious and ritualistic culture by adopting the teachings of Buddha. Buddhism, in its early form, devoid of rituals and superstitions, stood against oppression and advocated an easy and meaningful life based on cause and compassion.

Asoka and the later Indian kings provided generous grants to the Buddhist monasteries which supported learning and science. Nalanda, the great Buddhist monastery was the forum where scholars continuously met and exchanged thoughts on medicine, astronomy, humanities and theology. The Indian imperial state sustained to support the monasteries for an extensive time.

Monasteries, thus, became wealthy institutions and provided funds and capital to traders. With time, the ascetic simplicity of Buddhism came to be replaced by a more ritualistic religion. While Buddhism provided an initial challenge to the rigid caste laws of the Hindus, Hindus perhaps had the last say. For, Buddhist religion, in order to gain popularity, increasingly adopted the ideological as well as the ritualistic practices of the Hindu religion of those days.

Growths in Technology in the Mauryan Empire

We get a great deal of information in relation to the technological growths in the Maurya era from the treatise, Arthasastra. In Arthasastra, there are detailed descriptions of military machines which use the principle of centrifugal forces. Though, the thoughts to power these machines with inanimate sources such as wind, water, steam or electricity, did not exist then.

There was considerable development in civil engineering. For rising the productivity of sita land, several shapes of irrigation came to be used. Excellent roads were built throughout the empire to facilitate mobility of the army and the traders. Corduroy roads were built in excess of swamps using trimmed logs. For instance, in Bihar, such roads ran for miles even in the seventh century A.D. Mainly of the structures were made of wood. Asoka, perhaps for the first time in India, introduced stones to construct structures. Stones were polished to a mirror-like finish and used for the construction of pillars and arches.

There was some development of rural industries also. Small industries and relevant technology came into being close to the sita lands for husking of grain, pressing of oilseeds, carding of cotton and wool, spinning of yam, grading and processing of wool, manufacture of blankets and shaping of timbers into planks and begins. The concept of factory manufacture took form, almost certainly for the first time, as the commodities were produced under the direct supervision of the superintendent of the "crown store homes". Local labour was seasonally occupied, when agricultural operations were slack. The books showed meticulous recording of normal loss of every type of material at each state of processing, average output of efficient labour, final weight or measurement of the finished product etc. These records were used to manage manufacture.

The greatest contribution to the advancement of technology was, perhaps, made in the region of metallurgy and metal working. The shifting of the seat of power from the north-west to Magadha, was mainly due to the rising demand for iron, copper, tin, lead and other metals. The metals were needed for creation weapons and ploughshares, the two essential pillars of the Mauryan state, as well as for manufacturing other goods of deal. There are careful, though brief, descriptions in the Arthasastra for reducing and smelting ores. Distinction flanked by dissimilar ores, in conditions of their appearance and other properties, and the corresponding distinction in processing techniques are elaborated. Metallurgy of creation alloys was also urbanized. The finest of iron ores from dissimilar parts of the empire, especially the south, were brought for creation alloy steels. Swords made from these alloys were sold in several countries, including Greece.

Growths in South India

Asoka's reign was followed by a fragmentation of the empire into small kingdoms, tom by bitter rivalry. The after that major empire to emerge was that of the Kushanas. This empire, which dates back to the first century B.C., incorporated regions not only of northern and north-western India but also of Central Asia and what are now Pakistan and Afghanistan. Under the reign of Kanishka (second century A.D.) the empire extended east as distant as parts of Bihar and into central India as distant as the river Narmada. In southern India, a few powerful kingdoms of Satavahanas, Kshatrapas and Vakatakas came into being at in relation to the time.

This was one of the mainly flourishing eras in the history of crafts and commerce in southern India. The inscriptions of the era mention weavers, goldsmiths dyers, jewellers, sculptors and workers in metal and ivory', indicating that these crafts were well urbanized. Iron apparatus and artifacts like ladles, razors, axes, hoes, sickles, ploughshares etc. have been establish in the Karimnagar and Nalgonda districts of the Telangana region of Andhra Pradesh.

Coins of lead, copper, bronze, silver and gold have also been establish. Several of these are from Satavahana era indicating the progress they had made not only in the metallurgy of iron, but also of brass, zinc, antimony etc. Cloth creation, silk weaving and creation of luxury articles of ivory, glass, drops etc. were also urbanized. Dyeing was a thriving craft in some south Indian cities. Brick built dyeing vats, dated first to third century A.D., have been exhumed at Uraiyur and Arikamedu in Tamilnadu. The manufacture of oil increased because of the use of oil wheel.

Extensive deal was accepted out by sea. The knowledge that monsoons aided sailing, greatly helped the sea-faring traders. Iron and steel articles, including cutlery, were exported to African ports. Muslin, pearls, jewels, valuable stones and spices were exported to Rome. This thriving deal led to the prosperity of Satavahana cities. Though, these empires declined from the third century onwards. The great age of the Indian empires reached its peak with the advent of the Gupta dynasty, at in relation to the beginning of the fourth century A.D. We will now describe the social organisation in the Gupta era and see how it helped the growth of science and technology, in India, in those times.

The Gupta Era

The Gupta empire expanded mainly in conditions of its territorial coverage of northern, southern, eastern and western India as well as in conditions of cultural development throughout the reign of Chandragupta II (380-415 A.D.) (see Fig. 1.39).

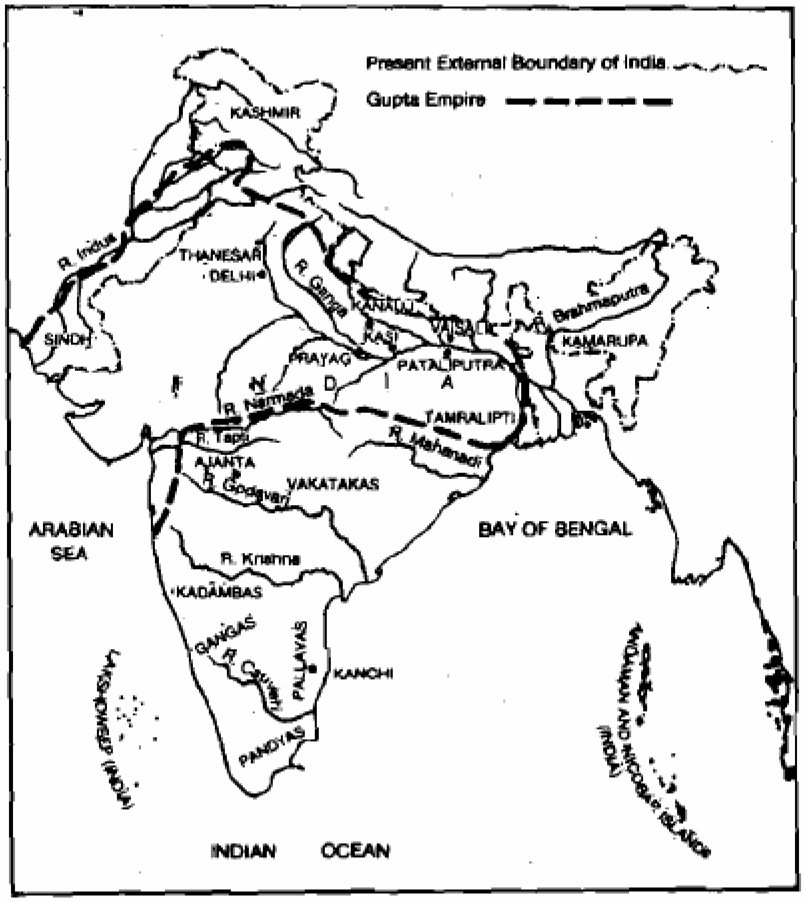


Fig. 1.39 : Gupta empire at the close of fourth century A.D.

It is worthwhile that we should consider a few feature characteristics of this era of in relation to the 100 years. You will then be able to understand the development of what may rightly be described the peak of the Golden Age of science in India.

Social Organisation

In the Gupta empire, the main mode of manufacture was still agriculture. The Gupta kings sustained the land acquisition started by the Mauryans. Samudragupta conquered a number of forest kingdoms in the valleys of the Ganges, Narmada and Mahanadi. The pattern of land resolution in this era was, though, very dissimilar from that of the Mauryans, State manage and ownership of the cleared land was greatly reduced and land passed into private ownership. New laws were enacted to allow individuals to administer land and collect taxes, irrespective of whether they tilled the land or not. Mainly of the Gupta kings, irrespective of their individual religious faith, were secular as distant as the state was concerned. Buddhism, Jainism and traditional Hindu institutions were all supported by the state through grants and patronage.

Lineage which had determined one's location in society, gave method, to a sure extent, to one's property status. Thus, Brahmins lost their pre-eminence. Importance of agricultural and craft manufacture meant some improvement in the condition of the Sudras. In common, what one did in society became significant. Even Brahmins were obliged to take up occupations other than performance of religious rites.

This relaxation of rigid state manage of the previous era had a liberating power initially, as it encouraged individual initiative. It heralded a sure decline in the hold of the Brahmins and that of the rigid 'varna' system in excess of agricultural society.

So distant, we have described the nature of social organisation in the Gupta era. We discover that the social structure in that era was very dissimilar from the days of the Mauryan empire. We shall now tell you in relation to the tremendous improvement in techniques and crafts that took lay in the Gupta empire.

Improvement of Techniques and Crafts

In this era, there was a spurt in agriculture, as new techniques and seeds were introduced. More importantly, the crafts greatly improved in conditions of excellence as well as diversity.

Agriculture

Pepper and spices were grown for export as well as domestic consumption. A wide diversity of crops like rice, wheat, barley, sesame, pulses, beans and lentils, vegetables such as cucumbers, onions, garlic, pumpkin, and betel were grown. New fruits like pears and peaches were introduced for the first time. All this did not take lay at random or as a matter of chance. There were proper manuals which gave information on the kind and excellence of soil required for each plant, several plant diseases, the distances flanked by plants as well as sowing techniques (e.g., working of the soil before sowing). These manuals also described techniques for processing grain, vegetables and fruits. As a wide diversity of soil kinds had to be cultivated, new diversities of agricultural implements also appeared. Weights and designs of ploughshares for dissimilar kinds of soil were fixed and the use of iron for creation agricultural implements became widespread.

Crafts

Rapid strides were made throughout this era in metallurgical and weaving crafts. Rust-proof iron and copper alloys were establish and worked into intricate articles for civilian as well as military purposes.

The excellence of the articles was so good that they were widely exported, even as distant as Africa. In the design of these articles, there was, to an extent, Greco-Roman and Central Asian power. Though, on the whole, they had a local character.

In weaving, techniques were perfected for the creation of cotton and silk materials. Manufacture of dyes and their widespread use in coloring textiles came into practice.

Indian textile materials, especially from Varanasi and Bengal became well-known for their light weight and fine texture. The textiles became popular in the West and became a significant commodity for export and deal.

Guilds or ‘shrenis’ of artisans in this new situation of reduced state intervention, became powerful and significant. They enjoyed a great deal of independence and often drew up contracts in the middle of individuals, and even entered into agreements with state authorities. The 'shrenis’ borrowed capital from individuals and paid them back with interest. This gave a tremendous impetus to improve the crafts.

We also discover that the improvements in crafts were greatly helped by rising deal.

Deal

The importance of direct producers became greater as internal and external deal reached unprecedented volume and proportions. Opening up of previously inaccessible and uninhabited regions, organisation of better transport, communication and deal routes helped the growth of deal. The subsistence of a vast market, spread in excess of a vast empire, gave rise to extensive circulation of money through a flourishing deal. For merchants, just as for artisans, there lived associations which were also recognized as shrenis. The main deal routes were based approximately the rivers Ganges and Indus. The state still supervised the influx and sale of commodities. Internal deal was augmented by rapid development of foreign deal, actively encouraged through the foreign diplomatic contacts recognized by the Kushanas, the Satavahanas and the Guptas.

The account provides the picture of an Indian society, where commodity manufacture and exchange were in full swing due to an expansion of internal market as well as foreign deal. These behaviors demanded new techniques of manufacture, new mathematics and numbers to facilitate management, and new ways of construction, communication and navigation. What is significant is that this social demand for new technologies took lay in an atmosphere where rigid state manage of a previous era had been relaxed in favor of individual initiative. The old ruling elite were, to an extent, giving method. And there was a sure amount of social mobility that perhaps encouraged contacts flanked by the literate and illiterate strata of the society. It was a society where the old caste system still prevailed, though somewhat weakened, and where a new caste system, which was not yet oppressive, came into subsistence, on the foundation of division of labour.

REVIEW QUESTIONS

- What factors decide the broad areas of scientific activity?
- What areas of activity set the specific goals for science to achieve?
- Explain how the transition from the primitive society to an agriculture-based civilization led to the birth of science.
- Describe how the growth of cities, trade between cities, and the corresponding socioeconomic needs gave rise to various areas of scientific activity.
- Explain the factors that led to the decline of science in Europe.
- Explain the features of the Indian state and the social organisation that helped the growth of science and technology in the Maurya and Gupta periods.
- Describe the developments in science and technology in India, from the fourth century B.C. to the seventh century A.D.

CHAPTER 2

Science: Medieval and Modern Time

STRUCTURE

- Learning objectives
- Science in the medieval times
- Renaissance, the industrial revolution and after
- Science in colonial and modern India
- The method of science and the nature of scientific knowledge
- Review questions

LEARNING OBJECTIVES

After studying this chapter you should be able to :

- Describe the contribution of Arabs to the body of scientific knowledge.
- Analyze the factors that impeded the growth of science in India in the medieval times.
- Outline the important scientific developments in the post-Renaissance period.
- Compare the Indian and European societies of the period from the sixteenth to the eighteenth century and analyze the features of the then European society that helped the birth of modern science.
- Outline the few scientific developments in colonial India and analyze why these were so meager,
- Outline the scientific method and describe each of its operations.
- Apply the scientific approach to solve problems of everyday life.

SCIENCE IN THE MEDIEVAL TIMES

The Arab Renaissance

By the end of the second century A.D., the Roman Empire had begun to decline. Its economy was overburdened by a vast army. Stagnating manufacture had led to the imposition of heavy taxes. Consequently, the social structure became very exploitative.

Christianity, mainly almost certainly, grew out of the distress and protest of the slaves and other general people of the Roman Empire. It is no accident that it first arose in the middle of the Jews who were the mainly oppressed. They were also imbued with the spirit of rejecting any compromise with the powers of this world. The popular appeal of Christianity lay in its outward submissiveness combined with absolute determination to have no part in the prevailing oppressive and sinful society. This also led to its persecution, which gave it even greater appeal and strength. Christianity spread rapidly in the middle of all people. Very soon it was no more confined to the lower classes. Its teachings became influenced by the prevalent social thoughts. Within a few centuries, the Church itself recognized the rule of dogmas and became a partner in maintaining the state. By the sixth century A.D., people on the eastern borders of the Roman Empire began to identify Christianity with an alien, hostile and oppressive government.

Though, we discover that to these negative factors, there was soon added a positive one—the appearance and spread of a new religion, Islam, in the seventh century A D. Islam incorporated what was mainly agreeable in Christianity. With its message of universal brotherhood, easy but exacting personal conduct and a sure hope of realistic paradise for the believer, it soon establishes popular support. As the Arabs from Syria and Iraq came to conquer lands stretching upto the Mediterranean with the message of Islam, they very often establish little resistance from the local population.

Soon a vast region stretching from Spain to India came under the power of Islam and, thus, extensive deal and cultural exchanges became possible. The flourishing deal gave rise to demand for commodities' This, in turn, encouraged invention of new techniques for creation steel, paper, silk, porcelain etc.

Christianity had, by then, become recognized with a decaying and corrupt empire. Therefore, scholars and intellectuals from the eastern and African parts of the Roman Empire started escaping to Persia which was becoming the new centre of learning and scholarship. These people were mainly heretics and were safer from persecution under Muslim Caliphs than under the orthodox Roman Empire. In 431 A.D., the Syrian monk Nestor and his followers who challenged the Christian dogma were condemned and persecuted. They fled to Persia where a vigorous culture was being promoted by the Sassanian kings. Likewise, the Egyptian monk Eutyches of Alexandria (378—454 A.D.) and his followers had to flee from Egypt to Persia under pressure from the Church. Both these scholars made important contributions to mathematics and astronomy.

Arab Science

What was crucial in relation to the new Arab-centered civilization was its willingness to look at and understand the classical scientific and philosophical traditions of the Greeks in the context of its new and vigorous culture. This was possible because of the written documents which reached the Arabs with the spread of the Roman Empire. Besides, they also had a strong feeling of being the heirs of the ancients. They traced the store of knowledge step by step back to the original Greek works. They translated these writings, absorbed them and urbanized them further. Caliph-al-Mamun founded a bureau of translation, Dar el Hikhma, where the great scholars Hunain ibn Ishaac and Thabit ibn Khurra prepared Arabic texts of mainly of Aristotle’s and Ptolemy’s writings and other major Greek classics of science. These scholars prospered under the patronage of the great Caliphs, al-Mansur, Haroun-al-Raschid, al-Mamun and al-Mutawahkil. They also translated the

Indian medicinal, surgical and astronomical texts. This was aided by the extensive travels undertaken by merchants, travelers and scholars such as al-Biruni (973-1048 A.D.), who brought back the knowledge of local practices from the distant lands of India, Greece and China.

It is motivating to note that only the scientific and philosophical books were selected for translation, and not history, drama or poetry. Centuries later, when Europe tapped this source of learning, which was preserved in Arabic, they got a lot of scientific and philosophical writings of all the previous civilizations. The social sciences and humanities were, though, to be rediscovered by Europe directly from Greek and Latin. Thus, science and humanities entered into the contemporary custom by separate channels. This, perhaps, explains to some extent the persisting divides flanked by these regions of knowledge.

One of the reasons which ensured the growth of Arabic science, separately from flourishing deal by land and sea, was the information that it was practiced in a language used by the kings and slaves alike. This provided strong links flanked by ordinary craftsmen and scholars, links which never fail to give a great impetus to the growth of science.

The Arab science provided a genuine stability to classical Greek science, and was also a melting pot for scientific thought of other civilizations. Yet, it appears to have had little ambition to improve upon or revolutionize these traditions. In learning Arab scientific works, we are struck by the rationality of treatment usually associated with contemporary science. Though, mysticism and too much respect for Greek science and its leading figures like Aristotle became a handicap. The main pillars of science were astronomy and medicine. These were united by astrology which furnished the link flanked by the outer big world of the heavens and inner small world of men. We would, though, like to state categorically at this stage, that the greatest figures of Arab science such as al-Kindi, al-Razi (Rhazes), Ibn Sina (Avicenna) and al-Biruni clearly rejected the extravagant claims of astrology and alchemy.

Astronomy and Mathematics

Arabs accepted on the Greek custom in astronomy. They translated Ptolemy's Almagest and sustained astronomical observations in spite of occasional religious interference. Although they did not add considerably to the Greek ways, the stability that they provided was to prove invaluable to the sixteenth century astronomers.

The practice of astronomy provided the necessary incentive to develop mathematics. In this, the Arabs adopted the Indian system of numbers and introduced them on a big level, to the extent that warehouse clerks and traders started using these numerals to conduct their business. The widespread use of the number system simplified calculations and had the similar effect on mathematics as alphabets had on writing. Arabs translated Indian works on algebra and trigonometry and applied them to solve several physical and practical troubles.

Geography

We have seen that Arabs were great travelers. Arab scholars traveled as distant as Russia, Central Africa, India and China. They wrote well-ordered and rational accounts of their journeys and made maps and charts. Their geography was not only descriptive, they also had some thought of the size and level. In this method, they laid the base of modem geography of Asia and northern Africa.

Scientific Chemistry

The Arab doctors, perfumers and metallurgists made their greatest contribution in chemistry. This was mainly due to the information that Arab scholars, unlike their precursors in Greece, never hesitated to take part in laboratory practices in handling drugs, salts and valuable metals. The Arabs sustained the Egyptian and Babylonian traditions, and learnt extensively from the Indian and the Chinese sources. To these they added their own rich contributions, giving rise to the first statements of scientific chemistry.

Arab chemists greatly improved the earlier distillation tools and used it for big level manufacture of perfume. They also undertook big level manufacture of soda, alum, copperas (iron sulphate), and other salts which could be exported and used particularly in textile industry. While they perfected new techniques, they were not satisfied till they were able to get at the bottom of the reactions which made these techniques possible. Arab chemists stipulated the positive and negative nature of two reacting constituents. This was the first time that chemical transformation was approached rationally, to lay the foundation for modem chemistry.

Medicine

The Arabs sustained the Greek custom in medicine also, but added to it the knowledge of new diseases and drugs which was made possible by the wide geographical spread of Islam. The doctors, who were not only Muslim, but also Jewish, studied a great range of diseases. They concerned themselves with questions of the effect of climate, hygiene and diet on health. They also paid attention to the practical art of cookery.

Optics

The prevalence of eye diseases in the desert and tropical countries led to the study of the eye by Arab doctors. Surgical treatment of the eye led to renewed interest in the structure of the eye. This was to provide the Arab physicians the first real understanding of dipodic, the part of optics dealing with the passage of light through transparent bodies like a lens or glass. This also laid the base of contemporary optics. The lens of the eye was to point the method to the use of crystal or glass lenses for magnification and reading, particularly by the old. The 'Optical Thesaurus' of Ibn al-Haitham (in relation to the 1038 A.D.) was the first serious scientific treatment of the subject.

Decay of Arab Culture and Science

The association of science with kings, wealthy merchants and nobles which was initially very fruitful, ultimately proved to be the weakness of Arab culture and science. The patronage provided opportunities to translate, observe, experiment and reflect upon several characteristics of science. It also resulted in Arab science getting cut off from the people, who began to suspect that the learned advisors of the elite were upto no good. This made the general people an easy prey to religious fanaticism. The link also tied up the fortunes of science with the strength of the kingdoms. After the eleventh century A.D., both the Byzantine and Islamic empires started breaking up internally and grew more dependent for military and economic purposes on local kings. By the time of the Crusades (flanked by eleventh to thirteenth century), the empires broke up into local feudal estates where peasants and craftsmen were subjugated with renewed brutality. This destroyed the market for industry and the need for innovative science. In this situation of decay and stagnation came new barbarians from the steppe lands. They in excess of-ran the Arab lands and effectively stifled their culture.

The genius of Arab science lay in the information that it provided a crucial link flanked by the rise of contemporary science, and growths in Greece, in India and, to a lesser extent, in China in the classical era. Modem science, as we know it, arose in the sixteenth century after the Renaissance in Europe. The Renaissance took up the classical science as it was transmitted by the Arabs and urbanized it in a revolutionary sense. Thus started a new age in which science and technology could play pre-eminent roles, roles they had never been described upon to play before.

Science and Technology in Medieval India

Let us now turn our attention to what was happening in India in the medieval times. Al-Biruni (973-1048 A.D.) had visited India and traveled extensively. He had studied the social life, political system and religious beliefs of the Indian people in depth. We get a great deal of information in relation to the India from his writings. In his writings he gave a detailed explanation of the stage of scientific growths in India, in the early decades of the eleventh century A.D. His works also contain reference to the earlier advances. Al-Biruni points out that the Indian views concerning matter were similar to those of the Greeks. According to al-Biruni, the greatest Indian contribution was in the use of the decimal system. The numeral signs that the Indians used were the source of Arabic and the present day international numerals.

Al-Biruni's explanation is not a mere account of things as they were. He also tried to analyze why things were as they were. He realized that Indian science was already on the decline and lamented that "it is quite impossible that a new science or any new type of research should arise in our days. What we have of sciences is nothing but the scanty remnants of bygone better days". He attributed this situation to the lack of patronage to the scholars. This, incidentally, highlights the very elitist character of Indian science. It was restricted to a few people who practiced science only as an intellectual exercise. Science in India had lost its connection with the life of general people or productive procedures. There was, though, some change in the state of affairs with the coming of Islam to India.

Islam came to India at a time when the vigorous intellectual stage of the Islamic civilization was mainly in excess of. With al-Ghazzali's mysticism, a stiff resistance to rational philosophy had urbanized. Nevertheless, the Arab body of knowledge had inherited the best of sciences from the Greek civilization, from China and from India. It also incorporated innovations from within the widespread Arab civilization. This whole body of knowledge became an Indian possession, all the more so as Indian scholars learnt Persian and Arabic after the establishment of the Delhi Sultanate. This influenced to a great extent the development of science in medieval India.

Achievements in Science

The interaction flanked by Indian sciences and those brought by the newcomers remained limited for some time. Though, astronomy and medicine received ready patronage from the Delhi Sultans as well as from Mughal Emperors and their nobility. We shall now tell you in relation to the achievements in several regions of science in medieval India.

Astronomy and Physical Sciences

Astronomy was used not only for working out the calendar, the dates of the eclipses and for the determination of time but also for casting horoscopes for astrological purposes. Astronomy was also needed for fixing the direction of Mecca, in order to properly align the mosques. We discover that Firozeshah Tughlaq (1351-88) recognized an observatory where a special kind of astrolabe and water-clock were set up.

The interest of the rulers in astronomy sustained throughout the Mughal era. Humayun is reputed to have employed a number of astronomers and with their help, he attempted to create astronomical observations.

The astrolabes made in India throughout the seventeenth century, were no doubt an attainment of metal and wood-workers and of mathematical arts. Also, a high degree of accuracy was achieved in circular gradation, which affected all measurements.

The mainly significant stride in the field was made at the beginning of the eighteenth century. Raja Jai Singh, under the patronage of Emperor Muhammad Shah, recognized observatories at a number of spaces, such as Delhi, Jaipur, Ujjain, Benaras and Mathura.

He paid special attention to the instruments of observation. A noticeable characteristic was the construction of big sized observational instruments for fixing time and determining latitudes. He succeeded in compiling fairly accurate astronomical tables, rectifying the calendar and in creation more accurate predictions of eclipses. Jai Singh's astronomical tables entitled Zif-i Muhammad Shahi borrowed heavily from the Zif-i Ulugh Beg (1394- 1449) in the text, but his actual calculations and figures are dissimilar. Nevertheless, in the theory of astronomy, there was hardly any advance in excess of the Ptolemaic system. It is the astrological aspect and preparation of horoscopes which proved to be the mystifying distraction.

A familiarity with the knowledge of specific gravity and laws of motion, based on classic sources, was shown by Abu'l Fazl (d. 1603). This is indicated by a full chapter devoted to these matters in his book A,in-i Akbari, completed in 1595. In this he shows a clear understanding of the Archimedes principle, and the differences in the weights of bodies in air and under water. He also grappled with the problem of molecular arrangement in several substances and tried to relate it to specific gravity. He reproduced a table from al-Biruni giving the specific gravity of several metals and valuable stones. The application of events of specific gravity were given a practical turn by Akbar when he sought to determine the excellence of timber by this means. Abu'l Fazl also gave in his book, a table of specific gravity of seventy two kinds of wood.

Geography

Geography was another science where development took lay. The astrolabes helped determine more accurate latitudes. A big advance was made in the field of cartography when in 1647 Sadiq Isfahani prepared an encyclopedic work that contained a World Atlas. The maps prepared by him, particularly of India, were fairly accurate in on behalf of India as a peninsula and adding Sri Lanka at its southern tip. Rivers were sparingly shown. In India, only the rivers Ganga and Jamuna were drawn. Though, their courses were shown quite accurately, unlike in the modern European maps of India. He had also indicated the physical characteristics, for instance, mountain ranges by wavy rows and used several colors to spot rivers and oceans. Though, Sadiq made no effort to illustrate routes, a practice that started in

Europe approximately 1500 A.D. By this time, India had also become aware of the detection of the New World (America).

Chemistry

In the field of metallurgy too we notice some extra ordinary growths. Before the secure of the sixteenth century, zinc was in accessible by a procedure recognized neither to the Arab civilization nor to the Europeans who learnt the art in the early nineteenth century. It has now been suggested by archaeological excavations at Zawar in Rajasthan that Indians knew how to isolate zinc by in relation to the first century after Christ. In China, zinc was in accessibled only throughout the ninth century.

The separation of zinc was accompanied by another attainment, namely the manufacture of brass, an alloy of copper and zinc. Abu'l Fazl gave three proportions of zinc and copper for obtaining brass of dissimilar diversities .

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

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

Medicine

Aristocratic patronage for physicians and surgeons was not wanting, though, perhaps, surgeons did not enjoy a very high status in comparison to physicians.

The Greek (Unani) system of medicine still widely practiced in India arrived with the Muslims. One would have expected improvement by the mutual exchange flanked by it and the already existing Indian system of

Ayurveda. But the two systems remained separate. Miyan Behwa (in relation to the 1500 A.D.) wrote a significant work on medicine Tibbi-i Sikandar Shahi, based on a number of Ayurvedic sources that are explicitly mentioned. Jahangir's favorite surgeon Muqarrab Khan made use of selections from this book in his two tracts on medicine. The two systems sustained to coexist but almost certainly without any great interaction. Both hakims and vaids were employed by the Emperor and the nobles. In the list of physicians at Akbar's court one discovers four vaids, i.e. practitioners of Ayurveda.

In surgery, blood letting, and in orthopaedic, setting right dislocated bones were the recognized practices. A practice attributed to the surgeons of Kangra was that of treating those whose noses had been cut. They could make an artificial nose by a partial skin transplant. Though, unlike in modern Renaissance Europe, no significant systematic researches in the field of anatomy or physiology were made. Observations, such as plague spreading through rats, were chance observations. A motivating technique, which was pursued by popular practitioners, was smallpox inoculation, since the disease appears to have spread silently all in excess of West Asia and India in the seventeenth-eighteenth centuries. The practice, though, was not safe.

Europeans were also employed as physicians by Mughal nobility but the effort to create use of their knowledge remained confined to individuals. For instance, Danishmand Khan (a Mughal noble in relation to the 1660 A.D.) tried to understand Harvey's detection of blood circulation from the French traveler Bernier who dissected a sheep for demonstration. But such display of interest in European medicine on the part of Indian scholars was exceptional, and even the translations of European scientific works prepared on the orders of Danishmand have not survived.

On the whole, we discover that the development of science in medieval India was at a rather slow pace. There was no adequate response to advances in science made in Europe. The lack of endeavour to understand European science is apparent from the information that an Atlas presented to Jahangir by

Thomas Roe was returned to him because Jahangir's scholars were unable to understand it. It is hard to explain this failure when the European merchants, priests, travelers and physicians were establish in mainly parts of the country.

One possible factor could be the narrow social base of learning, i.e. learning was restricted to a small elite group. This was to some extent due to the absence of printing. Printing was introduced in India by the Portuguese. Though, the products of their printing press were not aesthetic enough to be appreciated by the Mughal court and nobility. The possession of books was a privilege of the rich. Thus, the spread of knowledge was prevented.

Technological Innovations and Inventions

Medieval India witnessed considerable improvement and changes in the field of technology. While these changes were mainly a result of diffusion from outside, some technological innovations also originated in India. Diffusion from outside suggests readiness and skill to imitate, apply and extend the use of technological devices. On the whole, there appears to have been no inhibition against technological change. We shall now describe some technological devices that were invented or improved upon in medieval India.

Gearing

Gearing gives a device for transforming horizontal motion into vertical and vice versa and for rising or reducing speed.

One form of gearing is that of the parallel worm which originated in ancient India. It was received in Kampuchea, in all probability, from India before 1000 A.D. Parallel worm gearing was used in wooden cotton-gin in medieval times; it was also applied to sugar milling, with wooden rollers.

Right-angled pin-drum gearing came with the Persian wheel (sagiya), an improved water lifting device received from the Arab world. India already had water lifting devices such as pulley-system (ghirni) and noria (araghatta) with pot-chain (mala). The application of pin-drum gearing to the araghatto, converting it into what is recognized as the Persian wheel, enabled water to be lifted from deeper stages, in a continuous flow, by use of cattle power. The gear wheel and the shaft were of wood. A horizontal pin-drum, meshing with a vertical pin wheel, was rotated by cattle power. The Persian wheel was being widely used in the Punjab and Sind by the fifteenth century. This improved the means of irrigation and almost certainly resulted in extension of agriculture in the region.

BeIt-drive

The belt-drive is a comparatively simpler device than gearing for transmission of power and for rising or decreasing the speed of motion. Belt-drive came to India in the form of the spinning wheel. The spinning wheel quickened the speed of spinning by in relation to the six fold. This necessity have resulted in reducing the prices of yam and, thus, of cloth. The other improvement in the spinning wheel was the addition of crank handle throughout the seventeenth century. The belt-drive was extended to the diamond cutting drill, by the seventeenth century.

Weaving

Proof of an improvement in weaving comes from a fifteenth century dictionary which describes the foot-pedals used by a weaver to manage speed. The addition of treadles to the loom facilitated the use of feet by the weaver for lifting alternately the heddles and freed his hands to throw the shuttle to and fro. This could more than double the rate of weaving.

By the seventeenth century both ways of multi-color pattern dyeing, namely, the use of resist to confine colors to patterns and of mordant to take colors was used. It was, perhaps, throughout the similar century that direct block printing, a time-saving technique as compared to painting, became popular in India.

Paper Manufacture

Paper was not used in India until the eleventh century. This Chinese invention of the first century A.D. reached India mainly through the Ghorian conquerors. Once introduced, its manufacture spread quickly, and by the middle of the fourteenth century, paper became so cheap that it was used not only for writing but also for wrapping purposes by the sweetmeat sellers.

Distillation

The know-how of liquor distillation also came to India throughout the thirteenth century. Though it has been argued by the well-known Indian chemist P.C. Ray (1861-1944 A.D.) and recently by the Allchins and Needham on the foundation of archaeological proof , that liquor distillation was recognized in ancient India, the stills appear to have been small and inefficient. With the thirteenth century came several kinds of stills (for liquor as well as for rose-water) and there is little doubt that the manufacture of distilled spirits received great impetus.

Architecture

The architectural approach of India underwent a drastic change after the Turkish conquest. The Sultans and their nobles insisted on having arches and domes and competent Indian masons succeeded in structure them. The first surviving instance of arch is Balban’s tomb, dated 1280, and of dome, Alai Darwaza, dated 1305. It was the change in structure technology accompanied by the introduction of lime mortar that made possible the change from trabeate architecture to arcuate approach. The principle of true arch appears to have been recognized in ancient India, but somehow big arches could not be made. Though, false arches were constructed in ancient times.

Use of lime mortar made it possible to waterproof floors and walls for tanks. Thus, it became possible to build tanks and vats such as those needed for producing India’s major dye, indigo.

Military Technology

Significant changes were introduced in military technology. Rope and wooden stirrups for horsemen were recognized in India before the thirteenth century. Though, the iron stirrup appears to have been introduced by the Ghorians and the Turks. This greatly improved the combat power of horsemen. At the similar time, shoeing improved the performance of horses.

Turks also brought with them the cross-bow. The cross-bow had an additional tube at right angles to the bow in which the arrow was fitted; the tube gave greater accuracy of direction to the arrow. This tube appears to be a direct precursor of the barrel of the hand-gun.

The after that stage of development in military technology was the use of cannon and gun powder. This innovation came to India throughout the latter half of the fifteenth century from the Ottoman Empire which had itself received it from Europe.

By Akbar’s time, match-locks and their manufacture became general in the imperial arsenal. Some improvements were attempted mainly with a view to do absent with the match and strengthen the barrel. Akbar’s arsenal succeeded in manufacturing a gun that had mainly almost certainly a wheel-lock. Here the spring released by trigger caused a wheel with serrated edges to revolve against a piece of pyrites and so send sparks into the priming pan. The flintlock widely used in Europe by the first half of the seventeenth century was adopted in India later on.

Manufacture of the barrel of a gun posed a problem for the gunsmith. The barrel had to be very strong to withstand the explosion within it; the creation of the bore and alignment required high accuracy. In Akbar’s arsenal, the barrel was made by rolling flat iron sheets and welding the edge. Thereafter, the bore was worked from inside. The similar technique was used in Europe down to the eighteenth century.

India was credited with casting the heaviest bronze cannons in the world at the secure of the sixteenth century. But the heavy guns were not necessarily efficient as they lacked mobility as well as accuracy. We discover that Akbar paid great attention to the manufacture of lighter guns that could be pulled by a single man.

A significant device used in the Indian army was barn or rocket. This was made of bamboo, with iron cylinders containing combustible materials at the tip. It was this Indian rocket that inspired the invention of rockets by Congreve in early nineteenth century.

Metal Screw

One significant device that had a great potential in the manufacture of precision instruments and machinery was the metal screw. It came into use in Europe from the middle of the fifteenth century for holding metal pieces jointly. Its use was of great importance in mechanical clocks. The screw began to be used in India by the second half of the seventeenth century and even then it was a less efficient version of the European screw. The grooves were not cut, but wires were soldered approximately the nail to make the semblance of grooves. This had to be done owing to the absence of lathes which were used in Europe for cutting grooves. Due to this limitation, the Indian screw did not fit properly.

Ship-structure

The ship-structure industry in the seventeenth century witnessed distant-reaching changes that mainly resulted from imitating European techniques. The Indian sea-going ships, until the first half of the seventeenth century, were described ‘junks’ by the Europeans. These were very big and supported immense main sails. In some methods, the imitations even improved upon the originals. The Indian way of riveting planks one to the other gave much greater strength than easy caulking used by European ship-builders. A lime compound dabbed on planks of Indian ships provided an extraordinarily firm protection against sea-weeds.

Though, it was the instruments used on ship where India lagged much behind Europe.

Indians failed to fashion modem navigation instruments. The main instrument used on Indian ships still remained the astrolabe. Later, in the seventeenth century, European captains and navigators were employed on Indian ships, and they naturally used telescopes, quadrants, and other instruments that were imported from Europe.

Agriculture

Agriculture has been India's main industry. The Indian peasants have used seed drill from antiquity; in the seventeenth century they practiced dibbling that is, dropping of seeds into holes driven into the ground by sticks. They also practiced crop rotation in mainly regions. The number of crops grown by Indian peasants was quite big. Abu'l Fazl mentions approximately 50 crops for kharif and 35 for rabi seasons, though their number varied from region to region.

The mainly extra ordinary excellence of the Indian peasant was his readiness to accept new crops. The new crops introduced in the seventeenth century that came from the New World were tobacco and maize. These crops came to be grown quite widely. By the fifteenth century, the peasants of Bengal also took up sericulture and by the seventeenth century, Bengal had appeared as one of the great silk exporting regions in the world.

Horticulture urbanized considerably under aristocratic patronage. Several kinds of grafting were introduced. In Kashmir, sweet cherry was obtained by grafting, and the farming of apricot was also extended by the similar means. Throughout Shah Jahan's time, the excellence of oranges was greatly improved by use of the similar technique. On the western coast, the Portuguese introduced mango grafting and Alfonso was the first mango produced in this fashion. Mango grafting appears to have spread in northern India throughout the eighteenth century.

If we seem at the 600 years of development of science in medieval India, we cannot but be disappointed. There appears to have been progress here and there, in astronomy, medicine and technology, but all within the old frame of thought which is often described Aristotelian : a world which always was as it is now, and will continue to be so: a universe at the centre of which was the earth and all things were made of five elements—fire, air, water, earth and ether. The concept of master and slave of the Greek society or hierarchical structure was so natural that it also pervaded the physical world where everything knew its lay and fulfilled its purpose.

There was, indeed, no effort to incorporate the latest findings in each subject, to even be aware of the discoveries being made in modern Europe. There was still less effort to develop a theoretical and philosophical understanding in which each element of knowledge could fit. Little interest was taken in such extra ordinary advances as Copernican model of the solar system, Galileo's work (1610), Newton's great work on gravitation (1665), or even circulation of blood exposed by Harvey (1628). The invention of the printing press which had the potential to create knowledge accessible to a superior number of people or again the telescope (in relation to the 1600) and the microscope attracted no attention. It is extra ordinary that the few centers of learning that lived propounded theology, either Hindu or Muslim, or explained a body of knowledge that already lived. Their role was not to break fresh ground and develop new things.

Why was it so? We shall now attempt to analyze why science and technology did not grow in India as in Europe in those times.

Impediments to the Growth of Science in India

By the end of the eighteenth century, Indian society had become very intricate. Hence it is hard to talk about even one aspect of it that of science, as it arose from this society and contributed to it, without in excess of-simplifying. Though, if simplification creates sense and does not distort the picture, it is a good thing, because it provides us an overview which helps in understanding the interaction flanked by science and society.

What may have struck you from the brief presentation given here is that Indian science was at the similar stage as science anywhere else in the world. In scrupulous, it was at the similar stage as European science, upto in relation to the middle of the sixteenth century. But, then European science took big strides forward and left Indian science method behind in the era that followed. In information, the British were able to subjugate this country, and create it their colony, on the foundation of science, technology and industry which had urbanized there. The question that naturally arises is what the variation flanked by Europe of sixteenth century and India of that era was. If you get interested in pursuing the question, you would almost certainly have to read history in depth. Though, to put it basically , the variation in the two societies was in their social structure, in the degree of the hold of religious orthodoxy, and the intellectual atmosphere. Let us explain what we mean.

We have seen that one type of pressure for advancing knowledge and technology comes from the necessity of satisfying human needs. There is an old saying that necessity is the mother of invention. Well, it appears that in spite of periodic wars flanked by the rulers of several regions and states in the country, there was a very considerable stability in Indian society. Population was small, the land was fertile and even from small land holdings Indian peasants were able to meet the necessities of survival. They could feed and clothe themselves. Although there were poor people, poverty and hunger of the type we see today did not exist. The deprivation Science in the Medieval Time that we see today is mainly a result of British policies imposed on us. The hold of religion, particularly in the rural regions, and the subsistence of the caste system, contributed both to a sure reconciliation with fate, and an acceptance of the social hierarchy. There was a fascination with the thought of an infinitely old universe condemned to an endless cycle of deaths and rebirths, in which nothing fundamentally new could ever happen. What can be described a peculiar type of satisfaction prevailed, which did not allow pressures to build up for either enhancing manufacture through technological innovation, or to change the society.

Another cause was that those who worked with their hands did not contribute to the stock of knowledge. And those who possessed even out-dated knowledge never had to test it on the touchstone of practice. Either the kingdoms fought wars or settled down to extensive eras of peace. It appears natural to think that in such a society there was no clamor to develop new products or new procedures. Social stability and stagnation can easily go hand in hand. The rich had no need for change, the poor had no power to bring in relation to the change.

We have seen that when Islamic power entered India in successive waves, it tended not to disturb the life of the general people who existed in rural societies. It did not interfere with the prevailing religious ethos, which remained predominantly Hindu, with its ideology tolerant of great variations, but at the similar time protecting the caste system which was well recognized in India. We discover that at the stage of administering the country, and in the armed forces there was mutual support flanked by the higher strata of people in the two societies. Muslim kings with Hindu Commanders-in-chief, and Hindu Rajas with Muslims at the head of their armies are recognized to have fought and also defended each other. Naturally, there was provide and take, and intermingling of cultures. What we call Indian culture today is a result of centuries of interaction flanked by our people of dissimilar regions and of those who came and settled down here in dissimilar eras.

At the stage of religion, there was coexistence flanked by Islam and Hinduism, perhaps, out of necessity, since the Muslims were in a small minority. They could certainly not afford a confrontation with the vast majority if their rule was to last in India and was to be extended in the centuries to come. This was also because priests had a great hold in excess of people and any interference in each other's affairs would have had serious political consequences. It could have led to turmoil. So, each steered clear of the other. Further, the priests of the two societies were well off, and satisfied with their economic condition. Within the two religious systems too, there were no active controversies and no strong movements of reform.

The Bhakti and Sufi movements did arise in the medieval era. These movements preached religious tolerance and were highly critical of the caste system. Though, they did not create a wide impact as their word did not reach distant.

This was perhaps due to the absence of printing. Typically, when a printed book was presented to Jahangir, he is said to have thrown it absent, saying that it was ugly and unaesthetic as compared to the beautiful calligraphy in which they prided. He little realized or was, perhaps, little interested in the possibility of enriching people's life on a big level through the availability of cheaper books. This was in contrast to the sixteenth century Europe where the availability of printed word greatly helped the spread of knowledge that created a wider and deeper impact for bringing in relation to the social change.

In India education was, by and big, limited to religious teaching and the intellectual atmosphere was not in favor of demanding the recognized methods of thinking, or of propounding new theories. In such an atmosphere few would venture to propose freedom of thought. It was still harder to accept such new things as a sun-centered universe demonstrated by Galileo. For, the new theory changed the order which was whispered to have been recognized by God to provide the abode of man a central location in the whole creation.

Indeed, astrology was, perhaps, esteemed enough to let astronomy go on! Alchemy still held some promise of converting base metals to gold, howsoever mysteriously or irrationally, to allow dabbling in chemical techniques! The reign of the orthodoxy with its belief in eternal or revealed truths never allowed free thinking and imaginative adventure of thoughts. To put it in another method, the learned had fixed thoughts which they did not need to change. And those whose social status was low and who were exploited by the feudal order had no access to learning.

If it were not for these factors, we had a tremendous advantage in excess of Europe in the sense that the strong streams of Arab and Indian science coexisted here, and we should have been miles ahead of Europe. In Europe, comprehensive books of Arab authors like Compendium of Astronomy by al-Fargani, Howi, Liber Continens by al-Razi, the Canon of Ibn Sina and the Colliget of Averroes (all medical treatises) were used as text books in the seventeenth century. All these books were accessible in India and could have been used, but were not. The exciting advances made in science throughout the sixteenth and the seventeenth centuries in Europe, such as the works of Copernicus, Galileo and even Newton did not draw widespread attention, since they were not secure to the hearts of such scholarship as lived in India at that time.

All this can, perhaps, be summarized by saying that a traditional, hierarchical society with a low stage of discontent and conservatism promoted by both the religions, made scientific advance superfluous. Naturally, such a society could not bring in relation to the scientific revolution such as was taking lay in modern Europe in the sixteenth and the seventeenth centuries. It could, and did, devote its attention to the good things of life such as drama and music, dance and painting, architecture and poetry. This, at least, was the saving grace of the medieval society.

RENAISSANCE, THE INDUSTRIAL REVOLUTION AND AFTER

Science and Technique in Medieval Europe

In relation to the second century A.D., the collapse of the Roman Empire and the barbarian invasions by Franks, Goths, Magyars, Vandals, Slavs and others brought in relation to the circumstances in Europe, in which, the slaves could revolt and free themselves. But even in freedom, slaves could not do much since they had no land to produce food for themselves. Though the Romans had conquered the whole of Western Europe and had come as distant as England, agricultural land was limited. Mainly regions in western Europe were sheltered with thick forests and even the soil was clayey and heavy. The Romans did not have the agricultural apparatus and techniques for working such land for farming. This led to widespread scarcities of food and other daily necessities, which resulted in discontent. In other words, the breaking up of slave society was accelerated by its own tensions and scarcities. We discover that from the fifth century onwards, slaves were disappearing and their lay was being taken by serfs.

Towards the beginning of the tenth century, a new productive system and a new society had recognized itself in several parts of Europe. This was the feudal system.'

The Feudal Society

The economic foundation of the feudal system was land, and the village was its economic unit. The feudal economy was dependent on local agricultural manufacture and a scattered handicraft industry. In the villages, peasants or serfs shared the land and work. But they were forced to yield part of the produce or labour to their lords in the form of rent, taxes or feudal service. Usually, a lord owned one or more villages or land in many villages. The serfs were obliged to uphold their lords and they were not allowed to leave the land on which they worked.

This obligation of feudal service, that is, of work exacted by force or by custom backed by force, is the feature of the feudal system. What distinguished the serfs from the slaves of classical times is that unlike the latter that were owned by the slave-owners, the former were free men and had a secure tenure to cultivate land. Though the serfs were nominally free, their condition was not much better than that of slaves. Though, social pressures on them had been somewhat reduced. This feudal order lasted until in relation to the seventeenth century in Europe.

The era from the tenth century to in relation to the fifteenth century is usually described the Middle Ages in Europe. In this era, the Church was the centre of power. It provided a general foundation of power for all Christendom. It was also an instrument for intellectual expression. All intellectual action was accepted on by people who were part of the Church. Thus, the Church dominated all walks of life. Therefore, the clergy had to be trained to think and write, in order that they may be able to defend the faith and take up missionary work. At first, this need was met by setting up cathedral schools. By the twelfth century, these had grown into universities. The first university to come up in this era was at Paris, in France, in 1160. It was followed by the founding of Oxford University in 1167 and Cambridge University in 1209 in Britain. Then came the universities in Padua (1222), and Naples (1224) in Italy, Prague (1347) in Czechoslovakia, and many others. These universities were mainly for training the clergy.

Teaching in these institutions had to be only by lectures and debates because books were still unusual. The curriculum comprised grammar, rhetoric, logic, arithmetic, geometry, astronomy, music, philosophy and theology. In practice, the amount of science that was taught was very little. Arithmetic dealt with only numbers, geometry with the first three books of Euclid and astronomy got no further than the calendar and how to compute the date of Easter. There was little get in touch with the world of Nature or the practical arts, but, at least, a love of knowledge and an interest in argument was fostered. As we know, education by itself can be a positive factor in human development In this case religious personnel were being trained according to a specific curriculum, and the universities were bastions of conservatism. Though, they did come in get in touch with the creative thought of others, particularly the classical Greek thought and, to some extent, Arab, Indian and Chinese thought. This led to an intellectual climate which proved good for the future growths and discoveries in science.

But in the Middle Ages, education was still restricted to a small number of people. What may be described 'scientific' investigation was undertaken only by the clergy. And it was done to somehow justify religious beliefs. There was a constant debate flanked by faith and cause, but even cause was used to prove the supremacy of divine thinking, revelation and every aspect of Christian dogma. We will now describe very briefly the 'scientific achievements' of the Middle Ages.

Medieval Science

We can record the sum total of the medieval attainment in the natural sciences in a few rows. It can be put down as a few notes on natural history and minerals, a treatise on sporting birds, such as falcons, hawks etc., some improvements in Ibn al-Haitham's optics and some criticism of Aristotle's thoughts. In mathematics and astronomy, the Arabic algebra and Indian numerals were introduced and Ptolemy's Almagest was translated. The medieval European astronomers could not go much beyond the Arab contribution in observational astronomy although they added a few details. They made some contribution to trigonometry and the construction of instruments. Though, there was no radical revision of astronomy. Robert Grosseteste (1168-1253), a Bishop and Chancellor of Oxford University, was a leading scientist of the Middle Ages. He thought of science as a means of illustrating theological truths. He experimented with light and thought of it as divine illumination. There were several other such 'scientists' in the Middle Ages.

Those who questioned the prevalent religious beliefs, were likely to be prosecuted for heresy! Even the thought that man could reach God directly without intermediaries, such as priests, was measured a heresy. The Middle Ages were an era of faith and of regimented thinking. The feudal society in its social, economic and intellectual character was again a stagnant society. The limited contribution of medieval science under such circumstances is understandable. It is, indeed, unfair to expect more of such a science than what was demanded from it in its time!

Though, the feudal society was definitely on a higher technological stage than the slave society of the Iron Age. In information, the impetus to technological innovations had lived from the beginning of the Middle Ages. This arose from the need for better use of land. It was here that the peasant and the workman could use and improve the classical techniques. For mainly of the Middle Ages there was a chronic labour shortage with the labour force of slaves no longer accessible and with the expansion of cultivable land in the countryside. Thus, human labour was sought to be substituted by mechanical means; manpower shortage led to the use of animal, wind and water-power. Thus, we discover that several technological growths took lay in medieval Europe though mainly of them appear to have come from the East, especially from China.

Technological Growths in Feudal Society

Major inventions, namely, the horse collar, the clock, the compass, gunpowder, paper and printing, were not urbanized in feudal Europe. Mainly of these were being used in China throughout the first few centuries of Christian era. We need to know in relation to the these advances because, in Europe, the use of some of these techniques set in motion a revolution, which contributed to the breakdown of the feudal system.

The horse collar and the mills were more efficient means of using power. The horse collar originated in seventh-century China and reached Europe in the eleventh century. Its use resulted in a manifold augment in the horse's skill to pull loads and work longer. Horses took the lay of oxen at the plough and more acres of land could be cultivated.

The water-mills were also invented in the classical era. But they came to be widely used only in the Middle Ages. The wind mills and water-mills harnessed nature for performing mechanical work. These mills were used for grinding granules, extracting oil from seeds and drawing water from wells, thus helping agriculture. They were also used for blowing bellows, forging iron or sawing wood. Mills became so popular that a mill and a miller were establish in every lord's domain. The task of creation and servicing the wind and water-mills was beyond the ability of mainly village smiths. Therefore, there grew a deal of millwrights who went in relation to the country, creation and mending mills. These men were the first mechanics who knew all in relation to the creation and working of gears. They also had a hand in the development of mechanical clocks and watches.

There were two navigational inventions, the compass and the stem post rudder, that had a profound impact on sea voyages in the Middle Ages. The earlier sea deal routes were beside the coastline of several countries. With these two inventions, the oceans were thrown open to deal, exploration, and even war for the first time. Open-sea navigation required accurate charts of the location of stars, latitudes etc. and gave an impetus to later growths in astronomy and geography. It also raised the urgent problem of finding the longitude. The need for compasses and other navigation instruments brought into being a new skilled industry.

Other innovations used and improved by the Europeans were the lenses and the spectacles. This gave an impetus to the further study of optics and there were some contributions to Ibn al-Haitham's optics. The demand for spectacles also gave rise to the profession of lens grinders and spectacle makers.

Distillation of perfumes and oils was already recognized in Europe through the Arabs. To this was added the distillation of alcohol, which gave rise to the first scientific industry, that of distillers, and laid the base of modem chemical industry.

Of all the innovations introduced in the West from the East, gunpowder had the greatest effect politically, economically and scientifically. With its use in cannons and hand guns, gunpowder enormously altered the balance of power. In science, the creation of gunpowder, its explosion, the expulsion of the ball from the cannon and its subsequent flight, furnished several practical troubles. Solutions to these troubles and the accompanying explanations occupied the attention of medieval scientists for several centuries and led to sciences like mechanics and dynamics. The preparation of gunpowder required a careful separation and purification of niter giving rise to the study of solutions and crystallization. Niter gives the oxygen needed for explosion of gunpowder. So, unlike ordinary fire, it does not require air. Studies related to the explosion of gunpowder led to attempts to explain combustion, i.e. burning. These attempts were later extended to studies on breathing which gives the oxygen needed to convert food into power inside the animal body. These explanations were not easy at that time and taxed the ingenuity of medieval chemists mainly.

Two other technological introductions from the East had a distant greater effect in the West than in the land of their origin. They were the inventions of paper and printing. The need for a writing material cheaper than parchment became urgent with the spread of literacy. Linen rags provided the foundation for the first paper of excellence. Paper turned out to be so good and cheap that its increased availability led to a shortage of copyists. This contributed a lot to the success of printing, originally a Chinese invention of the eleventh century.

Printing, with movable metal kinds, was first used by Koreffis in the fourteenth century. It was introduced into Europe in the mid-fifteenth century and it spread rapidly, first for prayers and then for books. The new, cheap, printed books promoted reading and created increased access to education for a superior number of people. This became a medium for great technological and scientific changes as well as changes in the society throughout the Renaissance.

The Transformation of Medieval Economy

The new techniques led to greater manufacture in agriculture and, therefore, a surplus from the needs of people. Increased productivity led to greater deal which was aided by better manners of transport. Manufacture of other articles such as cloth, chemicals, wine, and iron for apparatus and weapons also expanded, leading to a considerable augment and diversification in deal. The more the deal grew, the more money it brought in by method of profit to the merchants, who traded the goods produced by peasants and urban workers. The increased profit led to the manufacture of more goods and manufacture of cash crops from the land. With better techniques, better manners of transport and ample markets, the manufacture of commodities for sale increased considerably. Thus, a trading and urban manufacturing economy grew inside the feudal system. These changes succeeded in breaking down the local self sufficiency of feudal economy at the local village stage.

Although, the manufacture of commodities was accepted on more often in the countryside as a part-time peasant job, the markets were dominated by city merchants. By the mid-thirteenth century, the merchants had become rich and powerful enough to acquire a monopoly location in deal. They had shaped guilds and used their location to buy goods cheap, and sell them at vast profits. As the markets expanded, the merchants wanted freedom of movement as well as safety beside the deal routes which passed through numerous feudal estates with their own laws and restrictions. A conflict of power flanked by the feudal landowners and the new-rich merchant class was taking lay all in excess of. Slowly, the merchants gained the upper hand. By the fifteenth century, they had grown so strong that they were beginning to change the economy. The feudal economy, characterized by agricultural manufacture based on forced services of the serfs, was transforming into one in which commodity manufacture by craftsmen and hired workers, and money payments became dominant.

These economic, technological and political changes were accompanied by changes in the Church. Till this time the Church was all-powerful. It had a monopoly of learning and even of literacy. The Church had a hold on the state and was deeply involved in the maintenance of feudal order. As the rising merchants and artisans of the cities threatened the feudal order, the might of the Church began to be questioned. The Church tried to suppress all such people by branding them as heretics. Though, in the last two centuries of the Middle Ages, the Roman Church was considerably weakened. In some spaces, kings started asserting themselves against the central power at Rome. In this they were helped by merchants, though the country nobility was still aligned with the orthodox Church. Thus, the unity of the Church began to be threatened. Flanked by 1378 and 1418, the Christian Church was split flanked by two or three Popes. More power had to be given to the common councils of the Churches. Substantial movements of reform in the Church were initiated and there was soon to be a thrash about for power flanked by the Pope and the Emperors.

It is obvious that the European society, in common, was on the threshold of major changes approximately the beginning of the fifteenth century. The stage was set for the full flourishing of the Renaissance.

The Renaissance (1440-1540)

The Renaissance was a revolutionary movement. It marked a definite and deliberate break with the past. It swept absent the medieval shapes of economy, of structure, of art and thought. These were replaced by a new culture, capitalist in its economy, classical in its art and literature, and scientific in its approach to Nature. The feudal system dominated by the lords and the Church had given method to nation-states, where the kings or princes provided patronage to the new scientists. So they didn't have to depend any more on the Church. With the economy picking up again, the despair of the Dark Ages and the resignation of the ages of faith gave method to an era of hope marked by a frank admission of physical enjoyment. In the changing social milieu, money became much more significant than it had ever been before.

Even the attitude towards creation money changed. Any method of creation money was good as extensive as it worked, whether by honest manufacture of deal, by inventing a new device, by opening a mine, by raiding foreigners or by lending money at interest. In these changed social circumstances, the technicians and artists were no longer as despised as they had been in classical or medieval times because they were essential to the creation as well as spending of money. The practical arts of weaving, pottery, spinning, glass creation, mining, metal-working etc. became respectable. Initially, this enhanced the status of craftsmen. But later, by the seventeenth century the merchant and the capitalist manufacturers started controlling the manufacture more and more. As a result, both craftsmen and peasants were reduced to the status of wage laborers.

In its intellectual aspect, the Renaissance was the work of a small and conscious minority of scholars and artists who set themselves in opposition to the whole pattern of medieval life and thought. The Renaissance also re-recognized the link flanked by the traditions of the craftsmen and those of the scholars. With this coming jointly of the doers and the thinkers in the changed economic situation, the stage was set for a rapid growth in science.

Science and Technology throughout the Renaissance

This stage in the history of science was one of account and criticism. First came the exploration of ancient knowledge, mainly of the Greeks. The scholars encountered the thoughts of Plato and Aristotle in the original, as well as those of Democritus and Archimedes. Then came the challenge to old power. At the similar time the arts and techniques flourished and provided the material means for the growth of science.

Art

The visual arts, such as painting and sculpture, came to inhabit a significant lay in society. These had a profound power on the development of science. For instance, painters were required to have a thorough knowledge of geometry, so that they could symbolize three dimensional figures in two dimensions. For this, they also used several mechanical and optical aids. The realistic life-like paintings required the mainly detailed observations of nature and thus, laid the base of geology and natural history. The anatomy of human beings was also studied in much detail.

The professions of artists, architects and engineers were not separated in the Renaissance. Artists were also the civil and military engineers. They could cast a statue, build a cathedral, drain a swamp or even besiege a city. The great Renaissance artist Leonardo da Vinci is well recognized to all of us for his beautiful painting ‘Mona Lisa’. Not several of us may know of his contributions to the study of human anatomy, study of plants and animals as well as of machines and military devices. His drawings indicate that he was also a keen observer of the operations of metal-workers and technicians who constructed structures and bridges.

Medicine and Technology

The faculties of medicine in the universities, especially in Italy, were the first ones to break out of the common obscurantism. The doctors mingled freely with artists, mathematicians, astronomers and engineers. These associations gave European medicine its feature descriptive, anatomical and mechanical bent. The human body was dissected, explored, measured and explained as an enormously intricate machine. The new anatomy, physiology and pathology were founded on direct observation and experiment.

In technology, the greatest advances of Renaissance were in the meadows of mining, metallurgy and chemistry. The need for metals led to the opening up of mines. With rising capitalist manufacture, mining became a big level operation. As mines grew deeper, pumping and hauling devices became essential. This led to a new interest in mechanical and hydraulic principles.

The smelting of metals like iron, copper, zinc, bismuth, cobalt etc., their handling and separation led to a common theory of chemistry involving oxidation and reduction, distillation and amalgamation. For the first time, metallic compounds were introduced into medicine. Other chemical substances such as alum and clay were studied to improve cloth and leather industries or to create fine pottery. By the end of the Renaissance, the chemical laboratory with its furnaces, retorts, stills and balances had taken a form that was to remain approximately the similar till into modem times.

Navigation and Astronomy

As we have said earlier, by the end of the Middle Ages, deal on land and in excess of the seas was being taken up on a big level. By the fifteenth century, the Turks had acquired a monopoly of deal routes on land. Therefore, new sea routes for deal were being explored. Great voyages were undertaken. We all know in relation to the Vasco da Gama, a Portuguese sailor, who reached India in 1497 via the Cape of Good Hope in Africa. Approximately the similar time, a great and adventurous voyage was undertaken to sail westward on the Atlantic Ocean in the hope of reaching India. Columbus, an inspired adventurer, though a penniless sailor, was able to obtain the assistance of Portuguese, Spanish, English and French courts to undertake this journey. He reached the continent, later named as America, in 1492 thinking that he had reached India. The adventure, the common excitement and ultimately, the great profitability of these voyages created great enthusiasm for structure new ships and instruments for navigation. Interest in astronomy was strongly revived.

The Copernican Revolution

It was right in the midst of these growths in the fifteenth century, that there came the first major break from the whole system of ancient thought. This was the work of Copernicus, who gave a clear and detailed explanation for the rotation of earth and other planets on their axis and their motion approximately a fixed sun which was at the centre. This model simplified astronomical calculations, and also made them more precise. Such a model had been proposed by Greek astronomers like Aristarchus several centuries earlier. Though, it was not given any importance because it ran counter to the recognized thoughts of those times. This work of Copernicus was published in the very year of his death in 1543. Although his book attracted limited attention and there were objections to his model, his work gave a great boost to further work by Galileo.

This was the first stage of what we now call the Scientific Revolution. In this stage, the old methods of thought were proving inadequate. By rejecting the old thoughts, the men of Renaissance had cleared the grounds for new thoughts of the succeeding century. In the use of science for practical purposes too, the Renaissance set the scene for. future growths. From now on science had become a necessity for profitable enterprises, deal and war.

Science in the Post-Renaissance Era (1540-1760)

These were made in search of spices, silver, fur, sugar plantations, slaves, gold and other commodities. The one to have very distant reaching effects was the voyage undertaken by Columbus in 1492, which, eventually, resulted in a lot of Europeans going to America. There they cleared the land, settled down and started plantations of sugar and tobacco exploiting the hard labour of African people. The Africans were forcibly taken on board west-bound ships to be transported to the new country and were sold there as slaves. The stealing, selling and use of people as slaves caused terrible suffering. Yet, it was done unashamedly because there was great profit to be made from the new colonies. Money was being piled up for investment in shipbuilding, mining and manufacturing other articles in Europe.

These growths greatly strengthened the merchant class and in excess of the after that two or three centuries they were able to replace the feudal lords and landowners in power in excess of their regions. Society tensions, peasant revolts, religious wars and the race to acquire colonies were all playing a role in changing the feudal society of the Middle Ages into a capitalist society of the eighteenth century in some regions of Europe. The development of capitalism as a leading way of manufacture was accompanied by the birth of a new way of natural science, that of experiment and observation.

In science, this era from the mid-sixteenth century to the mid-eighteenth century comprises the first great triumphs of the new observational, experimental approach. This new approach jointly with the development in science and technology throughout the Renaissance, amounted to a "Scientific Revolution". Technically, this era was of steady advance without any revolutionary inventions. The rising demand for iron led to development of new blast furnaces. The shortage of wood for iron-smelting led to widespread use of coal. From then on, the centre of industry was to move towards the coal meadows. With time, the demand for limited possessions increased, forcing the search for new possessions and techniques. This also altered the attitudes towards change and novelty, which could not be shunned anymore. You may recall that in the regimented feudal society, new thoughts and change were resisted.

It was in this atmosphere that European science grew to maturity. The first institute for teaching science, the Gresham College, was opened in England in 1579. The revolutionary Copernican model of the solar system helped in improving astronomical tables. What the theory lacked was an accurate account of the orbits of the planets. This was done by two extra ordinary men, Tycho Brahe (1546-1601) and Johannes Kepler (1571-1630). Brahe, composed a series of exact observations on the positions of stars and planets with specially made tools. His results were theoretically worked in excess of by Kepler. Kepler establishes that the observations could be explained only if the orbits were taken as ellipses. Thus, he broke absent from the thought of circular orbits. Kepler's laws of planetary motion struck a mortal blow to the old Greek thought of perfect circular motion.

The telescope, invented approximately this time, proved to be the greatest scientific instrument of this era. In the hands of Galileo Galilei (1564-1642), a professor of physics and military engineering at Padua, it became a means of revolution in science. Galileo was able to see that the moon was not a perfect round and smooth body but it had ridges and valleys. He also observed that three moons circled approximately the planet Jupiter, more or less like the system Copernicus had proposed for the earth going round the sun. Within a month, in 1610, he published his observations in his book Siderius Nuntius, (Messenger from the Stars). It created a great sensation because the 2000 year old model of heavenly bodies going round the earth was threatened. It challenged the accepted world view that man, specially created by God, existed on earth, hence, it was natural to consider that the whole universe revolved approximately the earth.

Galileo's more detailed work, entitled Dialogue concerning the Two Chief System of the World, the Ptolemaic and the Copernican was published in 1632 and was, indeed, dedicated to the Pope. In this he criticized and ridiculed the ancient Ptolemaic cosmology. The challenge put down by Galileo could not be ignored. Distant more was seen to be at stake than a mere academic point in relation to the motion of the earth and planets. If the challenge in one respect was ignored, more such challenges would arise. The new knowledge threatened the stability of the Church and the social order itself. It immediately led to disagreement with the Church which resulted in Galileo's trial. He was condemned and forced to go back on his words.

The trial of Galileo dramatized the disagreement flanked by religious dogma and cautiously observed and analyzed scientific data and theory. It is a sheer chance that the year Galileo died, Newton was born. Newton was to continue Galileo's scientific custom. He provided a complete scientific theory of motion of all objects, whether planets in the heavens or bodies on earth. This shows that given the socio-economic circumstances of those times, it was not easy any more for the Church to suppress the scientific custom. Whereas earlier Giordano Bruno (1548-1600) was burnt to death and Campanella (1568-1639) was imprisoned for years for opposing the Aristotelian world view and supporting the Copernican theory, Galileo suffered a nominal imprisonment in the palace of one of his friends. By Newton's time, interference from the Church in science had more or less stopped.

Galileo did not stop even after being tried and condemned by the Church. He tried to explain how the Copernican system lived. For this, it was necessary to explain how the earth's rotation did not produce a mighty wind blowing in the opposite direction and how bodies thrown in the air were not left behind. This led to a serious study of bodies in motion. On the foundation of cautiously mannered experiments, Galileo succeeded in formulating a mathematical account of the motion of bodies. This was the major work of his life expressed in his Dialogue on Two New Sciences. Galileo questioned all accepted views. This he did by the new way, the way of experiment. When Galileo's experiments gave him results he did not expect, he did not reject them. Rather, he turned back to question his own arguments. This was the hallmark of experimental science.

Galileo and Kepler could formulate mathematical descriptions of the motion of bodies because they were masters of the new mathematics that had grown throughout the Renaissance. Algebra, geometry and the decimal system, taken from the ancients and the Arabs, as well as the introduction of logarithm by Napier (1550-1617), greatly simplified astronomical calculations. Forty years later, the observational laws of Kepler were combined with the explanations of Galileo in Newton's theory of universal gravitation.

There were other significant growths in science in this era. Magnetism was experimentally studied for the first time. Another significant development was William Harvey's (1578-1657) detection of the circulation of blood in the human body. A totally new approach was formulated and the human body was analyzed on the principle of pumps and valves like the ones seen in machinery. As a result, a new type of experimental anatomy and physiology appeared.

The growths in the latter half of the seventeenth century paved the method for an outburst of action which created contemporary science in mainly of its meadows in the after that fifty years. These were helped by the emergence of stable governments in France and England, the two principal centers for scientific action in those times. The merchants in Britain had arranged a compromise with landlords, in which the king became the constitutional monarch. The economy was dominated by the merchants. But, more importantly, a new class of manufacturers was emerging from in the middle of the skilled craftsmen. The courtiers and the learned men of the universities, dependent on the favor of the princes of yesteryears, were being replaced by men of independent means. These were mostly merchants, landowners, doctors, lawyers and quite a few parsons. They financed science out of their pockets. As they grew in number, they tended to come jointly for discussion and exchange of thoughts.

Thus were shaped the first well-recognized scientific societies, the Royal Society of London (1662) and the French Royal Academy (1666). These societies set themselves the task of concentrating on the pressing technological troubles of those times, those of pumping and hydraulics, of gunnery and of navigation. In science, it appeared at first that anything and everything could be improved by enquiry. Though, sure meadows of interest drew special attention. Those were the ones directly related to the needs of expanding deal and manufacture. Foremost in the middle of these was astronomy which was an essential need of ocean navigation. The growths in astronomy led to the new mathematical explanation of the universe, finally arrived at by Newton. This was a major triumph of science.

The greatest triumph of the seventeenth century was the completion of a common system of mechanics. This system could explain the motion of heavenly bodies as well as the motion of matter on the earth in conditions of universal laws and theories. Several mathematicians and astronomers including approximately all great names of science of that era—Galileo, Kepler, Descartes, Hooke, Huygens, Hailey and Wren, had worked to discover this complete form of mechanics. Standing on the shoulders of these giants, it was ultimately Newton who worked out and proved his theory of universal gravitation and set it down in his 'De Philosophiae Naturalis Principia Malhematica.

Newton's theory of universal gravitation applied to all particles or bodies possessing mass, whether on the earth, on the sun, or anywhere else in the universe. Newtonian mechanics, as it is recognized to us now, provided a coherent explanation for the motion of all bodies in this universe, i.e. how bodies moved as they did. By the use of Newtonian mechanics it was possible to determine the path of any body in motion, if all the forces acting on it were recognized. Newton's laws of motion are now taught in all the science courses all in excess of the world. The immediate practical consequence of Newton's work was that the location of the moon and the planets could be determined distant more accurately with a minimum of observations. It also became the foundation for the design of a great diversity of machines and structures which are used today and will be used for centuries to come.

Newton's theory of gravitation and his contribution to astronomy spot the final stage of the transformation of the Aristotelian world-picture begun by Copernicus. Newton recognized a dynamic view of the universe in which things were changing with time. Yet, he stopped short of questioning the subsistence of a divine plan. His world moved according to an easy law, but it still needed divine intervention to make it and set it in motion. His theory gave no reasons why the planets went round the similar method. He postulated that this was the will of God at the beginning of creation. Newton felt he had revealed the divine plan and wished to inquire no further question. By Newton's time, the stage of criticism in the Renaissance was in excess of. A new compromise flanked by religion and science was being sought. Newton's work provided this foundation for a compromise flanked by science and religion which was to last until Darwin upset it in the nineteenth century.

There were other growths too, such as in optics and the theory of light, closely connected to astronomy by the telescope and to biology by the microscope. Seventeenth century optics grew mainly from the attempts to understand refraction. At the similar time, theories in relation to the nature of light were also given. Another development was pneumatics, the science of mechanical properties of gases. The question of vacuum was also significant. The actual manufacture of vacuum and the use of air pump for this led Robert Boyle to study the behaviour of air. Thus, it led to his epoch-creation work on the gas laws. Robert Hooke, an assistant of Boyle, was the greatest experimental physicist of those times. His interests ranged in excess of the whole of mechanics, physics, chemistry and biology, though he is best recognized for his study of elasticity.

The world of biology saw great advances with the coming of the microscope. Small creatures were observed and the anatomy of superior ones was refined. In chemistry, new substances such as phosphorus were accidentally produced and new metals such as bismuth and platinum were exposed. The demand for new chemicals led to a growth in the chemical industry.

Why Science Grew in Europe

Looking back in excess of the development of the new science in the fifteenth to the seventeenth centuries, we can understand why the birth of science occurred when and where it did. We have seen that it closely followed the revival of deal and industry. The profit from expanding deal and successful voyages was being invested in new behaviors giving rise to a climate of intellectual enterprise. The birth of contemporary science follows closely after that of capitalism. The merchants and gentlemen of the seventeenth century had cleared the ground for the flourishing of a humbler set of manufacturers. These were the ones who made use of and urbanized the traditional techniques beyond all recognition in the after that century. In science, as in politics, a break with custom also meant venturing into hitherto strange regions. No part of the universe was too distant, no deal too humble, for the interest of the new scientists. The information that these scientists often interacted with each other, recognized societies and published journals also helped the advance of science.

Science was also able to flourish as it did because of the Church's internal feuds, its friction with the emerging merchant class and a common erosion of its power. The resistance of the Church to scientific thoughts seemed to be quite strong in the beginning. This was evidenced by the trial of Galileo and by the execution of Bruno who uttered the heresy that just like our own world, there may be other worlds in the heavens. But later on the success of the new scientific thinking based on observations was unstoppable.

As we have said earlier, a compromise was being sought flanked by science and religion. Hence, methods and means were explored to discover a method of coexistence flanked by science and religion. This was to be on the foundation that science should deal with the phenomena which affect the senses, but it should leave aside other matters which are spiritual or aesthetic in nature. An artificial divide which we see even today was, thus, created flanked by science, social science, arts and humanities. On the other hand, from the time of Newton onwards, scientists were able to work with greater freedom, and with practically no interference from religion. Scientific societies were recognized to see that the advancement of science was connected to practical benefits, to business or to society at big.

The success of science in this era was also due to the working jointly of the people who produced or manufactured dissimilar articles, and the scientists who tried to understand the properties of materials that were being handled. This was because manual work was given greater social prestige as it was a source of great profit. The economic and social world had changed from one with the fixed hierarchical order of the classical and feudal era where each human being knew his or her lay. Now, it was a world of individual enterprise where each human being paved his own method.

These exciting growths in Europe had two facets. Expanding manufacture and deal and the resulting search for markets led to European entry into several countries of Asia, Africa and North and South America. Colonies came into subsistence and their wealth began to flow into the European countries, which improved the lot of even the general man in these countries. On the other face, it was a misfortune for the colonial people whose crafts and industry were ruined and whose natural possessions were harnessed for export to the ruling countries. The role of the East India Company in bringing India into the colonial system is well recognized. Extreme poverty and deprivation in India has its origin in the colonial use of our land and our people.

We will now tell you in relation to the major event towards the second half of the eighteenth century, viz. the “Industrial Revolution” in Europe, particularly in Great Britain. This arose from the skill to use steam powered machines on a big level, resulting in a radical change in the means and the mode of manufacture. It also resulted in bringing in relation to the deep-seated changes in the structure of the society.

The Industrial Revolution (1760-1830) and After

We will first provide a brief account of the social and economic changes of this era so that growths in science can be seen in the proper perspective. Already, by the end of the seventeenth century, the stage was set for the further advance of the capitalist mode of manufacture. The feudal and even royal restrictions on manufacture, deal and business had been swept absent. The triumph of the bourgeoisie, and of the capitalist system of economy which they had evolved, had taken lay only after the mainly severe political, religious and intellectual struggles.

In Britain, the urban middle class had broken absent totally from feudal limitations by the eighteenth century. With an ever rising market for their products all in excess of the world, they could finance manufacture for profit. With an expansion of markets, rising freedom from manufacturing restrictions and rising opportunities for investment in profitable enterprise, the time was ripe for great technological innovations.

Thus, we-discover that by the middle of the eighteenth century, the slow and gradual changes in the manufacture of goods gave method to a rapid change. The new ways of experimental science that appeared from the Scientific Revolution of the sixteenth and the seventeenth century were now extended in excess of the whole range of human experience. Their applications in creating new techniques brought in relation to the great transformation of the means of manufacture which we call the Industrial Revolution. The architects of the Industrial Revolution were artisan inventors. Workmen with their small accumulated or borrowed capital were, for the first time, establishing their claim to change and to direct the manufacture procedures. The power of merchants in excess of the manufacture of small artisans was also being broken.

The Industrial Revolution came mainly from growths in industry, that too within the major industry of those times: the textile industry. As the demand for cloth increased, the old industry could not expand rapidly to meet it. Also, by 1750, the industry came to deal with a new fiber, cotton. Earlier, cotton cloth had been imported from India. With the import of cotton textile from India into Britain being prohibited, there was a great impetus to augment manufacture of cotton textiles. The use of cotton described for new techniques. Here, at last' in the cotton industry there was unlimited scope to substitute machinery for manual work. Thus, from the technological changes which had been taking lay for several decades, came the thought of introducing many mechanical gadgets for spinning ana weaving. Manual work was greatly reduced as machines replaced the operations that were done by hand.

The textile industry led the method to growths in other regions as well. The market for textile machinery and textile processing stimulated the iron and chemical industries. All these industries described for an ever rising supply of coal, which required new growths in mining and transport. The new mechanical industry urbanized approximately coal meadows. Though, it was the use of the steam engine for power in the textile industry that really created the industrial intricate of the contemporary world. It revolutionized textile manufacture, so much so, that manufacture of goods increased approximately five fold within 20 years.

The thought of mechanization rapidly spread to other regions such as mining, metallurgy and even agriculture. Very soon the attention of the whole society was drawn to its explosive potential. With soaring profits, the search for markets became more acute. It became necessary to have radically new means of transport and communication to carry on this deal. The steam engine, as a stationary device, had extensive been used in mines and then in "factories" which had come into subsistence. Now it was put on rails to draw heavy loads in excess of extensive distances. Thus, the railways connected the centers of industry; and the steamships composed its raw materials and distributed its finished products distant and wide.

While the eighteenth century had establish the key to manufacture, the nineteenth century was to discover that to communication. Electricity had been used as extensive ago as 1737 to transmit messages for distances of a few kilometers. But now it was absolutely necessary to transact business in excess of extensive distances. This was ensured by the successful invention of the telegraph in 1837. Soon, wires were laid for speedier communication flanked by cities, from one country to another. By 1866, crossways the Atlantic Ocean, on its bed in the form of cables, wires were laid to form a telegraphic link flanked by Britain and America. Within a hundred years from the beginning of the Industrial Revolution, factory cities had sprung up and the appearance of even the countryside had changed. A complete transformation had taken lay in the lives of millions of people livelihood in the newly industrialized countries like Great Britain, France, Germany, Holland, USA etc.

Introduction of machines in manufacture centers which moved from houses to specially constructed premises described factories, led to reorganization of work, and, in scrupulous, to "division of labour". This meant that intricate operations were broken down into simpler ones, and one man at his workplace performed only one or two very easy operations. Thus, the manufacture per person was greatly enhanced. Though, at the similar' time; this increased human drudgery, reduced requirement of mental involvement, and, in information, made human beings work like machines.

It is recognized these days that, in common, "industrialization" creates one person produce several times more surplus than agriculture. More surplus yields more profits. Therefore, capital gets multiplied much more rapidly, and it can be used to put up more machines for more manufacture. Hence, the tendency is to multiply manufacture as a whole. The history of early industrialization in all countries shows how workers were exploited, how every ounce of the workers' power was extracted so that the machines could chum out vast profits; and how miserable were the circumstances in which the workers had to live. This gave rise to the new phenomena of deal unions and workmen's thrash about to improve their lot.

There was another aspect of this industrialization. With augment in manufacture, the cost of manufacture came down. Since goods were produced on a big level, the overhead costs did not augment proportionately. Thus, industrially produced goods turned out to be cheap. This led to goods from industrialized countries swamping markets in the colonies and ruining local industry. Where the industrial goods were not competing well, the colonial governments went out of their method to use their power to ensure the sale of imported products.

It may be said that science did not play a direct role in the Industrial Revolution—but, of course, technology did. On the other hand, technological understanding and design of machines depended on science—particularly Newton's thoughts on motion, force, power and power etc. The steam engine, the centre-piece of the Industrial Revolution which was used in factories, railways and steam ships, owes a great deal to a correct understanding of the nature of heat and the behaviour of gases with change of pressure. Purification of ores, casting of machine parts from iron, and printing of doth gave further impetus to growths in chemistry. Oxygen was exposed by Joseph Priestley (1733-1804) at approximately the time of the Industrial Revolution. Based on his experiments on combustion, Antoine Leurent Lavoisier (1743-1794), a French scientist formulated a theoretical framework for a rational and quantitative study of chemistry. John Dalton (1766-1844) proposed the atomic theory a few decades later.

Other sciences soon gathered momentum and the list of inventions or new laws exposed in the decades following the Industrial Revolution is mainly impressive. The list ranges from the detection of Coulomb's law in 1770, in relation to the force of attraction or repulsion flanked by two electric charges, to the invention of electric light and the detection of radio waves towards the end of the eighteenth century. In the mid-nineteenth century,

Louis Pasteur's detection of bacteria and his theory that diseases were caused by germs, provided a great impetus to medicine. It led to the development of immunization against diseases like anthrax in cattle and rabies in human beings. Pasteur also demonstrated that several of these microbes bring in relation to the chemical changes in foodstuffs and that it is possible to select specific microbes to produce products like wines and vinegar. This detection shapes the foundation of industrial microbiology which has enabled us to get several valuable drugs, like the antibiotics cheaply today. It has also made it possible to explore alternative sources of fuel like biogas, power-alcohol etc. But, perhaps, the mainly important contribution of Pasteur was that through cautiously intended experiments, he gave a convincing proof against the thought of spontaneous generation of life. He postulated that livelihood beings can arise only from the livelihood and not from non-livelihood matter. Can you consider that approximately till the nineteenth century it was widely held, even by some scientists, that life could arise spontaneously from non-livelihood matter?

Approximately the similar time, a major contribution came from Charles Darwin (1809-82) in his revolutionary thoughts in relation to the biological development. Until this time, it was whispered that each form of life was specially and separately created and, thus, had a specific lay and function in the hierarchy of creation. Through careful observations and painstaking research, Darwin built up a theory in relation to the development of dissimilar shapes of life from some simpler ones.

To sum up, we have outlined some of the major growths in science and technology in the eighteenth and nineteenth centuries. It totally shed the ancient and medieval myths, and replaced them by a rational analysis of observed or. experimented phenomena. In this manner, it helped to carry the Industrial Revolution to great heights and to spread it to many European countries. Science and technology are now recognized to be essential ingredients of industrialization. This has yet to take lay in mainly countries which were under colonial power till recently.

Science education was introduced as a subject in some universities in Europe even throughout the eighteenth century. Though, it spread widely throughout the nineteenth century when scientific academies were founded in several countries and scientific research took root in several European centers. The Industrial Revolution and science grew hand in hand, and if the Industrial

Revolution bears sure features of science, science too carries many characteristics of that revolution, as we will soon look at.

Unluckily, these growths in industrialized countries further strengthened or expanded their colonial hold. India came under colonial power approximately at the similar time as the Industrial Revolution and we suffered all the negative effects. Our industry was undermined, our natural possessions were packed off, as much as possible, to England which would manufacture articles and force them on our market. Disruption of social life and extreme poverty began at the similar time. Although science was irresistibly rising in the West, our education and research were totally neglected. Thus, India fell back in the race of economic development by at least a hundred years. Since the international rate of scientific progress is very high, this tragedy almost means that scientifically we are likely to be dependent on the West, perhaps, forever, unless we take extraordinary events to pull ourselves up.

It would be motivating for you if we went on to explore the relation flanked by science, technology and society in the present-day world. But we would not be able to do justice to such an exploration without discussing the several branches of science and technology and their special role. In this course, through the units that will follow, you will begin to appreciate the present situation by learning troubles of health, food, agriculture and industry, which will be presented in our social context.

SCIENCE IN COLONIAL AND MODERN INDIA

Science in Colonial India

The rise of modem science in Europe strengthened European economic power in excess of the colonies where education, science and research were kept backward.

The advancing European trading companies of Holland, Portugal, France and Great Britain became deeply involved in political and military rivalries in India. The British East India Company appeared as the dominant trading company. This culminated in the establishment of the British supremacy in excess of the Indian Sub-continent. This was a very exciting time for the British rulers; a new empire was in the creation and in the procedure of consolidation. The colonizers were out to collect the maximum possible information in relation to the India, its people and possessions. They faithfully accounted what was best in India's technological traditions, what was best in India's natural possessions, and what could be the mainly advantageous for their employers. The rulers were also quick to realize that a thorough knowledge of the geography, geology and botany of the regions being conquered was essential. They fully recognized the role and importance of science in empire-structure.

A motivating characteristic in the early stage of this era was that colonial scientists would attempt their hand at many meadows simultaneously and each scientist was, in information, a botanist, geologist, geographer and educator—all rolled into one. As data-gatherers, the individual scientists were efficient. Though, for analysis and drawing conclusions, they had to depend upon the scientific institutions in Britain, which received such data from several colonies. The British made investment in botanical, geological and geographical surveys from which they hoped to get direct and substantial economic and military advantages. Medical and zoological sciences did not hold such promise and, thus, they were neglected. Research in physics or chemistry was basically out of question because these subjects were related to industrial development which the British did not want to encourage. India was measured to be only a source of raw materials and a wonderful market for all sorts of articles manufactured in Britain, from needles, nibs and pencils to shoes, textiles and medicines.

Though, the setting up of some scientific bodies and museums was a positive step. Pre-British India had a weak scientific base and, therefore, neither scientific institutions lived nor were there any journals to spread scientific information. William Jones, a judge of the Supreme Court of Calcutta and some other European intellectuals in the municipality realized this and founded the Asiatic Society in Calcutta in 1784. This society soon became the focal point of all scientific action in India. It was followed by Agricultural-Horticultural Society of India

- Calcutta Medical & Physical Society (1823), Madras Literary and Scientific Society and the Bombay Branch of the Asiatic Society (1829). These societies rendered invaluable service, particularly through their journals which compared very favorably with the European ones.

When the Crown formally took in excess of the Indian management in 1858, behaviors for exploring the natural possessions in the country had already passed their formative stage. The problem was more of consolidating the gains which individual efforts had made possible. For this, several institutions were set up and the government expanded the survey organisations. In 1878, the three survey branches—the trigonometrically, topographical and the revenue which had upto that time been separate departments, were amalgamated. Naturally, Revenue Survey got the upper hand. Likewise, geological explorations were patronized because of their direct economic benefit. The Geological Survey of India was created in 1851. Unlike the Geological Survey or Survey of India, an organisation for carrying out botanical explorations did not come up.

The establishment and development of several scientific departments and institutions described for a dissimilar cadre. The major and the oldest was the Indian Medical Service which was raised and maintained basically to serve the army. The mainly disorganized sector was that of agriculture. Though the maximum revenue came from agriculture, the troubles of its improvement were too intricate and the government left it in the hands of private agricultural societies. Much later, in 1906, an Indian Agricultural Service was organized. Though, it did not grow into a well-knit and integrated scientific department because of financial and administrative constraints. A few branches which were of military or instant economic significance could manage to develop. But, on the whole, the efforts remained ad hoc, sporadic and local in nature. The government wanted practical results rather than research papers. An excessive administrative manage, exercised at dissimilar stages, ensured that the colonial scientists would always dance to the official tune.

In the educational scheme, science was never given a high priority. The charter of 1813 described for ‘the introduction and promotion of knowledge of science in the middle of the inhabitants of British India’. But it remained a pious wish, at least partly because the indigenous educational system was also not sympathetic to the thought . In 1835, Macaulay succeeded in creation a foreign language English the medium of instruction. Also, his personal distaste for science led to a curriculum which was purely literary. The entry of science in schools was, thus, delayed. A few medical and engineering institutions were opened but they were meant mainly to supply assistants to British trained doctors and engineers. Ancient universities in India were leading centers of learning in their time and attracted scholars from other countries. So were the well-known centers of Islamic learning in the medieval era in India. But these traditions did not survive. It was in 1857 that the Universities of Calcutta, Bombay and Madras were set up more or less on the pattern of London University.

Though, it was only in 1870 that the Indian universities began to illustrate some interest in science education. In 1875, Madras University decided to look at its matriculation candidates in geography and elementary physics in lay of British history. Bombay was the first to grant degrees in science. Calcutta University divided its B.A. into two branches— ‘A’ course, i.e. literary, ‘B' course, i.e. science. Information of great significance, though, was that the whole direction of colonial education was not towards opening up the minds of students or developing a questioning attitude. Rather it encouraged passive acceptance of what was taught or written in the books. The books were in English and were mostly written and printed abroad. They depicted the British culture. Education so imparted, by and big, tended to alienate the educated people from their own culture. Further, the educational milieu ensured lack of enterprise, which was indeed the intention of the rulers. Institutions and teachers looked at the British educational model as the ideal and, by and big, they tried to copy it even though they were in a very dissimilar social and economic situation.

Scientific Research in Colonial India

In the absence of higher scientific education, scientific research remained an exclusive governmental exercise for an extensive time. It was, therefore, connected to the economic policies pursued by the imperial power. A scientist serving the colonial power was supposed to not only discover new economic possessions, but also to help in their use. In agriculture, it was basically plantation research with emphasis on experimental farms, the introduction of new diversities , and the several troubles related to cash crops. These were basically cotton, indigo, tobacco and tea, which were all to be exported to Britain. After that came surveys in geology to use mineral possessions, again for export as raw material. Another major region of concern was health. The survival of the army, the planters and other colonizers depended on it.

In spite of hard circumstances and the government's lukewarm attitude, quite a few scientific works were accepted out in this era. Ronald Ross did original work on the relation flanked by malaria and the mosquito. Macnamara worked on cholera, Haffkine on plague and Rogers on kalazar. The well-known medical scientist, Robert Koch visited Calcutta to work on cholera. Bacteriological laboratories were set up in Bombay, Madras, Coonoor, Kasauli and Mukteswar. This shift towards bacteriological research had one important result. It led to the growth of clinical treatment, private practice and a booming drug industry. Though, preventive events like sanitary reforms, or even supply of drinking water to villages and cities remained neglected. In other meadows too important growths took lay through the effort of foreign and Indian scientists working in institutions here.

The British behaviors did evoke some response from the local populace, particularly the educated part, who were looking for jobs in the colonial management and economy. A few Indians participated in the officially patronized scientific associations or institutions. Though, they often searched for a separate identity and recognized institutions, scholarships and facilities of their own. Ram Mohun Roy's petition to Amherst asking for a proper science education became well recognized. Bal Gangadhar Shastri and Hari Keshavji Pathare in Bombay, Master Ramchander in Delhi, Shubhaji Bapu and Onkar Bhatt Joshi in Central Provinces, and Aukhoy Dutt in Calcutta worked for the popularization of modem science in Indian languages.

Geography and astronomy were the regions chosen first because, in these meadows, the Pauranic myths were measured the strongest. Vyas, the author of Srimad Bhagwat, for instance, had talked in relation to the oceans of milk and nectar. This is part of popular myth even now, and this was attacked by these persons. For instance, Onkar Bhatt explained that Vyas was only a poet, not a scientist, and his interest was merely to recount the glories of God, so he wrote whatever he fancied. Even Urdu poets, devoted mainly to the romances of life, took notice of the western science and technology. Hali and Ghalib, for instance, talked in relation to the achievements of western civilization based upon steam and coal power. The after that logical step from these individual efforts was to provide some organizational form to the rising yearning for modem science.

In 1864, Syed Ahmed Khan founded the Aligarh Scientific Society and described for introduction of technology in industrial and agricultural manufacture. Four years later, Syed Imdad Ali founded the Bihar Scientific

Society. These societies slowly became defunct. In 1876, M.L. Sarkar recognized the Indian Association for the Farming of Science. This was totally under Indian management and without any government aid or patronage. Sarkar's scheme was fairly ambitious. It aimed at original investigations as well as science popularization. It slowly urbanized into a significant centre for research in optics, acoustics, scattering of light, magnetism etc. In Bombay, Jamshedji Tata drew up a similar scheme for higher scientific education and research. This led to the establishment of the Indian Institute of Science at Bangalore in 1909. There was, thus, greater awareness in relation to the science in India by the turn of the century. This was especially so, as a movement to gain freedom from colonial rule appeared.

Impact of the Freedom Movement

By the early twentieth century, the Indian society had started witnessing the first stirrings for freedom from colonial rule. While their political aspirations led to a demand for self-rule, the frustration resulting from economic stranglehold establish expression in their insistence on using only goods made in India. This Swadeshi Movement provided further impetus for:

- Promotion of education beside national rows and under national manage with special reference to science and technology,
- Industrialization of the country.

In 1904, an Association for the Advancement of Scientific and Industrial Education of Indians was shaped. The substance was to send qualified students to Europe, America and Japan for learning science-based industries. In colonial India the environment was not conducive to higher studies, much less to research. Indians were allowed only, subordinate posts and even those who had distinguished themselves abroad were given less salary than the Europeans of the similar grade and rank. This 'apartheid' in science made the Indians reacts strongly. J.C. Bose, the first noted Indian physicist, refused to accept this reduced salary for three years. Not only this, till the Royal Society recognized Bose, the college authorities refused him any research facility and measured his work as purely private. J.C. Bose was unorthodox in one more sense. He was one of the first in the middle of the modem scientists to take to interdisciplinary research. He started as a physicist but his interest in electrical responses took him to plant physiology. To fight for a lay and recognition in the scientific circles in Britain was no less hard than fighting against the administrative absurdities of a colonial government. Bose persisted and won.

Another noted Indian scientist, P.C. Ray had also suffered likewise. On his return from England in 1888 with a doctorate in chemistry, he had to hang approximately for a year and was finally offered a temporary assistant professorship. All through he had to remain in Provincial Service. P.N. Bose, preferred to resign, when in 1903 he was superseded for the directorship of the Geological Survey by T. Holland who was 10 years junior to him.

These troubles were reflected on the political platform of the country. In its third session (1887), the Indian National Congress took up the question of technological education and has since then passed resolutions on it every year. K.T. Telang and B.N. Seal pointed out how, in the name of technological education, the government was merely imparting lower shapes of practical training. The Indian Medical Service was also severely criticized. In 1893, the Congress passed a resolution asking the government "to raise a scientific medical profession in India by throwing open meadows for medical and scientific work to the best talent accessible and indigenous talent in scrupulous." Whether it is education, agriculture or mining, the Congress touched many troubles under its wide sweep.

We discover that the behaviors of this era had two significant characteristics. One was that approximately all the exponents of Swadeshi looked to Japan as a major source of inspiration. Japan's emergence as a viable Asian industrial power and its subsequent military victory in excess of Russia in 1904-05 caught the imagination of Indians. Another feature was that quite often they showed revivalist tendencies. This may have been because the distant past comes in handy for the recovery of a lost self or reassertion of one's identity. This search for moorings made P.N. Bose, a geologist writes 'A History of Hindu Civilization' in three volumes. J.C. Bose gave Sanskrit names to the instruments he had fabricated, like Kunchanagraph and Shoshangraph. Several sciences popularizes had a tendency to illustrate that whatever was good in western science lived in ancient India also. For instance, Ramendrasundar Trivedi's discussion on Darwin ends with comparing his theory with what is written in Gita. Later, B.K. Sarkar wrote on the Hindu Achievements in Exact Science.

All these scientists were for the industrial application of contemporary science but failed to overcome sure cultural constraints, which was necessary for this effort. All they tried to do was to demonstrate that the Indian ethos and the values of modem science were congruent and not poles separately. In such a situation, it was not easy to evolve a correct understanding of our intellectual and cultural heritage. This was all the harder because of the total colonial power both in education and in social life.

These efforts had, nonetheless, a galvanizing effect. Taking advantage of the University Act of 1904, which allowed the existing Indian universities to organize teaching and research instead of merely affiliating colleges, Sir Asutosh Mookherjee took the initiative of establishing a University College of Science in Calcutta. Eminent scientists such as P.C. Ray, C.V. Raman, S.N. Bose and K.S. Krishnan taught there. This very college, although starved financially all through, produced a group of physicists and chemists who received international recognition. By contrast, the contributions of several government scientific organisations staffed by highly paid Europeans were rather poor.

Those who put India on the scientific map of the world were several. J.C. Bose showed that animal and plant tissues display electric responses under dissimilar type of stimuli, like pricking, heat etc. We have referred to his work earlier also. S. Ramanujan, an intuitive mathematical genius contributed a lot to number theory. P.C. Ray analyzed a number of unusual Indian minerals and started the Bengal Chemical and Pharmaceutical Works, a pioneering and pace- setting organisation in the field of indigenous chemical and pharmaceutical industry. C.V. Raman's research on the scattering of light later won him the Nobel Prize in 1930. K.S. Krishnan did theoretical work on the electric resistance of metals. S.N. Bose's collaboration with Einstein on the study of elementary particles led to what is recognized as the Bose-Einstein Statistics. D.N. Wadia worked in the field of geology, Birbal Sahni in palaeobotany, P.C. Mahalanobis in statistics, and S.S. Bhatnagar in chemistry. Separately from the individual contributions of these scientists, their greatest contribution was in the field of teaching and guiding research. Several institutes were set up. For instance, the Bose Institute (1917), Sheila Dhar Institute of Soil Science (1936), Birbal Sahni Institute of Palaeobotany etc. This gave further impetus to scientific action in India.

The need for an annual scientific meeting had been felt all beside, so that dissimilar scientific workers throughout the country might be brought into touch with one another more closely. So distant it had been possible only in the purely official and irregular conferences such as the Sanitary Conference or the Agricultural Conference. Thus, was born the Indian Science Congress Association (ISCA) in 1914 with the following objectives:

- To provide a stronger impulse and a more systematic direction to scientific enquiry,
- To promote the interaction of societies and individuals interested in science in dissimilar parts of the country,
- To obtain a more common attention to the cause of pure and applied sciences.

The objectives have not changed much since then and the ISCA has now grown into the main organisation of Indian scientists and technologists on behalf of all disciplines of science and technology. In the wake of the first World War (1914-18), the Government realized that India necessity become more self-reliant scientifically and industrially. It appointed an Indian Industrial Commission in 1916 to look at steps that might be taken to lessen India's scientific and industrial dependence on Britain. The scope of the resulting recommendations was broad, covering several characteristics of industrial development But few of the Cominission's recommendations were actually implemented. Similar was the fate of numerous other Conferences and Committees. Whenever requests were made by Indians for starting new institutions or expanding existing ones, the government pleaded insufficiency of funds or inadequacy of demand. The interests of the colonial management and those of the nationalists in mainly instances often clashed.

If we seem at the events throughout the first quarter of the twentieth century, we discover that this era was Characterized by debate in relation to the further development. When Gandhiji started his campaign for cottage industries, varying notes were heard at the annual session of the Indian Science Congress. P.C. Ray, for instance, held that common progress through elementary education and traditional industries, is a necessary pre-condition for scientific progress. But several differed with him. M.N. Saha and his Science & Culture group opposed the Gandhian path of economic development and supported setting up of big industries. The socialist experiments in Russia had unveiled the immense potentialities of science for man in conditions of economy and material progress. The national leadership was veering towards heavy industrialization and socialism, both of which stood on the foundations of contemporary science and technology. On Saha's persuasion, the then Congress President Subhas Chandra Bose agreed to accept national scheduling and industrialization as the top thing on the Congress agenda.

The result was the formation of the National Scheduling Committee in 1938 under the chairmanship of Jawaharlal Nehru. This Committee appointed 29 sub-committees, several of which dealt with such technological subjects as irrigation, industries, public health and education. The sub-committee on Technological Education worked under the Chairmanship of M.N. Saha. Other members were Birbal Sahni, J.C. Ghose, J.N. Mukherjee, N.R. Dhar, Nazir Ahmed, S.S. Bhatnagar and A.H. Pandya. The sub-committee reviewed the behaviors of the existing institutions to discover out how distant the infrastructure of men and tools was enough in turning out technological personnel.

The outbreak of the Second World War (1939-45) and the interruption of the direct sea route flanked by India and England made it necessary for the colonial government to allow greater industrial capability to develop in India. It was, therefore, felt necessary to set up a Central Research Organisation and this was eventually followed by the establishment of the Council of Scientific and Industrial Research in 1942. As part of the post-war reconstruction plan, the government invited A.V. Hill, President of the Royal Society. In 1944, he prepared a statement that recognized several troubles confronting research in India. These growths offered greater opportunities to Indian scientists in policy-creation and management of scientific affairs. In information, the origins of the science policy of free India and of the whole national reconstruction can be traced to these behaviors .

Science in Post-Independence India

When the Second World War ended in 1945, Germany, Italy and Japan had been defeated and France had been badly shaken. Even Britain had suffered tremendous losses and its economy was approximately ruined. Thus, the colonial powers which had ruled the world and spread poverty, hunger and disease everywhere, were in no location to suppress people anywhere any more. The constant thrash about for freedom in the colonial countries had also reached a high pitch. The result was that, one after another, more than a hundred countries of Asia, Africa and South America became free. The war had shattered the old system, and a new world had been born, with an entirely dissimilar set of opportunities and troubles.

The countries which had become newly independent had the tremendous problem of reconstructing their economy so that tolerable circumstances of livelihood could first be created for all their people. The old ruling countries, on the other hand, had to think of methods and means of continuing to drain the wealth of their erstwhile colonies. This was necessary to enable their business enterprises to continue creation high profits so that they could uphold relatively high standards of livelihood to which their own people had become accustomed.

Science and technology had to be deliberately employed by both sets of countries. The only variation was that the developing countries had to create a start from scratch—with hardly any institutions or people who could engage in competitive science and technology, whereas the advanced or urbanized countries now had a stronger base of science and technology than ever before. Throughout the war great sums of money had been spent on developing nuclear science and the atomic bomb, on electronics as applied to radar and communication, and on advanced designs of aircrafts, submarines and other means of waging war. All other sciences were also in a much better location than before. This base of science and technology was to be used to the advantage of urbanized countries to regain the old glory and power. In other words, our thrash about for "development" and their thrash about for supremacy are two sides of the similar coin. Science and technology play a pivotal role in this international competition.

The Indian freedom movement had been conscious that political independence was only a stepping stone to economic independence. Our leaders had realized that our decisions in relation to the industry and deal would have to be taken by us alone without compulsion of foreign governments or their business counterparts. And that our economic development would have to serve the people and meet the minimum needs of their food, health, shelter, education, culture etc. For this, we could not leave economic development to chance, or to the purely profit motive on which private industry and deal operate, their natural tendency being to produce what can sell, rather than what is needed in our social context Therefore, an essential part of our approach to development was to plan our economy to bring in relation to the maximum human satisfaction combined with growth.

The role of science and technology was crucial for this endeavour and this was clearly expressed in the "Scientific Policy Resolution" adopted by the Parliament in 1958. This resolution was drafted and piloted through the Parliament by our first Prime Minister, Jawaharlal Nehru. In the words of this Resolution :

"The key to national prosperity, separately from the spirit of the people, lies, in the modem age, in the effective combination of three factors, technology, raw materials and capital, of which the first is, perhaps, the mainly significant, since the creation and adoption of new scientific techniques can, in information, create up for a deficiency in natural possessions, and reduce the demands on capital. But technology can only grow out of the study of science and its applications."

Since Independence, and particularly after the passage of the Resolution, a great expansion of science and technology in both education and research has taken lay. The situation today is distant dissimilar from what it was in 1947. We have now in relation to the 200 universities including 6 Indian Institutes of Technology, in excess of 800 engineering colleges and 110 medical colleges, a few hundred scientific research laboratories under the Central and State governments, as also R&D units in private industry. Research is being done in approximately all regions of contemporary science. The conspicuous success of our scientists in atomic power, legroom research and agriculture is well recognized.

The funds allocated to research have also vastly increased in excess of what they used to be 40 years ago. But in the contemporary world, it is not enough to be in the forefront of creative science or innovative technology. Out of the total world expenditure on research, excluding the socialist countries, 98% is spent by the urbanized countries, the old imperial powers. Only 2% is spent by all the developing countries taken jointly. In this, India's share may be half a per cent. Moreover, since the urbanized countries have better facilities, better opportunities for scientific world and higher standards of livelihood, a fairly high proportion of our talented young people migrate to those countries. They are, thus, unable to contribute towards national development by solving our troubles through science and technology. New discoveries and new inventions, therefore, still come from the advanced or urbanized countries. This location does not appear likely to change in the close to future.

A new characteristic of the world since the Second World War is the armaments race. It started with the Americans dropping the radically dissimilar weapon, the atom bomb, on Hiroshima and Nagasaki in Japan. Since then, contemporary bombs, each equivalent to a million tons of the old explosive, were urbanized both by the U.S., the then Soviet Union and other nuclear powers. Nuclear powers have missiles which can carry the bombs to targets half method round the globe. Each offensive weapon has led to a new suspicious system. There has also been a race to obtain bases in other countries. A dangerous aspect in relation to the nuclear weapons is that these could be triggered off even by mistake, and could destroy all civilization. Thus, we can see that the security of neither of these countries has improved. In information, several other countries are drawn into the race because weapons of one country have to be matched by another. It is calculated that the world is spending more than 1,00,000 crores rupees per year on armament and the developing countries arc spending in relation to the 20% of this amount, much of which goes to buy weapons from firms in the urbanized countries.

Imagine such a lot of money, on behalf of human labour, being wasted year after year. Naturally possessions for development are diverted to "security". On the other hand, people in underdeveloped countries are still mainly illiterate and deficiently served in vital necessities of life, such as food, drinking water, medicine etc. Interestingly, it is said that the arms race has led to vast profits being made by a small number of firms, and it is intended to suck absent the possessions of developing countries so that their dependence on foreign loans, technologies and strategic policies is increased. The more sophisticated the weapons are, the more is our dependence on the advanced countries.

Surely, this is neither a happy situation nor a stable one. The power of science has reached such a pitch that international dealings have to be readjusted, and national effort has to be recast so as to bring the benefits of science to the lives of general people.

THE METHOD OF SCIENCE AND THE NATURE OF SCIENTIFIC KNOWLEDGE

Science—Its Several Facets

Science is at once a personal and a social pursuit. It is marked by intense creative involvement of the individual. At the similar time, scientific development is affected by social circumstances and demands. And, in turn, science has a powerful impact on society. It is, thus, a vehicle of social change. The human approach to life and environment has always been conditioned by a sense of wonder and curiosity on the one hand, and the thrash about for survival and well being on the other. Both these vital instincts have shaped human thought from times immemorial. Science being an integral part of human thought and endeavour is also influenced by these instincts. Either of these motives could be dominant in any individual scientist. Society benefits from both, from a better understanding as also from a better manage of world approximately 'us.

Science is contemporary in the sense that it tries to explain things as they are recognized today. But we know that its origin is as old as human subsistence. The custom of science has lived from the earliest ages of man. It was there extensive before the name ‘science’ was invented or a ‘way of science’ separate from general sense and traditional lore had evolved. We have seen that early practitioners of this custom were establish in the middle of astrologers, priests, magicians and craftsmen, not to mention the latter day alchemists. In information, depending upon the character of societies, and the historic era of their subsistence, the nature of questions posed to man and his response have been changing and so has science been changing.

What is the world that science is concerned with? The world that science describes—the universe that science explores—is the natural world, the world of experience. It encompasses terrestrial and celestial, livelihood and the non-livelihood. Science may be regarded as a means of establishing new types of contacts with the world, in new domains, at new stages.

How do we set up these contacts? These are mainly through our senses. Though, the range of our senses is limited. For instance, we cannot see things that are too distant or too small; we cannot hear sounds that are too low or too high, and so on. There are other limitations as well. For instance, the perceptions gathered through our senses may be relative. Modem science has enabled us to overcome several of the limitations of our senses. For instance, limitation of the eye with respect to size or aloofness do not limit scientific observation because of the invention of apparatus like microscopes, telescopes etc. Atoms can now be ‘seen’ and so can the distant stars, invisible to the naked eye. With the help of scientific instruments, it is now possible to create observations which are independent of an individual’s sensory perception.

New ‘sounds’, new ‘lights’, new ‘spaces’, new ‘contacts’ of several sorts—that is what the modem science is in relation to the. Our role as ‘observers’ of nature, as witnesses to events happening approximately us, has undergone a tremendous change. The skill to observe nature beyond what our senses enable us to do, provides us a feeling of nearness or closeness with natural world, as well as a sense of manage in excess of the world and ourselves.

Science helps us to constantly invade regions of ignorance and convert them into meadows of knowledge. It extends our experience by the continual exploration of new domains. For instance, man landed on the moon and now preparations are going on for landing men in the coming future on Mars for investigating it. Means are now accessible to explore the internal structure of the earth, as well as to study the structure and function of the human brain. As newer and newer troubles are encountered, regions of experience are enlarged

Separately from the vital needs, the intricate world of today has varied necessities, of better means of manufacture to reduce human drudgery, of better facilities for health care, education, communication, transport, entertainment etc. These pose distant greater challenges to science than did the bare needs of food and shelter of the primitive man. These challenges lead to new regions of study which may not, at first, be clear or well defined. Though, systematic study using appropriate methodology, leads to an understanding of these new regions. This is how the pursuit of science is an endless search for knowledge, and an unlimited endeavour.

Science is the search for knowledge in relation to the world, the quest for understanding it. Man has always speculated in relation to the strange. When speculation in relation to the strange region is replaced by knowledge, then that region becomes a part of science. If we do not understand an observed phenomenon we often tend to provide it a mystical justification or explanation. Science enables us to ‘demystify’ natural phenomena, through an understanding based on facts and cause.

The body of scientific knowledge has grown tremendously in the modem times. It encompasses numerous regions. For convenience, we have demarcated these regions as biology, medicine, chemistry, geology, physics, astronomy, engineering, agriculture, and so on. Though, they are all inter-related. For instance, the study of biology goes down to the cell, and further to the atoms and molecules which create it. In this method it is related to the study of chemistry and physics. On the other hand, biology, especially botany, is related to forestry and agriculture implying a connection with climate and soil, and, in turn, to geography and geology. Thus, we discover that scientific knowledge and experience has a connectedness at the vital stage.

Further, quite often, knowledge and experience from dissimilar regions have to be pooled jointly for solving scientific troubles or creation technological advances. For instance, monitoring and manage of environmental pollution need the involvement of scientists from regions of physics, chemistry, biology, mathematics, sociology etc. Likewise, if we want to explore and utilize some sources of power which do not get exhausted, like bio-gas, wind or solar power, experts from several related regions would have to pool their knowledge and work jointly. Also, in the last few decades, the boundaries flanked by dissimilar regions of natural sciences have faded. Chemical reactions, biological procedures and physical phenomena are, nowadays studied by the similar ways and are based on general theoretical concepts.

The Way of Science

In this procedure, we have composed a lot of information and a separate body of scientific knowledge has grown. Let us now see how this knowledge has been acquired. Is there any special way of obtaining scientific knowledge? If so, how is it dissimilar from the method in which we ordinarily perceive the world approximately us? The answer to the first question is, yes. There is a ‘way’ of science. You are also well-known with the conditions observation, hypothesis, experiment, theories and laws. These are the several mental and physical operations that create up the way of science. Let us take a closer seem at each one of these operations.

Observations

All of us learn a lot in relation to the world from our observations. Our everyday experiences arising from what we see, hear, touch, taste and smell, form a part of general knowledge. For instance, we observe that the sun rises in the east and sets in the west; a ball when thrown up, comes down. A farmer usually separates the good seeds from the bad ones by putting all of them in water. This is based on the observation that the good seeds sink and the bad ones float. Likewise, you can know whether an egg is rotten or good by putting it in a bowl of water. A rotten egg will always float. To create such observations is, no doubt, very useful.

Artists are also very keen observers of the world approximately us. Their creative art is an expression of these observations, transformed in the light of their own experiences and feelings. These, though, cannot be described scientific observations.

In science, we go beyond just the general observation and experience and attempt to understand how a phenomenon occurs and why it occurs. Therefore, a scientist has to be clear in relation to the 'what' to observe and 'how' to observe it. Further, the observations made by the scientists have to be correct, and independent of their sentiments and wishes. In science, subjective response necessity is subordinated to information. It is in these compliments that a scientist differs from an artist or a lay person.

The confusion caused by inadequate or false observations can well be imagined. It is well to keep in mind what the great naturalist Charles Darwin said on this point that the mischief of false theories is slight compared with the mischief of false observations. Inadequate observations can be equally misleading. For instance, the believers in the earth-centered astronomy urged for years that the Copernican hypothesis could not be true. They argued that if this were so, Venus, which is a planet flanked by the sun and the earth, would illustrate phases like the moon. But since the phases of Venus could not be observed at that time, the Copernican astronomy was held to be false. This seemingly sound argument against the Copemican astronomy was shown to be baseless when people actually observed the phases of Venus through the telescope.

Scientific observations may be in relation to the natural events. For instance, the rainfall may be measured for each month for several years, to determine its pattern in a given lay. Observations could be in relation to the procedures created by man. For instance, in order to augment the efficiency of existing machines, or to develop new machines, observations would have to be made in relation to the design and working. Likewise, new materials like synthetic fibers, or rubber would have to be observed for their wear and tear, or any other desired property like fire resistance etc. Observations are also necessary in relation to the social phenomena. In order to analyze the socio-economic status of people in a given region or society, observations have to be made concerning the land holdings, incomes, educational stage, average of livelihood etc. All these observations are accepted out systematically, through cautiously intended experiments or surveys, in order to explain natural or social phenomena.

These systematic observations are then put in order, i.e. classified, cautiously recorded in the form of tables or graphs and analyzed. The aim is to discover regularities and patterns in the factual information obtained. A number of questions may be posed on the foundation of the observations, data, facts and figures. The importance of questioning cannot be undermined. Science progresses through asking questions and finding their answers.

Hypothesis

The after that step is to formulate hypothesis. A hypothesis is a statement, put forward on the foundation of reasoning, in relation to the things that are being studied. It is an effort to answer the questions that are posed. Other examples could be that plants need sunlight to grow, or a body falls to the ground because it is attracted by the earth: A hypothesis is formulated by taking into explanation all the observations that are recognized in relation to the phenomenon under investigation. It tries to explain the recognized or predict the strange but possible characteristics of the phenomenon. We may describe a hypothesis as an inspired guess, based on cause and experience. We may use both inductive and deductive logic to framea hypothesis.

What do we mean by inductive logic? If we have direct proof in relation to the only a part of the phenomenon, or some objects or situations and, if, on that foundation, we infer in relation to the properties, behaviour and other characteristics of the whole phenomenon, or the whole group of objects and situations, then we are using inductive logic. For instance, if we know that the population of a country has doubled in a given era of time, we may use induction to hypothesize that it will double again in the similar time. Again, if we study the shadows of easy objects like triangles, rectangles and circles cast on a wall due to light from a small bulb, we may conclude that light travels in a straight row. The conclusion is a big jump in thinking, and it is a sweeping, common statement based on induction. Inductive logic can mislead also: for instance to infer that all roses are red, if you happen to see only red roses in a garden is illogical. So you can see that inductive statements can have very dissimilar degrees of credibility and reliability. You cannot jump to conclusions on the foundation of insufficient proof , and the conclusions have to be further tested for their reliability.

Deductive logic may be measured as the opposite of induction. Here the reasoning is more direct. If we know a statement in relation to the whole class of objects, phenomena or situations then we can logically deduce the similar statement in relation to the one scrupulous substance, phenomenon or situation belonging to that class. Examples of deduction are: roses can be of any color, hence some roses can be red. All birds have wings; therefore, a sparrow, which is a bird, will have wings. Deductive logic is extensively used in chemistry, For instance, if a group of chemical salts exhibit some properties or behaviour, we can safely say that any salt belonging to this group will exhibit the similar property or behaviour. You could say that deduction may also mislead, because in the examples how do we know that a sparrow is a bird, or a salt belongs to that group of salts. These facts would have to be recognized before such deductions can be accepted.

Thus, logical analysis takes us from the recognized to the strange and it involves an element of doubt. Hence, the hypotheses arrived at from both types of reasoning have to be tested before they are accepted. A major operation in the way of science is that of setting up experiments specifically intended to test the hypotheses.

Experiments

Experiment is an essential characteristic of modem science. Experiments are artificially created or contrived situations intended to create sure observations under strictly controlled circumstances. The objective sometimes is to mimic nature. This allows the complexity of natural phenomena to be simplified for step-by-step study. For instance, several of us might have used a bicycle pump to inflate a bicycle tube. What we do is to pump air in it by pressing the piston. By pressing the piston the volume decreases, thereby rising the pressure and forcing the air into the tyre. Likewise, if we fill a balloon partially with air and leave it in sunlight, the air inside becomes warm and expands, thus inflating the balloon. These instances illustrate us that the volume of a gas depends both on its pressure and temperature.

If now we want to determine exactly how much the change in volume is with a sure rise or fall in pressure or temperature, we will have to conduct an experiment in two steps. In the first step we can stay the temperature constant and observe the changes in volume with pressure. In the second step, we will have to stay the gas at constant pressure and record the change in its volume with changing temperature. These experiments were accepted out by Robert Boyle and J.A.C. Charles. They derived precise mathematical relationships for the change of volume with pressure and temperature, respectively. These relationships are recognized after them, as Boyle's Law and Charles' Law.

The objective of an experiment may sometimes be to observe phenomena more minutely by the use of very sensitive instruments. For instance, in order to study minute details of cell structure, biologists now use the electron microscope. Sometimes experiments are accepted out with a sinister purpose. For instance, atom bombs were dropped on two municipalities of Japan in 1945 not only to cause destruction but also to study how the structures collapsed, the extent to which fires raged, and how radiations killed or injured people.

Cause and effect relationships are studied through a great diversity of experiments. Great ingenuity and care is required in designing experiments so that maximum information and clear cut results may be obtained from them. The results of such experiments prove or disprove a scrupulous hypothesis. Sometimes, a hypothesis may have to be rejected outright and a new hypothesis framed to explain the results obtained from the experiment. At other times, experiments give additional data for refinement or modification of a hypothesis.

Tools

Scientists use several types of instruments for observation and experimentation. Instruments like telescopes, microscopes or microphones can be used to extend or create more precise, the observations made through senses. Scientists also use instruments to manipulate things or phenomena in a controlled method. For instance, distillation stills are used for purifying liquids, incubators for keeping biological samples at a constant temperature, and computers for storing big amounts of information, for complicated calculations, for designing industrial products etc. In excess of the course of centuries, scientists have evolved a set of material apparatus of their own—the 'tools' of science. Some of these are basically adapted from ordinary life for special purposes, like the balance, forceps or crucibles. In turn, mainly of the tools used by scientists comes into everyday use. For instance, the major component of a television set is a scientific device described the cathode ray tube, which was originally fabricated to measure the mass of an electron. The commonly used pressure cooker is a form of the autoclave, an instrument used by the biologists for sterilization with high pressure steam.

Laws, Models and Theories

From the observations and the results of experiments comes a good deal of scientific knowledge. But scientific knowledge is not basically a list of such results. The results are tied up and related to each other in the form of logical, coherent theories or laws. In common, a connection flanked by things covering results of observations and experiments in excess of a wide range of individual cases is described a law. Hypotheses are accepted as 'laws' only if they are supported by a great deal of experimental proof and there are no recognized exceptions to them. Some examples of laws arc as follows:

- The planets move in elliptical orbits approximately the sun and the sun is at one of the two foci;
- A planet sweeps out equal regions in equal times;
- The square of the era of revolution of a planet round the sun, is proportional to the cube of its mean aloofness from the sun.

There are two more conditions which you will come crossways in scientific works, model and theory. Often scientists make a model to simulate the substance, phenomenon or situation they study. A model is an artificial construction to symbolize the properties, behaviour or any other characteristics of the real substance under study. For instance, the human heart is modeled as a mechanical pump, to study its structure and functions. In the earlier phases, the atom was modeled after a plum pudding. Later it was customized and modeled after the solar system. In a common sense, you may use a word, a picture, a formula or a symbol to model a situation. Don't confuse these models with toy A model should communicate some information in relation to it symbolizes. Models are models of spaceships, aeroplanes etc.; or useful because these symbolize in a simpler and well-known manner, a new, strange and with physical models of solar system, atom, DNA molecules etc., complicated substance, situation or phenomenon.

A theory is a set of a few common statements that can correctly describe or explain all experimental observations in relation to the properties and behaviour of a big number of varied objects, phenomena, situations or systems.

A law or theory can also predict observations. A classic instance is the prediction of the subsistence of Neptune. By 1845, the paths of all planets had been precisely calculated. All planets except Uranus were observed to follow the calculated paths. Adams in Cambridge and Leverrier in Paris reasoned that the observed deviation in the path of Uranus could be due to a strange outer planet beyond it. Using Newton's law of universal gravitation, they predicted its size and exact path. Then on September 23, 1846 Neptune was seen at approximately exactly the predicted location by Galle at the Berlin Observatory. In information, when a new theory is propounded, great care is taken to propose an experiment which would result in a scrupulous type of observations if the new theory were true. In this method theories get validated or rejected.

The Nature of Scientific Knowledge

Science is inseparable from the rest of human endeavour. In the past few thousand years of human history, an immense finance of scientific knowledge has been built up, the mainly dramatic scientific advances having been made in the last few hundred years. This vast storehouse of scientific knowledge encompasses everything, from particles smaller than atoms to the great system of the universe containing planets, stars and galaxies. It covers the study of plants and animals, health and disease, food and medicine and such intricate troubles as what life is, how the human mind functions, what the beginning and the end of the universe are etc.

As we have said before, we have been able to use this knowledge to meet our daily necessities of life, give leisure, communicate better and faster. We are able to harness power in a great diversity of shapes. From land-based creatures entirely dependent on nature for their survival, human beings have come to a stage where no barrier appears insurmountable. We have tried to traverse every nook and corner of this earth, the vast lands as well as the deep oceans and the high mountains. And now we are extending our sights upwards, not only to the solar system but to the legroom beyond. Our journey in legroom is a tremendous endeavour which has only just begun.

All such endeavors further enrich the body of scientific knowledge. Thus, scientific knowledge is never at a standstill. It is a dynamic, and an ongoing procedure. It is an ever-growing enterprise which will never end. This is because, in science, there is no single ultimate truth to be achieved after which all the scientists can retire.

An extra ordinary characteristic of scientific knowledge is that it is never complete. The more we add to this knowledge, the more questions arise in relation to the strange mysteries of nature. New information is, thus, continuously gathered. New theories arise if new facts can't be explained by the existing ones. Practitioners of science can never lay claim to a complete or ultimate knowledge.

We have seen that science is not static. Going a step further, we may say that scientific knowledge is also not immutable. Nothing can remain unchallenged in science. In information, some of the mainly honored scientists are those who attempt to alter, vary or replace existing theories by providing revolutionary proof or argument. In this sense, science is a self-correcting enterprise, i.e. it is open to change. Several hypotheses proposed by scientists turn out to be wrong. Science is generated by and devoted to the thought of free inquiry, the thought that any hypothesis, no matter how strange, deserves to be measured on its merits. Thus, science is not dogmatic. It does not unreasonably insist on standing by preconceived notions, concepts or thoughts that have been proved wrong through careful experimentation. Science progresses by disproving. It has no high priests who cannot be questioned. What would be measured highly undesirable in science is the unquestioned acceptance of things as they are.

Any new detection, finding or interpretation of phenomena is cautiously scrutinized, discussed and verified by the scientific society before its common acceptance. In this sense, the scientific 'truths' are truths by consensus, and, therefore, always tentative. The consensus is arrived at after cautiously following the way of science. But, if new facts emerging from the natural world challenge this 'truth', scientists are always ready to re-look at their theories.

Last but not the least, scientific knowledge is objective. That is, scientific results are repeatable and verifiable by anyone anywhere if proper facilities are accessible. This characteristic of science is related to the ultimate test of any scientific statement; that it should be in accord with the observations of the natural world. Science prefers hard facts to the dearest illusions of scientists. To be accepted, all new thoughts necessity survives rigorous standards of proof .

Sometimes it takes years, or even hundreds of years, before the thoughts are verified. Nonetheless, in the extensive run, no brilliant arguments, high power or aesthetic appeal can save a scientific theory which disagrees with experiment or observation of nature. Since hard facts are independent of the prejudices and preferences of individual scientists, and experiments or observations are essentially repeatable, objectivity becomes an essential characteristic of scientific knowledge. In no sense is science based on experiences open only to a select few.

Scientific Approach to Problem Solving

These characterize a scientific approach to solving troubles whether they are scientific, economic, social or even personal. These attributes of science reflect an attitude of mind which is basically rational and can be adopted by anyone who has understood them. Thus, scientific approach can, and indeed should, form the foundation of not only solving dissimilar types of troubles in laboratory situations but also in everyday life.

Even if it appears repetitive, let us once again outline the scientific approach to problem solving. If we are faced with a problem, what should be our mental attitude towards it? First of all, we should approach it with an open mind, without any preconceived notions, whims or prejudices. Then, no external pressures of power should be allowed to affect our observations or analysis.

What ways should we adopt for solving the problem? While analyzing it, we should attempt to seem at it from all possible angles, consider all the factors involved, inquire all possible questions and gather all data and facts in relation to it. Doubt and skepticism are the hallmarks of scientific approach. We should not accept blindly, on faith, any statement without examining it critically. We should base our analysis on rational and objective thinking and then come to conclusions. In no case should we rush into hasty decisions. We should also avoid creation generalizations on the foundation of insufficient proof .

Further, we should not consider our conclusions as the last word on the said problem. If any new facts or evidences come to light which alter our results, we should always be prepared to revise our conclusions. We should be flexible in our attitude and avoid being dogmatic in our views concerning any matter. Hard work, discipline and vital integrity arc sure other attributes which we will have to adopt if we are to create the scientific approach a procedure of thinking and a way of acting, in other words, a method of life.

There are several social troubles associated with developmental projects wherein it becomes imperative to adopt a scientific approach. Let us take the problem of choosing a site for an industry to manufacture chemicals. Separately from the technological characteristics, social factors would also have to be taken into explanation while taking this decision. For instance, how densely populated that region is, how the displaced people will be resettled, what the industry's effect on the nearby environment will be. how and where would its waste products be disposed of, the wind direction in case there are any toxic leaks, where would the workers be housed, what industrial safety events would be needed and so on. Unless we take all such factors into explanation, weigh the pros and cons scientifically and then take decisions, we will never be able to avert disasters like the Bhopal gas tragedy of December, 1984. There can be several other similar examples, like setting up nuclear power plants, vast hydel projects, and other industrial projects which involve a careful scheduling based on a scientific approach.

This approach is applicable in social sciences too. For instance, a few years ago a study was accepted out to test the common belief that 'student unrest is caused by first generation learners whose parents are not educated'. Extensive data in relation to the students was composed and the analysis showed that this belief was wrong. Even in our everyday life, we use this approach to optimize our efforts. For instance, if you have to meet three persons in dissimilar parts of the city, you can plan your visit to optimally use your time and money. Housewives often optimize their monthly purchases by checking the prices and excellence of goods at several stores; if a cheap store is distant absent, they have to decide to buy a superior quantity so as to justify more traveling expenses.

Troubles often crop up in our society when people livelihood in dissimilar regions, speaking dissimilar languages, following dissimilar religions or social practices develops prejudiced opinions in relation to the each other. You may have come crossways all types of prejudiced generalizations made on the foundation of very little proof , such as, ‘North Indians are brash’, ‘South Indians are weak minded’, ‘Gorkhas are brave’, ‘Punjabis eat very rich food’, ‘Scheduled Castes are dull headed’, ‘Poor people are dishonest’ etc. All these notions would not have arisen if we were scientific in our approach, because proof and analysis designates that these are not usually true.

Often in a region, people fight with each other on issues that are thoroughly irrational and illogical. Much of the rioting and bloodshed in communal violence can be avoided if the people involved don’t blindly consider in rumors or get swayed by those who preach hatred. If one used scientific reasoning and logic, examined facts and the vital issues underlying these incidents, such as uneven economic development, role of vested interests in fanning riots etc., one would never become a party to such crimes. Instead, one could always help in averting these situations.

In our own lives, too, we should adopt a scientific approach to solving troubles. For instance, if things go wrong in dealings flanked by people, they could always sit jointly and analyze their troubles in a rational and objective manner instead of being accepted absent by emotions and adopting the dogmatic attitude of ‘I am right, you are wrong’. Likewise, if at any time of our lives, we do not do well and are faced with troubles, we should not lose heart and become fatalistic. Instead, we could illustrate a positive approach of creation and effort to understand what’s ’ wrong, inquire searching questions, seek their answers and attempt to proceed in a rational method. There are several troubles approximately us relating to health and nutrition, environment etc. where it would serve us well if we made the scientific approach an integral part of our thinking and livelihood.

To sum up this discussion, using the scientific way to solve our day-to-day troubles would mean to shun the attitudes of dogmatic beliefs and arrogance on the one hand, and helplessness, despair and diffidence on the other. It would do us good to adopt the positive attitudes of curiosity, a questioning bent of mind, confidence in our skill, open-mindedness, rational thinking, objectivity, humility. If we are successful even partially in this endeavour, we would have understood the essence of scientific way.

A Reflection in Relation to the Science

We have said several things in relation to the science, and there are several other things you may know in relation to it on your own. Now is the time to reflect in relation to the nature of scientific knowledge, of scientific work by individuals, and of the limitations of science.

We have seen that there is a tremendous store of knowledge which has been created in the short spell of perhaps a few thousand years. This knowledge has helped us to do wonderful things like flying in the air, landing on the moon, transmitting pictures in excess of extensive distances, rising the average span of human life to in excess of 70 years in some countries. It has also enabled man to engage in mass destruction. There are millions of people today who are occupied in several characteristics of using this store of scientific knowledge-educators, engineers, doctors, instrument designers and so on.

There is, though, the other face of scientific work which is creative. New knowledge is being exposed all the time. Millions of people are working to enlarge the store of knowledge, be it in relation to the cosmos, or the elementary particles, or the nature of genes and chromosomes in livelihood beings. There are those working with vast tools scanning the skies or smashing tiny particles against each other, and those working with pencil and paper to propound theories by condensing a great diversity of observations into simpler statements of laws of nature. If the first type is mostly using logic and cause, the creative workers are additionally using the power of imagination and intuition. It is also true that a big number of scientists are occupied simultaneously in both types of action, because no hard and fast row can be drawn flanked by them.

We have seen that the thrash about of the scientists to penetrate the sphere of the strange can rightly be described a quest for truth. It is to be realized that the result is beautiful—beautiful in its expression, and fascinating in the further possibilities that it opens up. Truth and beauty are one and the similar thing, according to some philosophers. In science it is true that a good deal of theoretical and experimental work which led to important findings was triggered off by the thoughts of symmetry or elegance in an equation. It provides as much thrill to a creative scientific worker to see his experiment yield new results, or to be able to express diverse scientific facts in an easy equation, as the painting of a picture to an artist or the conceiving of a new raga to a musician. The subjective experience of "doing" science, and the motivation of the scientists are as significant in their creative work as the experience of a poet.

We have also tried to illustrate that while there is tremendous diversity in scientific work, and scientists of dissimilar specializations use a great diversity of ways, there is also a set of general characteristics in the ways that are followed. One can speak of a way of science in this sense, and if one considers the attitude of mind which leads to successful endeavors in science, one could call it as the temper of science. In India one of our great promoters of science, Jawaharlal Nehru preferred the word 'scientific temper' because it can be applied to several regions of social and personal life. If the great scientific enterprise has succeeded because sure broad ways of enquiry have been used, or troubles have been tackled by sure attitudes of mind, it is worthwhile to look at these so as to benefit from them in all other spheres of life.

We have tried to illustrate that "objectivity" is one such feature of the scientific temper which implies approaching a problem with an open mind, without trying to fit our personal whims, fancies or prejudices into the result.

It also implies, on the other hand, that social pressures or the subsistence of some great power already having an opinion on the question, should not affect our scientific approach to a problem. For instance, let's suppose that 5000 acres of land is to be cleared for creation a station for testing missiles. Scientists may be asked to figure out the consequences of changing the pattern of land use on the environment, and also on human beings who may presently be livelihood in that region. The scientists should neither be accepted absent by emotion, nor unconsciously justify the clearing of land, or yield to any pressure by politicians or local inhabitants. Great integrity is part of objectivity in creation a scientific study. Of course, it does not mean that human troubles or even suffering likely to be created by the change of land use would not be cautiously assessed in the study and given due weight in arriving at the conclusions.

In the course of scientific work, one has to be flexible and ready to change from one type of approach to another if the first approach does not succeed. Change is the very essence of all subsistence and a scientific attitude is that which is not daunted by it. In information, science as a whole is a harbinger of change, and it flourishes in a society which is non-dogmatic and is in search of change.

In the scientific temper, cause and logic have a major part to play because they are the vital apparatus of all analysis. But imagination and even speculation are simultaneously used to tackle every problem.

A few limiting characteristics are also very significant to note. Scientific knowledge is not complete, nor is it ever likely to be final. This is because our experience so distant has been that as ignorance is removed and knowledge is recognized in any sphere, fresh questions are posed before our intellect, or a new region of ignorance is uncovered. For instance, when it was recognized that matter consists of particles and voids, we talked of "atoms" or elements; when atoms were deeply investigated they were establish to be made up of electrons, protons and neutrons; and when these have been further scrutinized, more fundamental particles have been exposed.

The search goes on. Scientific knowledge increases by leaps and bounds, but each advance opens up fresh avenues of enquiry. That is why scientists cannot be fundamentalists, they will always be enquiring into new regions. Nevertheless, in a scientific sphere, the best that we know is represented by the current knowledge of science. One cannot say that if present scientific knowledge has no answer to a problem, one should consider whatever a non-scientist says in relation to it. If the cure for cancer has not been exposed, a quack or a Goodman cannot cure it either. A profound trust in science, in spite of its limitation, is the sign of being civilized.

One should also know that there are spheres of knowledge other than science—there is knowledge of the individual in conditions of his feelings, behaviour, dreams and aspirations. This actually borders on scientific knowledge of the body and the brain; there is knowledge of human behaviour in groups and habitations; there is knowledge of history, of economic and political systems, international affairs, and so on. Knowledge of one sphere impinges on that of the other—economics and international affairs involve science and technology in a big method. It is because of this reality that a scientist being also a citizen, possessing access to a very powerful field of knowledge, necessity acquire other types of knowledge, for instance of sociology, economics and politics.

It is again because of several dissimilar facets of knowledge that there is a need to integrate it and develop what may be described a “philosophy” or an “ideology” or a “world-view”. Effective use of science can be made to overcome shocking deprivations which hundreds of millions of people livelihood in the old colonies of the “urbanized” countries suffer, such as malnutrition, ill health, lack of drinking water and sanitary arrangements, lack of shelter from sun and rain.

But, for this scientists have to possess social consciousness, and a spirit to change society for the better. Some people say science has to be combined with “spirituality”. Now, if spirituality means skill to distinguish flanked by good and evil, falsehood and truth, social justice and mere pursuit of profit, corruption and integrity—no one could contest the statement. But if “spirituality” comprises blind belief in sure dogmas, accepting superstition and obscurantism, or belief in supernatural powers then, obviously, the statement is not true. Scientific knowledge has come to be recognized, and scientific attitudes have come to be refined precisely by a thrash about against unfounded, preconceived notions and beliefs, and the ideology of ignorance.

REVIEW QUESTIONS

- Describe and assess the level of development of science in medieval India.
- Describe the developments in science and techniques in the European society during feudal times and explain how these led to the transformation of the feudal society.
- Describe the social changes brought about by the Renaissance and the consequent developments in science and technology.
- Discuss various issues related to the use of science and technology in our social context.
- Explain the impact of the freedom movement on the developments in science in pre-Independence India.
- Explain what constitutes the body of scientific knowledge.
- Describe the characteristic features of scientific knowledge.

CHAPTER 3

Know About Universe

STRUCTURE

- Learning objectives
- Universe as a system
- Exploring the universe
- The solar system
- Review questions

LEARNING OBJECTIVES

After studying this chapter you should be able to:

- Describe how human understanding of the universe has changed through the ages, from prehistoric to modern times.
- Describe the various physical objects that constitute the universe.
- Enumerate the various astronomical methods of exploring the universe, and explain how these methods are put to use to gather information.
- Understand the Solar System.
- Describe the origin and early history of our planet Earth.

UNIVERSE AS A SYSTEM

The Universe is commonly defined as the totality of subsistence, including planets, stars, galaxies, the contents of intergalactic legroom, and all matter and power. The broadest definition of universe is that it is basically everything, while a narrower definition is that the universe is limited to what can be observed. Similar conditions contain the *cosmos*, the *world* and *nature*.

Scientific observation of the Universe, the observable part of which is in relation to the 93 billion light years in diameter, has led to inferences of its earlier stages. These observations suggest that the Universe has been governed by the similar physical laws and constants throughout mainly of its extent and history. The Big Bang theory is the prevailing cosmological model that describes the early development of the Universe, which in physical cosmology is calculated to have occurred 13.798 ± 0.037 billion years ago.

There are several multi-verse hypotheses, in which physicists have suggested that the Universe might be one in the middle of several universes that likewise exist. The farthest aloofness that it is theoretically possible for humans to see is described as the observable Universe. Observations have shown that the Universe appears to be expanding at an accelerating rate, and a number of models have arisen to predict its ultimate fate.

History

Observational History

Throughout recorded history, many cosmologies and cosmogonies have been proposed to explanation for observations of the Universe. The earliest quantitative geocentric models were urbanized by the ancient Greek philosophers. In excess of the centuries, more precise observations and improved theories of gravity led to Copernicus's heliocentric model and the Newtonian model of the Solar System, respectively. Further improvements in astronomy led to the realization that the Solar System is embedded in a galaxy composed of billions of stars, the Milky Method, and that other galaxies exist outside it, as distant as astronomical instruments can reach. Careful studies of the sharing of these galaxies and their spectral rows have led too much of contemporary cosmology. Detection of the red shift and cosmic microwave background radiation suggested that the Universe is expanding and had a beginning.

History of the Universe

According to the prevailing scientific model of the Universe, recognized as the Big Bang, the Universe expanded from an very hot, thick stage described the Planck epoch, in which all the matter and power of the observable Universe was concentrated. Since the Planck epoch, the Universe has been expanding to its present form, perhaps with a brief era (less than 10^{-32} seconds) of cosmic inflation. Many independent experimental measurements support this theoretical expansion and, more usually, the Big Bang theory. Recent observations indicate that this expansion is accelerating because of dark power, and that mainly of the matter in the Universe may be in a form which cannot be detected by present instruments, described dark matter. The general use of the "dark matter" and "dark power" placeholder names for the strange entities purported to explanation for in relation to the 95% of the mass-power density of the Universe demonstrates the present observational and conceptual shortcomings and uncertainties concerning the nature and ultimate fate of the Universe.

On 21 March 2013, the European-led research team behind the Planck cosmology probe released the mission's all-sky map of the cosmic microwave background. The map suggests the universe is slightly older than thought. According to the map, subtle fluctuations in temperature were imprinted on the deep sky when the cosmos was in relation to the 370,000 years old. The imprint reflects ripples that arose as early, in the subsistence of the universe, as the first nonillionth of a second. Apparently, these ripples gave rise to the present vast cosmic web of galaxy groups and dark matter. According to the team, the universe is 13.798 ± 0.037 billion years old, and contains 4.9% ordinary matter, 26.8% dark matter and 68.3% dark power. Also, the Hubble constant was measured to be 67.80 ± 0.77 (km/s)/Mpc.

An earlier interpretation of astronomical observations indicated that the age of the Universe was 13.772 ± 0.059 billion years and that the diameter of the observable Universe is at least 93 billion light years or 8.80×10^{26} meters. According to common relativity, legroom can expand faster than the speed of light, although we can view only a small portion of the Universe due to the limitation imposed by light speed. Since we cannot observe legroom beyond the limitations of light (or any electromagnetic radiation), it is uncertain whether the size of the Universe is finite or infinite.

Etymology, Synonyms and Definitions

The word *Universe* derives from the Old French word *Univers*, which in turn derives from the Latin word *universum*. The Latin word was used by Cicero and later Latin authors in several of the similar senses as the contemporary English word is used. The Latin word derives from the poetic contraction *Unvorsum* — first used by Lucretius in Book IV (row 262) of his *De rerum natura* (*On the Nature of Things*) — which connects *un, uni* (the combining form of *unus*, or "one") with *vorsum, versum* (a noun made from the perfect passive participle of *vertere*, meaning "something rotated, rolled, changed").

An alternative interpretation of *unvorsum* is "everything rotated as one" or "everything rotated by one". In this sense, it may be measured a translation of an earlier Greek word for the Universe, ("circumambulation"), originally used to describe a course of a meal, the food being accepted approximately the circle of dinner guests. This Greek word refers to celestial spheres, an early Greek model of the Universe. Concerning Plato's Metaphor of the sun, Aristotle suggests that the rotation of the sphere of fixed stars inspired by the prime mover, motivates, in turn, terrestrial change via the Sun. Careful astronomical and physical measurements (such as the Foucault pendulum) are required to prove the Earth rotates on its axis.

Broadest Definition: Reality and Probability

The broadest definition of the Universe is establish in *De divisione naturae* by the medieval philosopher and theologian Johannes Scotus Eriugena, who defined it as basically everything: everything that is created and everything that is not created.

Definition as Reality

More customarily, the Universe is defined as everything that exists, (has lived, and will exist). According to our current understanding, the Universe consists of three principles: space-time, shapes of power, including momentum and matter, and the physical laws that relate them.

Definition as Linked Legroom-time

It is possible to conceive of disconnected legroom-times, each existing but unable to interact with one another. An easily visualized metaphor is a group of separate soap bubbles, in which observer's livelihood on one soap bubble cannot interact with those on other soap bubbles, even in principle. According to one general terminology, each "soap bubble" of legroom-time is denoted as a universe, whereas our scrupulous legroom-time is denoted as *the Universe*, just as we call our moon *the Moon*. The whole collection of these separate legroom-times is denoted as the multi-verse. In principle, the other unconnected universes may have dissimilar dimensionalities and topologies of legroom-time, dissimilar shape of matter and power, and dissimilar physical laws and physical constants, although such possibilities are purely speculative.

Definition as Observable Reality

According to a still-more-restrictive definition, the Universe is everything within our linked legroom-time that could have a chance to interact with us and vice versa. According to the common theory of relativity, some regions of legroom may never interact with ours even in the lifetime of the Universe, due to the finite speed of light and the ongoing expansion of legroom. For instance, radio messages sent from Earth may never reach some regions of legroom, even if the Universe would live forever; legroom may expand faster than light can traverse it.

Distant regions of legroom are taken to exist and be part of reality as much as we are; yet we can never interact with them. The spatial region within which we can affect and be affected is the observable Universe. Strictly speaking, the observable Universe depends on the site of the observer. By traveling, an observer can come into get in touch with a greater region of legroom-time than an observer who remnants still, so that the observable Universe for the former is superior to for the latter. Nevertheless, even the mainly rapid traveler will not be able to interact with all of legroom. Typically, the observable Universe is taken to mean the Universe observable from our vantage point in the Milky Method Galaxy.

Size, Age, Contents, Structure, and Laws

The size of the Universe is strange; it may be infinite. The region visible from Earth (the observable universe) is a sphere with a radius of in relation to the 46 billion light years, based on where the expansion of legroom has taken the mainly distant objects observed. For comparison, the diameter of a typical galaxy is 30,000 light-years, and the typical aloofness flanked by two neighboring galaxies is 3 million light-years. As an instance, the Milky Method Galaxy is roughly 100,000 light years in diameter, and the adjacent sister galaxy to the Milky Method, the Andromeda Galaxy, is situated roughly 2.5 million light years absent. There are almost certainly more than 100 billion (10^{11}) galaxies in the observable Universe. Typical galaxies range from dwarfs with as few as ten million (10^7) stars up to giants with one trillion (10^{12}) stars, all orbiting the galaxy's center of mass. A 2010 study by astronomers estimated that the observable Universe contains 300 sextillion (3×10^{23}) stars.

The observable matter is spread homogeneously (*consistently*) throughout the Universe, when averaged in excess of distances longer than 300 million light-years. Though, on smaller length-levels, matter is observed to form "clumps", i.e., to cluster hierarchically; several atoms are condensed into stars, mainly stars into galaxies, mainly galaxies into groups, super clusters and, finally, the main-level structures such as the Great Wall of galaxies. The observable matter of the Universe is also spread *isotropically*, meaning that no direction of observation appears dissimilar from any other; each region of the sky has roughly the similar content. The Universe is also bathed in a highly isotropic microwave radiation that corresponds to a thermal equilibrium blackbody spectrum of roughly 2.725 kelvin. The hypothesis that the big-level Universe is homogeneous and isotropic is recognized as the cosmological principle, which is supported by astronomical observations.

The present overall density of the Universe is very low, roughly 9.9×10^{-30} grams per cubic centimeter. This mass-power appears to consist of 73% dark power, 23% cold dark matter and 4% ordinary matter. Thus the density of atoms is on the order of a single hydrogen atom for every four cubic meters of volume. The properties of dark power and dark matter are mainly strange. Dark matter gravitates as ordinary matter, and thus works to slow the expansion of the Universe; by contrast, dark power accelerates its expansion.

The current estimate of the Universe's age is 13.798 ± 0.037 billion years old. The Universe has not been the similar at all times in its history; for instance, the relative populations of quasars and galaxies have changed and legroom itself appears to have expanded. This expansion accounts for how Earth-bound scientists can observe the light from a galaxy 30 billion light years absent, even if that light has traveled for only 13 billion years; the very legroom flanked by them has expanded. This expansion is constant with the observation that the light from distant galaxies has been red shifted; the photons emitted have been stretched to longer wavelengths and lower frequency throughout their journey. The rate of this spatial expansion is accelerating, based on studies of Kind Ia supernovae and corroborated by other data.

The relative fractions of dissimilar chemical elements — particularly the lightest atoms such as hydrogen, deuterium and helium — appear to be identical throughout the Universe and throughout its observable history. The Universe appears to have much more matter than antimatter, an asymmetry perhaps related to the observations of CP violation. The Universe appears to have no net electric charge, and therefore gravity appears to be the dominant interaction on cosmological length levels. The Universe also appears to have neither net momentum nor angular momentum. The absence of net charge and momentum would follow from accepted physical laws (Gauss's law and the non-divergence of the stress-power-momentum pseudo tensor, respectively), if the Universe were finite.

The Universe appears to have a smooth legroom-time continuum consisting of three spatial dimensions and one temporal (time) dimension. On the average, legroom is observed to be very almost flat (secure to zero curvature), meaning that Euclidean geometry is experimentally true with high accuracy throughout mainly of the Universe. Space-time also appears to have a basically linked topology, at least on the length-level of the observable Universe. Though, present observations cannot exclude the possibilities that the Universe has more dimensions and that its space-time may have a multiply linked global topology, in analogy with the cylindrical or toroidal topologies of two-dimensional spaces.

The Universe appears to behave in a manner that regularly follows a set of physical laws and physical constants. According to the prevailing Average Model of physics, all matter is composed of three generations of leptons and quarks, both of which are fermions. These elementary particles interact via at mainly three fundamental interactions: the electroweak interaction which comprises electromagnetism and the weak nuclear force; the strong nuclear force described by quantum chromo dynamics; and gravity, which is best described at present by common relativity. The first two interactions can be described by renormalized quantum field theory, and are mediated by gauge bosons that correspond to a scrupulous kind of gauge symmetry. A renormalized quantum field theory of common relativity has not yet been achieved, although several shapes of string theory appear promising. The theory of special relativity is whispered to hold throughout the Universe, provided that the spatial and temporal length levels are sufficiently short;

otherwise, the more common theory of common relativity necessity be applied. There is no explanation for the scrupulous values that physical constants appear to have throughout our Universe, such as Planck's constant h or the gravitational constant G. Many conservation laws have been recognized, such as the conservation of charge, momentum, angular momentum and power; in several cases, these conservation laws can be related to symmetries or mathematical identities.

Fine Tuning

It appears that several of the properties of the Universe have special values in the sense that a Universe where these properties differ slightly would not be able to support intelligent life. Not all scientists agree that this fine-tuning exists. In scrupulous, it is not recognized under what circumstances intelligent life could form and what form or form that would take. A relevant observation in this discussion is that for an observer to exist to observe fine-tuning, the Universe necessity be able to support intelligent life. As such the conditional probability of observing a Universe that is fine-tuned to support intelligent life is 1. This observation is recognized as the anthropic principle and is particularly relevant if the creation of the Universe was probabilistic or if multiple universes with a diversity of properties exist.

Historical Models

Several models of the cosmos (cosmologies) and its origin (cosmogonies) have been proposed, based on the then-accessible data and conceptions of the Universe. Historically, cosmologies and cosmogonies were based on narratives of gods acting in several methods. Theories of an impersonal Universe governed by physical laws were first proposed by the Greeks and Indians. In excess of the centuries, improvements in astronomical observations and theories of motion and gravitation led to ever more accurate descriptions of the Universe. The contemporary era of cosmology began with

Albert Einstein's 1915 common theory of relativity, which made it possible to quantitatively predict the origin, development, and conclusion of the Universe as a whole. Mainly contemporary, accepted theories of cosmology are based on common relativity and, more specifically, the predicted Big Bang; though, still more careful measurements are required to determine which theory is correct.

Creation

Several cultures have stories describing the origin of the world, which may be roughly grouped into general kinds. In one kind of story, the world is born from a world egg; such stories contain the Finnish epic poem *Kalevala*, the Chinese story of Pangu or the Indian Brahmanda Purana. In related stories, the creation thought is caused by a single entity emanating or producing something by him- or herself, as in the Tibetan Buddhism concept of Adi-Buddha, the ancient Greek story of Gaia (Mother Earth), the Aztec goddess Coatlicue myth, the ancient Egyptian god Atum story, or the Genesis creation narrative. In another kind of story, the world is created from the union of male and female deities, as in the Maori story of Rangi and Papa. In other stories, the Universe is created by crafting it from pre-existing materials, such as the corpse of a dead god — as from Tiamat in the Babylonian epic Enuma Elish or from the giant Ymir in Norse mythology – or from chaotic materials, as in Izanagi and Izanami in Japanese mythology. In other stories, the Universe emanates from fundamental principles, such as Brahman and Prakrti, the creation myth of the Serers, or the yin and yang of the Tao.

Philosophical Models

From the 6th century BCE, the pre-Socratic Greek philosophers urbanized the earliest recognized philosophical models of the Universe. The earliest Greek philosophers noted that appearances can be deceiving, and sought to understand the underlying reality behind the appearances. In scrupulous, they noted the skill of matter to change shapes (e.g., ice to water to steam) and many philosophers proposed that all the apparently dissimilar materials of the world are dissimilar shapes of a single primordial material, or arche. The first to do so was Thales, who proposed this material is Water. Thales' student, Anaximander, proposed that everything came from the limitless apeiron. Anaximenes proposed Air on explanation of its perceived attractive and repulsive qualities that cause the arche to condense or dissociate into dissimilar shapes. Anaxagoras, proposed the principle of Nous (Mind). Heraclitus proposed fire (and spoke of logos). Empedocles proposed the elements: earth, water, air and fire. His four element theory became very popular. Like Pythagoras, Plato whispered that all things were composed of number, with the Empedocles' elements taking the form of the Platonic solids. Democritus, and later philosophers—mainly notably Leucippus—proposed that the Universe was composed of indivisible atoms moving through void (vacuum). Aristotle did not consider that was feasible because air, like water, offers resistance to motion. Air will immediately rush in to fill a void, and moreover, without resistance, it would do so indefinitely fast.

Although Heraclitus argued for eternal change, his quasi-modern Parmenides made the radical suggestion that all change is an illusion, that the true underlying reality is eternally unchanging and of a single nature. Parmenides denoted this reality as "The One". Parmenides' theory seemed implausible to several Greeks, but his student Zeno of Elea challenged them with many well-known paradoxes. Aristotle responded to these paradoxes by developing the notion of a potential countable infinity, as well as the infinitely divisible continuum. Unlike the eternal and unchanging cycles of time, he whispered the world was bounded by the celestial spheres, and thus magnitude was only finitely multiplicative.

The Indian philosopher Kanada, founder of the Vaisheshika school, urbanized a theory of atomism and proposed that light and heat were diversities of the similar substance. In the 5th century AD, the Buddhist atomist philosopher Dignāga proposed atoms to be point-sized, duration less, and made of power. They denied the subsistence of substantial matter and proposed that movement consisted of momentary flashes of a stream of power.

The theory of temporal finitism was inspired by the doctrine of Creation shared by the three Abrahamic religions: Judaism, Christianity and Islam. The Christian philosopher, John Philoponus, presented the philosophical arguments against the ancient Greek notion of an infinite past and future. Philoponus' arguments against an infinite past were used by the early Muslim philosopher, Al-Kindi (Alkindus); the Jewish philosopher, Saadia Gaon (Saadia ben Joseph); and the Muslim theologian, Al-Ghazali (Algazel). Borrowing from Aristotle's *Physics* and *Metaphysics*, they employed two logical arguments against an infinite past, the first being the "argument from the impossibility of the subsistence of an actual infinite", which states:

- "An actual infinite cannot exist."
- "An infinite temporal regress of events is an actual infinite."
- "∴ An infinite temporal regress of events cannot exist."

The second argument, the "argument from the impossibility of completing an actual infinite by successive addition", states:

- "An actual infinite cannot be completed by successive addition."
- "The temporal series of past events has been completed by successive addition."
- "The temporal series of past events cannot be an actual infinite."

Both arguments were adopted by Christian philosophers and theologians, and the second argument in scrupulous became more well-known after it was adopted by Immanuel Kant in his thesis of the first antinomy concerning time.

Astronomical Models

Astronomical models of the Universe were proposed soon after astronomy began with the Babylonian astronomers, who viewed the Universe as a flat disk floating in the ocean, and this shapes the premise for early Greek maps like those of Anaximander and Hecataeus of Miletus.

Later Greek philosophers, observing the motions of the heavenly bodies, were concerned with developing models of the Universe based more profoundly on empirical proof . The first coherent model was proposed by Eudoxus of Cnidos. According to Aristotle's physical interpretation of the model, celestial spheres eternally rotate with uniform motion approximately a stationary Earth. Normal matter, is entirely contained within the terrestrial sphere. This model was also refined by Callippus and after concentric spheres were abandoned, it was brought into almost perfect agreement with astronomical observations by Ptolemy. The success of such a model is mainly due to the mathematical information that any function (such as the location of a planet) can be decomposed into a set of circular functions (the Fourier manners). Other Greek scientists, such as the Pythagorean philosopher Philolaus postulated that at the center of the Universe was a "central fire" approximately which the Earth, Sun, Moon and Planets revolved in uniform circular motion. The Greek astronomer Aristarchus of Samos was the first recognized individual to propose a heliocentric model of the Universe. Though the original text has been lost, a reference in Archimedes' book The Sand Reckoner describes Aristarchus' heliocentric theory. Archimedes wrote: (translated into English)

- You King Gelon are aware the 'Universe' is the name given by mainly astronomers to the sphere the center of which is the center of the Earth, while its radius is equal to the straight row flanked by the center of the Sun and the center of the Earth. This is the general explanation as you have heard from astronomers. But Aristarchus has brought out a book consisting of sure hypotheses, wherein it appears, as a consequence of the assumptions made, that the Universe is several times greater than the 'Universe' just mentioned. His hypotheses are that the fixed stars and the Sun remain unmoved, that the Earth revolves in relation to the Sun on the circumference of a circle, the Sun lying in the middle of the orbit, and that the sphere of fixed stars, situated in relation to the similar center as the Sun, is so great that the circle in which he supposes the Earth to revolve bears such a proportion to the aloofness of the fixed stars as the center of the sphere bears to its surface.

Aristarchus thus whispered the stars to be very distant absent, and saw this as the cause why there was no visible parallax, that is, an observed movement of the stars relative to each other as the Earth moved approximately the Sun. The stars are in information much farther absent than the aloofness that was usually assumed in ancient times, which is why stellar parallax is only detectable with telescopes. The geocentric model, constant with planetary parallax, was assumed to be an explanation for the unobservability of the parallel phenomenon, stellar parallax. The rejection of the heliocentric view was apparently quite strong, as the following passage from Plutarch suggests (On the Apparent Face in the Orb of the Moon):

- Cleanthes [a modern of Aristarchus and head of the Stoics] thought it was the duty of the Greeks to indict Aristarchus of Samos on the charge of impiety for putting in motion the Hearth of the Universe [i.e. the earth], . . . supposing the heaven to remain at rest and the earth to revolve in an oblique circle, while it rotates, at the similar time, in relation to the its own axis.

The only other astronomer from antiquity recognized by name who supported Aristarchus' heliocentric model was Seleucus of Seleucia, a Hellenistic astronomer who existed a century after Aristarchus. According to Plutarch, Seleucus was the first to prove the heliocentric system through reasoning, but it is not recognized what arguments he used. Seleucus' arguments for a heliocentric theory were almost certainly related to the phenomenon of tides. According to Strabo (1.1.9), Seleucus was the first to state that the tides are due to the attraction of the Moon, and that the height of the tides depends on the Moon's location relative to the Sun. Alternatively, he may have proved the heliocentric theory by determining the constants of a geometric model for the heliocentric theory and by developing ways to compute planetary positions using this model, like what Nicolaus Copernicus later did in the 16th century. Throughout the Middle Ages, heliocentric models may have also been proposed by the Indian astronomer, Aryabhata, and by the Persian astronomers, Albumasar and Al-Sijzi.

As noted by Copernicus himself, the suggestion that the Earth rotates was very old, dating at least to Philolaus (c. 450 BC), Heraclides Ponticus (c. 350 BC) and Ecphantus the Pythagorean. Roughly a century before Copernicus, Christian scholar Nicholas of Cusa also proposed that the Earth rotates on its axis in his book, *On Learned Ignorance* (1440). Aryabhata (476–550), Brahmagupta (598–668), Albumasar and Al-Sijzi, also proposed that the Earth rotates on its axis. The first empirical proof for the Earth's rotation on its axis, using the phenomenon of comets, was given by Tusi (1201–1274) and Ali Qushji (1403–1474).

This cosmology was accepted by Isaac Newton, Christiaan Huygens and later scientists. Edmund Halley (1720) and Jean-Philippe de Cheseaux (1744) noted independently that the assumption of an infinite legroom filled consistently with stars would lead to the prediction that the nighttime sky would be as bright as the sun itself; this became recognized as Olbers' paradox in the 19th century. Newton whispered that an infinite legroom consistently filled with matter would cause infinite forces and instabilities causing the matter to be crushed inwards under its own gravity. This instability was clarified in 1902 by the Jeans instability criterion. One solution to these paradoxes is the Charlier Universe, in which the matter is arranged hierarchically (systems of orbiting bodies that are themselves orbiting in a superior system, *ad infinitum*) in a fractal method such that the Universe has a negligibly small overall density; such a cosmological model had also been proposed earlier in 1761 by Johann Heinrich Lambert. An important astronomical advance of the 18th century was the realization by Thomas Wright, Immanuel Kant and others of nebulae.

The contemporary era of physical cosmology began in 1917, when Albert Einstein first applied his common theory of relativity to model the structure and dynamics of the Universe.

Theoretical Models

Of the four fundamental interactions, gravitation is dominant at cosmological length levels; that is, the other three forces play a negligible role in determining structures at the stage of planetary systems, galaxies and superior-level structures. Because all matter and power gravitate, gravity's effects are cumulative; by contrast, the effects of positive and negative charges tend to cancel one another, creation electromagnetism relatively insignificant on cosmological length levels. The remaining two interactions, the weak and strong nuclear forces, decline very rapidly with aloofness; their effects are confined mainly to sub-atomic length levels.

Common Theory of Relativity

Given gravitation's predominance in shaping cosmological structures, accurate predictions of the Universe's past and future require an accurate theory of gravitation. The best theory accessible is Albert Einstein's common theory of relativity, which has passed all experimental tests hitherto. Though, because rigorous experiments have not been accepted out on cosmological length levels, common relativity could conceivably be inaccurate. Nevertheless, its cosmological predictions appear to be constant with observations, so there is no compelling cause to adopt another theory.

Common relativity gives a set of ten nonlinear partial differential equations for the space-time metric (Einstein's field equations) that necessity be solved from the sharing of mass-power and momentum throughout the Universe. Because these are strange in exact detail, cosmological models have been based on the cosmological principle, which states that the Universe is homogeneous and isotropic. In effect, this principle asserts that the gravitational effects of the several galaxies creation up the Universe are equivalent to those of a fine dust distributed consistently throughout the Universe with the similar average density. The assumption of a uniform dust creates it easy to solve Einstein's field equations and predict the past and future of the Universe on cosmological time levels.

Einstein's field equations contain a cosmological constant (Λ) that corresponds to a power density of empty legroom. Depending on its sign, the cosmological constant can either slow (negative Λ) or accelerate (positive Λ) the expansion of the Universe. Although several scientists, including Einstein, had speculated that Λ was zero, recent astronomical observations of kind Ia supernovae have detected a big amount of "dark power" that is accelerating the Universe's expansion. Preliminary studies suggest that this dark power corresponds to a positive Λ, although alternative theories cannot be ruled out as yet. Russian physicist Zel'dovich suggested that Λ is a measure of the zero-point power associated with virtual particles of quantum field theory, a pervasive vacuum power that exists everywhere, even in empty legroom. Proof for such zero-point power is observed in the Casimir effect.

Special Relativity and Legroom-time

The Universe has at least three spatial and one temporal (time) dimension. It was extensive thought that the spatial and temporal dimensions were dissimilar in nature and independent of one another. Though, according to the special theory of relativity, spatial and temporal separations are interconvertible (within limits) by changing one's motion.

To understand this interconversion, it is helpful to consider the analogous interconversion of spatial separations beside the three spatial dimensions. Consider the two endpoints of a rod of length *L*. The length can be determined from the differences in the three coordinates Δx, Δy and Δz of the two endpoints in a given reference frame

$$L^2 = \Delta x^2 + \Delta y^2 + \Delta z^2$$

using the Pythagorean theorem. In a rotated reference frame, the coordinate differences differ, but they provide the similar length

$$L^2 = \Delta \xi^2 + \Delta \eta^2 + \Delta \zeta^2.$$

Thus, the coordinates differences (Δx, Δy, Δz) and (Δξ, Δη, Δζ) are not intrinsic to the rod, but merely reflect the reference frame used to describe it; by contrast, the length *L* is an intrinsic property of the rod. The coordinate differences can be changed without affecting the rod, by rotating one's reference frame.

The analogy in spacetime is described the interval flanked by two events; an event is defined as a point in spacetime, a specific location in legroom and a specific moment in time. The spacetime interval flanked by two events is given by

$$s^2 = L_1^2 - c^2 \Delta t_1^2 = L_2^2 - c^2 \Delta t_2^2$$

where *c* is the speed of light. According to special relativity, one can change a spatial and time separation (L_1, Δt_1) into another (L_2, Δt_2) by changing one's reference frame, as extensive as the change maintains the spacetime interval *s*. Such a change in reference frame corresponds to changing one's motion; in a moving frame, lengths and times are dissimilar from their counterparts in a stationary reference frame. The precise manner in which the coordinate and time differences change with motion is described by the Lorentz transformation.

Solving Einstein's Field Equations

The distances flanked by the spinning galaxies augment with time, but the distances flanked by the stars within each galaxy stay roughly the similar, due to their gravitational interactions.

In non-Cartesian (non-square) or curved coordinate systems, the Pythagorean theorem holds only on infinitesimal length levels and necessity be augmented with a more common metric tensor $g_{\mu\nu}$, which can vary from lay to lay and which describes the local geometry in the scrupulous coordinate system. Though, assuming the cosmological principle that the Universe is homogeneous and isotropic everywhere, every point in legroom is like every other point; hence, the metric tensor necessity is the similar everywhere. That leads to a single form for the metric tensor, described the Friedmann–Lemaître–Robertson–Walker metric

$$ds^2 = -c^2 dt^2 + R(t)^2 \left(\frac{dr^2}{1 - kr^2} + r^2 d\theta^2 + r^2 \sin^2 \theta \, d\phi^2 \right)$$

where (r, θ, φ) correspond to a spherical coordinate system. This metric has only two undetermined parameters: an overall length level R that can vary with time, and a curvature index k that can be only 0, 1 or −1, corresponding to flat Euclidean geometry, or spaces of positive or negative curvature. In cosmology, solving for the history of the Universe is done by calculating R as a function of time, given k and the value of the cosmological constant Λ, which is a (small) parameter in Einstein's field equations. The equation describing how R varies with time is recognized as the Friedmann equation, after its inventor, Alexander Friedmann.

The solutions for $R(t)$ depend on k and Λ, but some qualitative characteristics of such solutions are common. First and mainly importantly, the length level R of the Universe can remain constant *only* if the Universe is perfectly isotropic with positive curvature (k=1) and has one precise value of density everywhere, as first noted by Albert Einstein. Though, this equilibrium is unstable and because the Universe is recognized to be inhomogeneous on smaller levels, *R* necessity change, according to common relativity. When *R* changes, all the spatial distances in the Universe change in tandem; there is an overall expansion or contraction of legroom itself. This accounts for the observation that galaxies appear to be flying separately; the legroom flanked by them is stretching. The stretching of legroom also accounts for the apparent paradox that two galaxies can be 40 billion light years separately, although they started from the similar point 13.8 billion years ago and never moved faster than the speed of light.

Second, all solutions suggest that there was a gravitational singularity in the past, when *R* goes to zero and matter and power became infinitely thick. It may appear that this conclusion is uncertain because it is based on the questionable assumptions of perfect homogeneity and isotropy (the cosmological principle) and that only the gravitational interaction is important. Though, the Penrose–Hawking singularity theorems illustrate that a singularity should exist for very common circumstances. Hence, according to Einstein's field equations, *R* grew rapidly from an unimaginably hot, thick state that lived immediately following this singularity (when *R* had a small, finite value); this is the essence of the Big Bang model of the Universe. A general misconception is that the Big Bang model predicts that matter and power exploded from a single point in legroom and time; that is false. Rather, legroom itself was created in the Big Bang and imbued with a fixed amount of power and matter distributed consistently throughout; as legroom expands (i.e., as *R(t)* increases), the density of that matter and power decreases.

Third, the curvature index *k* determines the sign of the mean spatial curvature of spacetime averaged in excess of length levels greater than a billion light years. If k=1, the curvature is positive and the Universe has a finite volume. Such universes are often visualized as a three-dimensional sphere S^3 embedded in a four-dimensional legroom. Conversely, if *k* is zero or negative, the Universe *may* have infinite volume, depending on its overall topology. It may appear counter-intuitive that an infinite and yet infinitely thick Universe could be created in a single instant at the Big Bang when R=0, but exactly that is predicted mathematically when k does not equal 1. For comparison, an infinite plane has zero curvature but infinite region, whereas an infinite cylinder is finite in one direction and a torus is finite in both. A toroidal Universe could behave like a normal Universe with periodic boundary circumstances, as seen in "wrap-approximately" video games such as *Asteroids*; a traveler crossing an outer "boundary" of legroom going *outwards* would reappear instantly at another point on the boundary moving *inwards*.

The ultimate fate of the Universe is still strange, because it depends critically on the curvature index k and the cosmological constant Λ. If the Universe is sufficiently thick, k equals +1, meaning that its average curvature throughout is positive and the Universe will eventually recollapse in a Big Crunch, perhaps starting a new Universe in a Big Bounce. Conversely, if the Universe is insufficiently thick, k equals 0 or −1 and the Universe will expand forever, cooling off and eventually becoming unfriendly for all life, as the stars die and all matter coalesces into black holes (the Big Freeze and the heat death of the Universe). Recent data suggests that the expansion speed of the Universe is not decreasing as originally expected, but rising; if this continues indefinitely, the Universe will eventually rip itself to shreds (the Big Rip). Experimentally, the Universe has an overall density that is very secure to the critical value flanked by recollapse and eternal expansion; more careful astronomical observations are needed to resolve the question.

Big Bang Model

The prevailing Big Bang model accounts for several of the experimental observations, such as the correlation of aloofness and red shift of galaxies, the universal ratio of hydrogen: helium atoms, and the ubiquitous, isotropic microwave radiation background. The red shift arises from the metric expansion of legroom; as the legroom itself expands, the wavelength of a photon traveling through legroom likewise increases, decreasing its power. The longer a photon has been traveling, the more expansion it has undergone; hence, older photons from more distant galaxies are the mainly red-shifted. Determining the correlation flanked by aloofness and red shift is a significant problem in experimental physical cosmology.

Other experimental observations can be explained by combining the overall expansion of legroom with nuclear and atomic physics. As the Universe expands, the power density of the electromagnetic radiation decreases more quickly than does that of matter, because the power of a photon decreases with its wavelength. Thus, although the power density of the Universe is now dominated by matter, it was once dominated by radiation; poetically speaking, all was light. As the Universe expanded, its power density decreased and it became cooler; as it did so, the elementary particles of matter could associate stably into ever superior combinations. Thus, in the early part of the matter-dominated era, stable protons and neutrons shaped, which then associated into atomic nuclei. At this stage, the matter in the Universe was mainly hot, thick plasma of negative electrons, neutral neutrinos and positive nuclei. Nuclear reactions in the middle of the nuclei led to the present abundances of the lighter nuclei, particularly hydrogen, deuterium, and helium. Eventually, the electrons and nuclei combined to form stable atoms, which are transparent to mainly wavelengths of radiation; at this point, the radiation decoupled from the matter, forming the ubiquitous, isotropic background of microwave radiation observed today.

Other observations are not answered definitively by recognized physics. According to the prevailing theory, a slight imbalance of matter in excess of antimatter was present in the Universe's creation, or urbanized very shortly thereafter, perhaps due to the CP violation that has been observed by particle physicists. Although the matter and antimatter mostly annihilated one another, producing photons, a small residue of matter survived, giving the present matter-dominated Universe. Many rows of proof also suggest that a rapid cosmic inflation of the Universe occurred very early in its history (roughly 10^{-35} seconds after its creation). Recent observations also suggest that the cosmological constant (Λ) is not zero and that the net mass-power content of the Universe is dominated by a dark power and dark matter that have not been characterized scientifically. They differ in their gravitational effects. Dark matter gravitates as ordinary matter does, and thus slows the expansion of the Universe; by contrast, dark power serves to accelerate the Universe's expansion.

Multi-verse Theory

Some speculative theories have proposed that this Universe is but one of a set of disconnected universes, collectively denoted as the multi-verse, demanding or enhancing more limited definitions of the Universe. Scientific multi-verse theories are separate from concepts such as alternate planes of consciousness and simulated reality, although the thought of a superior Universe is not new; for instance, Bishop Étienne Tempier of Paris ruled in 1277 that God could make as several universes as he saw fit, a question that was being hotly debated by the French theologians.

Max Tegmark urbanized a four-part classification scheme for the dissimilar kinds of multi-verses that scientists have suggested in several problem domains. An instance of such a theory is the chaotic inflation model of the early Universe. Another is the several-worlds interpretation of quantum mechanics. Parallel worlds are generated in a manner similar to quantum superposition and decoherence, with all states of the wave function being realized in separate worlds. Effectively, the multi-verse evolves as a universal wave function. If the big bang that created our multi-verse created an ensemble of multi-verses, the wave function of the ensemble would be entangled in this sense.

The least controversial category of multi-verse in Tegmark's scheme is Stage I, which describes distant legroom-time events "in our own Universe". If legroom is infinite, or sufficiently big and uniform, identical instances of the history of Earth's whole Hubble volume happen every so often, basically by chance. Tegmark calculated our adjacent so-described doppelganger, is 10^{10115} meters absent from us (a double exponential function superior than a googolplex). In principle, it would be impossible to scientifically verify an identical Hubble volume. Though, it does follow as a fairly straightforward consequence from otherwise unrelated scientific observations and theories. Tegmark suggests that statistical analysis exploiting the anthropic principle gives an opportunity to test multi-verse theories in some cases. Usually, science would consider a multi-verse theory that posits neither a general point of causation, nor the possibility of interaction flanked by universes, to be an idle speculation.

Form of the Universe

The form or geometry of the Universe comprises both local geometry in the observable Universe and global geometry, which we may or may not be able to measure. Form can refer to curvature and topology. More formally, the subject in practice investigates which 3-manifold corresponds to the spatial part in commoving coordinates of the four-dimensional legroom-time of the Universe. Cosmologists normally work with a given legroom-like slice of spacetime described the commoving coordinates. In conditions of observation, the part of spacetime that can be observed is the backward light cone (points within the cosmic light horizon, given time to reach a given observer). If the observable Universe is smaller than the whole Universe (in some models it is several orders of magnitude smaller), one cannot determine the global structure by observation: one is limited to a small patch.

In the middle of the Friedmann–Lemaître–Robertson–Walker (FLRW) models, the presently mainly popular form of the Universe establish to fit observational data according to cosmologists is the infinite flat model, while other FLRW models contain the Poincaré dodecahedral legroom and the

Picard horn. The data fit by these FLRW models of legroom especially contain the Wilkinson Microwave Anisotropy Probe (WMAP) and Planck maps of cosmic background radiation. NASA released the first WMAP cosmic background radiation data in February 2003, while a higher resolution map concerning Planck data was released by ESA in March 2013. Both probes have establish approximately perfect agreement with inflationary models and the average model of cosmology, describing a flat, homogenous universe dominated by dark matter and dark power.

EXPLORING THE UNIVERSE

Probing the Universe

'Now, my own suspicion is that the universe is not only queerer than we suppose, but queerer than we can suppose'. This remark of Haldane, a well-known scientist, reflects, in a method, what mainly of us feel in relation to the subject. The universe is a rather hard subject to study. We cannot bring it to the laboratory to carry out experiments on it. We cannot compare it with any other universe, this is the only universe we have. And finally, we are a part of it. We can study it only from within. We cannot go out of it and seem at it from the outside.

So, how do we study it? It is here that the scientific way comes to our aid. You necessity understand that the study of the universe is a rather special instance of the way of science, as we cannot experiment on it. Though, the observations that we create in relation to it give us with an enormous amount of information that we can analyze and interpret in conditions of the recognized laws of nature. Based on these laws, several theories and models of the universe are given by scientists.

What observations can be made in relation to the universe? And how are they made? We will now answer these questions. We will not talk about the underlying principles of the ways and instruments in detail. Our aim is to provide you and thought of the vast diversity of apparatus and ways accessible for creation observations in relation to the universe.

Mainly of what we know in relation to the universe has been learnt from a study of light, heat and other radiations like the radio waves, X-rays, gamma rays etc. coming from the Sun and the stars. These radiations are detected by special instruments set up at astronomical observatories on the Earth and in orbit approximately the Earth. In the last few decades, we have been able to send probes to the neighboring worlds. Several men have also visited the Moon and brought a lot of lunar material for study. Thus, there are a diversity of methods for creation observations and collecting information in relation to the universe. Though, before describing these ways, we will explain to you some characteristics of the radiations from legroom that bring the secrets of the universe" right to our doorstep.

Visible and Invisible Radiation

Light is very much a part of our subsistence. Without it we cannot see; It lends color to the world approximately us. Light is also termed as visible radiation. There are other types of radiations in nature that we cannot see. These are termed invisible radiations. Some examples of invisible radiations are the infrared and ultraviolet radiations, radio waves, X-rays and gamma rays. We may come crossways all these radiations in our lives. For instance, infrared (IR) radiation is given out by warm objects, such as our bodies, room heaters, structures and the Earth after a warm day. Rattlesnakes detect infrared radiation very well. Ultraviolet (UV) radiation can kill germs. It is invisible to us but can be detected by bumblebees. Radio waves are emitted by TV and radio broadcasting stations and are received by our TV or radio sets through the antennas. Thus, they are useful in communication. They can also be detected by bats. X-rays are used in medicine, gamma rays are used in cancer treatment and are also emitted in nuclear explosions.

All these radiations—the gamma ray, the X-rays, ultraviolet rays, light, infrared rays, and radio waves—are useful in astronomy. Actually they are dissimilar shapes of the similar type of radiation described the electromagnetic radiation. Electromagnetic radiation is a form of power. There are other shapes of power with which you necessity be well-known, like heat, sound or the power stored in the. spring of a watch. We usually think of electromagnetic radiation as being made up of waves that travel with the speed of light in vacuum. Now, the simplest examples of waves that you may know are waves of water in a pond or sea, waves on a string. You may have seen waves on a curtain fluttering in the air.

But clearly, the several types of electromagnetic radiation do not appear to be alike. What is the variation flanked by each of them? What do we mean by the wavelength of a wave? This is the usual method of showing a wave. The aloofness flanked by two successive crests (hills) or two successive troughs (valleys) is defined as its wavelength. It is measured in meters. The curve marked OABCD is described one cycle. The frequency of a wave is defined as the number of cycles it travels in a second.

In Pursuit of Starlight

The easiest way of learning light from a cosmic substance is to collect it through a telescope and record it on a photographic plate. Photographic films are exposed for extensive eras of time—sometimes night after night—to the light being composed by a telescope aimed at distant stars. Since the Earth rotates on its axis, the stars appear to move in the sky. The telescope is rotated following the daily movement of the stars at which it is aimed. Thus, its movement is synchronized with the movement of the stars being studied, stars, distant too faint for human eyes, slowly begin to register on the plate. This way of collecting and investigating light from the cosmos is described optical astronomy.

In excess of the centuries, astronomers have refined the telescope from the first crude lenses of Galileo's day to giant telescopes in use today. Three easy pieces of glass, the lens, the mirror and the prism in excess of the era of a few hundred years, have turned into sophisticated and powerful apparatus in human hands. Shouldn't we marvel at the ingenuity of the human mind?

As of today, a vast optical telescope described the Hubble legroom telescope, after Edwin Hubble, is in orbit approximately the earth. Many big telescopes are stationed in the USA, Hawaii, Australia, Chile, Russia, U.K. etc. In India the major optical observatories are at Nainital, Gurusikhar (Close to Mount Abu), Udaipur, Japal Rangapur (close to Hyderabad), Kavalur and Kodai Kanal. Several smaller telescopes scan the skies every night, adding to our knowledge of the cosmos. There are several other methods of learning in relation to the heavens than by just learning the light coming from them. One of them is radio astronomy. Nowadays, scientists use very sensitive radio telescopes to tune in on the cosmic objects and study them.

Tuning in on the Stars

The information that stars emit radio waves was exposed accidentally in 1932 by a young engineer Karl Jansky. He was trying to discover the source of noise in a transatlantic telephonic link. He made an experimental radio receiver set to study this problem. To his surprise, he establishes that the disturbance was due to radio waves coming from the Milky Method Galaxy. This was the beginning of radio astronomy, i.e. the study of cosmic objects through radio waves emitted by them. The radio telescope, a vital tool of radio astronomy, collects radiations from legroom in the radio wave region. One of the main radio telescopes in the world was intended and set up by Indian astronomers at Ootacamund. The other radio telescopes in India are stationed at Gulmarg, Ahmedabad, Gauribidanur close to Bangalore.

Radio telescopes may be tuned to receive radio waves of the desired wavelength in the similar method as we tune a radio to receive only the station we want. Radio telescopes not only provide a ‘view’ of the invisible universe, but can also probe much deeper into legroom when compared with optical telescopes. Radio waves can propagate through dust clouds in legroom, just as radio signals on the Earth can penetrate cloudy or foggy weather. Thus, they enable radio astronomers to construct images of regions totally hidden from the view of optical telescopes. Though, radio telescopes normally receive radiation within a narrow group of wavelengths. Radio telescopes have led to the detection of hundreds of cosmic objects that emit radio waves. Mainly of these could be recognized with the objects seen by optical telescopes. With the help of radio telescopes objects like pulsars were exposed. Pulsars are stars that send out pulses of light and radio waves in regular bursts. For instance, a pulsar in the centre of the Crab nebula at an aloofness of 6000 light years from the Earth sends out bursts of light and radio waves 30 times a second.

Sure radio sources like 3c273, detected by radio telecopes and later examined by optical telescopes, were named quasars. Quasar, an abbreviation of ‘quasi-stellar radio source’, is a star-like substance situated billions of light years absent. Not all quasars are radio sources. Since the electromagnetic waves from quasars are being detected on the Earth, they necessity be sending out vast amounts of power. Quasars are comparatively small in size, only in relation to the light month crossways. That is, if you imagined the Milky Method Galaxy to be a football field, a quasar would appear like a grain of sand. But it emits 100 times more power than the whole Milky Method Galaxy. Scientists have also establish that several elliptical galaxies that seemed unimportant when seen through optical telescopes, were powerful sources of radio waves. These galaxies were named radio galaxies. Often, the centre of a galaxy is a powerful source of radio waves. Violent movements of vast quantities of matter and gas take lay in the central part of the galaxies, emitting radio waves in the procedure. Radio telescopes also showed that organic molecules exist in interstellar legroom.

Messengers from the Sky

Light and radio waves are not the only messengers from the sky to our planet Earth. There are others; like the meteorites entering the Earth's atmosphere from time to time. They bring us several messages in relation to the cosmic objects from which they were chipped off. Earth is also constantly bombarded by cosmic rays which, as you've read earlier, are beams of electrons, protons and helium nuclei that cruise through spaces at very high speeds, approaching the speed of light. Their origin and their travel through legroom is a puzzle that scientists have not yet been able to solve totally. Ones it is solved, we will get to know a lot more in relation to the interstellar gas clouds, the stars and the galaxies.

Ventures in Legroom

Sometimes the atmospheric circumstances distort the light or radio waves coming in from legroom. For instance, there may be a storm disturbing the radio waves. Or clouds may obscure light. Then it is not possible to study the universe in these regions of the electromagnetic spectrum. Even otherwise, contemporary science and technology have given astronomers many new methods and means of probing the universe. We will briefly describe each one of them.

Observatories in Legroom

With the coming of the Legroom Age, observatories equipped with telescopes and cameras could be placed right in legroom, beyond the Earth's atmosphere. An observatory in legroom may be in the form of an orbiting satellite like the Unmanned Orbiting Solar Observatories, Orbiting Astronomical Observatory, Skylab, Einstein Observatory, IRAS (Infra Red Astronomy Satellite) and several others. An observatory may also be stationed on the Moon or any other planet having appropriate temperature and other circumstances. Instruments are also put aboard high flying balloons, rockets and aircrafts to record observations. These observatories can record radiation from a cosmic substance in the regions of the spectrum such as the IR, UV, gamma rays and X-rays that do not penetrate the Earth's atmosphere.

Visiting the Neighboring Worlds

As legroom research came of age, it became possible for us to send spacecraft to other planets and even land men and instruments on the Moon. These ventures also provided a rich stock of information in relation to the Solar System. For instance, astronauts of the Apollo mission to the Moon in the nineteen seventies brought back lunar rocks and soil samples, photographs of the lunar surface and left many instruments there for further study.

We have been able to send spacecraft, also described probes, crossways the Solar System to know more in relation to the our planetary neighbors. Legroom probes have visited a number of planets and a host of their moons, and successfully landed and operated on the surfaces of Mars and Venus.

The American spacecraft, Pioneer-10, crossed the orbit of Neptune in 1983, and, thus, became the first man-made substance to leave the Solar System. With the help of observations from the Earth and the data sent by these probes, scientists have been able to arrive at a better theoretical understanding of the origin and development of the Solar System.

Understanding the Universe

So distant you have studied how information in relation to the universe is composed. It is stored mainly in the form of photographs of the cosmic objects, and spectra of their light. The other radiations coming in from legroom are recorded in several methods. This information is analyzed and interpreted to construct theories in relation to the universe and the objects that constitute it.

The hypotheses and theories in relation to the universe and its constituents are always open to change in the light of new discoveries. Quite often a given theory may turn out to be wrong. Observed data may also be misinterpreted. In information, a given theory may never agree hundred percent with the observations in relation to the universe. A good scientific theory in relation to the universe is one that is very secure to all relevant observations. At the other extreme are tentative and speculative theories. We will now present some theories and concepts which symbolize the best possible understanding of stars, galaxies and the universe as a whole.

Let Us Know in Relation to the Stars

The point-like stars have always presented astronomy with several questions such as: Where are the stars? How bright are they really? What is their temperature, size, age, etc.? What are they made up of? The growths in astronomy have provided astronomers with a skill to interpret starlight correctly and answer such questions.

Where are the Stars?

Astronomers use several ways to measure the distances to stars. For determining the distances to nearby stars, the way of stellar parallax is used. For stars farther absent, more sophisticated ways are used. We will not go into their details. The aloofness to astronomical objects situated very distant absent is establish by measuring the 'red shift' of their spectral rows. As distant absent objects, such as galaxies and quasars, move absent from us, the rows in their optical spectra are shifted towards the red end. This shift can be measured and their distances calculated by using appropriate formulae.

Fingerprinting the Stars

Maximum information in relation to the starlight can be derived from its spectrum. When a lens-sized prism is put in excess of the front (or objective) end of a telescope, each star can be seen as a colorful spectrum. We can lay a photographic film at the focal plane of the lens-sized prism. Then it becomes possible to register the spectrum of starlight. Ironically, the astronomer sees the spectra, not as brilliant rainbows. Each star has its own feature spectrum—a fingerprint of its individual personality. From its spectrum, we can learn what elements a star is made up of, what its temperature is, how bright it is, how fast it is moving etc.

Stellar Motion

Stars are not fixed in the heavens. They are moving within the galaxies. The speed of a star moving toward or absent from the Earth is indicated by a shift of its spectral rows. If a star is approaching the Earth, its rows shift towards the blue end of the spectrum. If it is moving absent from the Earth, its rows shift towards the red end of the spectrum. The greater the star's speed, the more its rows shift.

You have read that there are several types of stars—blue, yellow or red, normal or giant, pulsating or releasing excessive power. Mainly stars move jointly in groups. Only one out of four stars may travel alone. Of the rest, approximately a third is double stars and the rest are groups of several stars. In a double star system, recognized as a binary, two stars orbit one another. In a triple system, there are three stars—all three may move approximately each other, or two of them may move approximately the third. Then there are loose groups, with a few dozen stars, to the big globular groups containing hundreds of thousands of stars, all moving in several possible methods.

The Expanding Universe

Hubble's observations had proved the subsistence of galaxies. After mapping as several galaxies as could be seen by the telescopes then accessible, he turned his attention to the motion of galaxies. He was motivated to do this by a puzzling statement of V.M. Slipher, an American astronomer. He had exposed in 1912 that several of the faint nebulae were moving absent from the

Earth at very great speeds. Their spectral rows exhibited big shifts towards the red end (what is described as red shift). This seemed peculiar because stars in the Milky Method Galaxy move at much smaller speeds, some moving absent from us with others moving towards us. Slipher had made these observations a decade before galaxies were exposed. Then it was thought that the nebulae were objects in our own galaxy. He did not know what to create of his observations.

But as Hubble knew that these nebulae were galaxies, he began a systematic study of the relation flanked by their speeds and their distances along with his colleague M.L. Humason. What they establish was very motivating. To put it basically , his observations showed that;

- All galaxies were moving absent from us;
- The farther absent a galaxy was from our Galaxy, the greater was the speed at which it moved absent.

Hubble's detection put forth the picture of an expanding universe. But if all the galaxies are moving absent from us, are we at the centre of the Universe? No. If we were situated in another galaxy, even then the other galaxies would appear to move absent from us.

Closing in on Creation

The mainly significant current theory for the origin of the universe is the Big Bang theory. According to this theory, the universe started with a vast explosion. It was not an explosion like the ones with which we are well-known, which start from a definite centre and spread out. It was an explosion which occurred everywhere in legroom at the similar time. It filled all legroom from the beginning, with every particle of matter rushing separately from every other particle. This was not a burst of matter into legroom but rather an explosion of legroom itself. Every particle of matter rushed absent from every other particle. It is so distant impossible to ‘picture’ the first moment of ‘creation’ of the universe.

One-hundredth of a second after the creation of the universe is the earliest time in relation to the scientists can speak with any confidence. At this instant, the temperature of the universe was in relation to the a hundred billion degrees centigrade. This is much hotter than in the centre of even the hottest star. At such temperatures none of the components of ordinary matter, atoms, molecules, or even nuclei of atoms, could have held jointly. Instead, the matter rushing separately in the explosion consisted of several kinds of elementary particles. The particles mainly abundant in the early universe were the electrons, positrons and neutrinos. There were also some protons and neutrons. The rest of the universe was filled with power. It was a type of a cosmic soup.

As the explosion sustained, matter and power rushed separately, the universe expanded and the temperatures dropped, reaching 30 billion degrees centigrade after in relation to the one-tenth of a second; 10 billion degrees after in relation to the one second; and 3 billion degrees after in relation to the fourteen seconds. At the end of the first three minutes, the universe became cool enough (in relation to the 1 billion °C) for the protons and neutrons to begin to form into easy nuclei. The first to be shaped was the nucleus of heavy hydrogen which was made up of one proton and one neutron. There were also helium nuclei made of two protons and two neutrons. It was still too hot for atoms to hold jointly, they were ripped separately as soon as they were created. This matter sustained to rush separately, becoming steadily cooler and less thick.

Several thousands of years later, it became cool enough for electrons to join with nuclei to form atoms of hydrogen and helium. Soon, the resulting gas began to form clumps under the power of gravitation. These clumps ultimately condensed to form the galaxies and stars of the present-day universe, approximately 5 billion years after the Big Bang.

There is another theory in relation to the origin of the universe recognized as the steady state theory. This theory holds that the universe has always been just in relation to the similar as it is now. As it expands, new matter is created continuously to fill up the gaps flanked by the galaxies. Thus, the problem of the origin and early moments of the universe is banished: there was no early universe. Though, the Big Bang theory is the mainly favored by the astronomers and astrophysicists. Why is it so? This is due to the proof based on observations which lend support to the 'Big Bang' universe.

Proof Favoring the Big Bang

One piece of proof comes from the expansion of the universe which we have already described. The expanding universe suggests that the matter was packed much more densely in the early stages of the universe. The proof for this also comes from the distant objects quasars. When we 'seem' at quasars situated 6 to 8 billion light years absent, we are looking at them as they lived then. If the universe were thicker in that epoch, we should be able to see some proof of that density in the quasars. We do see such high density in the middle of the quasars. Another substantial bit of proof for the Big Bang theory comes from the cosmic background radiation. For several years the astronomers whispered that if there was a cosmic explosion extensive ago, radiation from that event should still exist within the universe. This radiation may be weak, it may have lost its power due to the expansion and cooling of the universe, but it should exist. Radio-astronomers have, indeed, exposed faint signals—a constantly present background radio noise that pervades all legroom. Calculations done by astrophysicists illustrate that this radiation, described the cosmic microwave background radiation, is a relic of the ancient past when the universe was in its first throes of creation in the Big Bang.

An additional detection made by astronomers in the past two decades is that of the primordial abundance of elements, i.e. the elements hydrogen and helium first created in the aftermath of creation are establish to be mainly abundant in the universe. By examining the light coming from the several parts of the universe, astronomers have establish out that, out of every 100 atoms, approximately 93 are hydrogen atoms and seven are helium atoms. Elements heavier than helium are present in traces only. This suggests that the universe started out with a Big Bang from a very hot and thick state and quickly cooled as it expanded. The hot and thick circumstances lasted extensive enough for some hydrogen to fuse into helium. But they did not last extensive to allow other heavier elements to form in important amounts. These were made much later in the interior of huge stars.

THE SOLAR SYSTEM

The Solar System consists of the Sun and its planetary system of eight planets, their moons, and other non-stellar objects. It shaped 4.6 billion years ago from the gravitational collapse of a giant molecular cloud. The vast majority of the system's mass is in the Sun, with mainly of the remaining mass contained in Jupiter. The four smaller inner planets, Mercury, Venus, Earth and Mars, also described the terrestrial planets, are primarily composed of rock and metal. The four outer planets, described the gas giants, are considerably huger than the terrestrials. The two main, Jupiter and Saturn, are composed mainly of hydrogen and helium; the two outermost planets, Uranus and Neptune, are composed mainly of substances with relatively high melting points (compared with hydrogen and helium), described *ices*, such as water, ammonia and methane, and are often referred to separately as "ice giants". All planets have approximately circular orbits that lie within an almost flat disc described the ecliptic plane.

The Solar System also contains a number of regions populated by smaller objects. The asteroid belt, which lies flanked by Mars and Jupiter, is similar to the terrestrial planets as it mostly contains objects composed of rock and metal. Beyond Neptune's orbit lie the Kuiper belt and scattered disc, connected populations of trans-Neptunian objects composed mostly of ices.

Within these populations are many dozen to more than ten thousand objects that may be big enough to have been rounded by their own gravity. Such objects are referred to as dwarf planets. Recognized dwarf planets contain the asteroid Ceres and the trans-Neptunian objects Pluto, Eris, and Haumea. In addition to these two regions, several other small-body populations including comets, centaurs and interplanetary dust freely travel flanked by regions. Six of the planets, at least three of the dwarf planets, and several of the smaller bodies are orbited by natural satellites, usually termed "moons" after Earth's Moon. Each of the outer planets is encircled by planetary rings of dust and other small objects.

The solar wind, a flow of plasma from the Sun, makes a bubble in the interstellar medium recognized as the hemisphere, which extends out to the edge of the scattered disc. The Oort cloud, which is whispered to be the source for extensive-era comets, may also exist at aloofness roughly a thousand times further than the heliosphere. The heliopause is the point at which pressure from the solar wind is equal to the opposing pressure of interstellar wind. The Solar System is situated within one of the outer arms of Milky Method galaxy, which contains in relation to the 200 billion stars.

Detection and Exploration

For several thousands of years, humanity, with a few notable exceptions, did not recognize the subsistence of the Solar System. People whispered the Earth to be stationary at the centre of the universe and categorically dissimilar from the divine or ethereal objects that moved through the sky. Although the Greek philosopher Aristarchus of Samos had speculated on a heliocentric reordering of the cosmos, Nicolaus Copernicus was the first to develop a mathematically predictive heliocentric system. His 17th-century successors, Galileo Galilei, Johannes Kepler and Isaac Newton, urbanized an understanding of physics that led to the gradual acceptance of the thought that the Earth moves approximately the Sun and that the planets are governed by the similar physical laws that governed the Earth. Additionally, the invention of the telescope led to the detection of further planets and moons. In more recent times, improvements in the telescope and the use of unmanned spacecraft have enabled the investigation of geological phenomena such as mountains and craters, and seasonal meteorological phenomena such as clouds, dust storms and ice caps on the other planets.

Structure and Composition

The principal component of the Solar System is the Sun, a G2 main-sequence star that contains 99.86% of the systems recognized mass and dominates it gravitationally. The Sun's four main orbiting bodies, the gas giants, explanation for 99% of the remaining mass, with Jupiter and Saturn jointly comprising more than 90%.

Mainly big objects in orbit approximately the Sun lie close to the plane of Earth's orbit, recognized as the ecliptic. The planets are very secure to the ecliptic while comets and Kuiper belt objects are regularly at significantly greater angles to it. All the planets and mainly other objects orbit the Sun in the similar direction that the Sun is rotating. There are exceptions, such as Halley's Comet.

The overall structure of the charted regions of the Solar System consists of the Sun, four relatively small inner planets bounded by a belt of rocky asteroids, and four gas giants bounded by the Kuiper belt of icy objects. Astronomers sometimes informally divide this structure into separate regions. The *inner Solar System* comprises the four terrestrial planets and the asteroid belt. The *outer Solar System* is beyond the asteroids, including the four gas giants. Since the detection of the Kuiper belt, the outermost parts of the Solar System are measured a separate region consisting of the objects beyond Neptune.

Mainly of the planets in the Solar System possess secondary systems of their own, being orbited by planetary objects described natural satellites, or moons (two of which are superior than the planet Mercury), or, in the case of the four gas giants, by planetary rings; thin bands of tiny particles that orbit them in unison. Mainly of the main natural satellites are in synchronous rotation, with one face permanently turned toward their parent.

Kepler's laws of planetary motion describe the orbits of objects in relation to the Sun. Following Kepler's laws, each substance travels beside an ellipse with the Sun at one focus. Objects closer to the Sun (with smaller semi-major axes) travel more quickly, as they are more affected by the Sun's gravity. On an elliptical orbit, a body's aloofness from the Sun varies in excess of the course of its year. A body's closest approach to the Sun is described its *perihelion*, while its mainly distant point from the Sun is described its *aphelion*. The orbits of the planets are almost circular, but several comets, asteroids and Kuiper belt objects follow highly elliptical orbits. The positions of the bodies in the Solar System can be predicted using numerical models.

Although the Sun dominates the system by mass, it accounts for only in relation to the 2% of the angular momentum due to the differential rotation within the gaseous Sun. The planets, dominated by Jupiter, explanation for mainly of the rest of the angular momentum due to the combination of their mass, orbit, and aloofness from the Sun, with a perhaps important contribution from comets.

The Sun, which comprises almost all the matter in the Solar System, is composed of roughly 98% hydrogen and helium. Jupiter and Saturn, which comprise almost all the remaining matter, possess atmospheres composed of roughly 99% of those similar elements. A composition gradient exists in the Solar System, created by heat and light pressure from the Sun; those objects closer to the Sun, which is more affected by heat and light pressure, are composed of elements with high melting points. Objects farther from the Sun are composed mainly of materials with lower melting points. The boundary in the Solar System beyond which those volatile substances could condense is recognized as the frost row, and it lies at roughly 5 AU from the Sun.

The objects of the inner Solar System are composed mostly of *rock*, the communal name for compounds with high melting points, such as silicates, iron or nickel that remained solid under approximately all circumstances in the protoplanetary nebula. Jupiter and Saturn are composed mainly of *gases*, the astronomical term for materials with very low melting points and high vapor pressure such as molecular hydrogen, helium, and neon, which were always in the gaseous stage in the nebula. *Ices*, like water, methane, ammonia, hydrogen sulfide and carbon dioxide, have melting points up to a few hundred kelvins, while their stage depends on the ambient pressure and temperature. They can be establish as ices, liquids, or gases in several spaces in the Solar System, while in the nebula they were either in the solid or gaseous stage. Icy substances comprise the majority of the satellites of the giant planets, as well as mainly of Uranus and Neptune (the so-described "ice giants") and the numerous small objects that lie beyond Neptune's orbit. Jointly, gases and ices are referred to as *volatiles*.

Distances and Levels

The aloofness from the Earth to the Sun is 1 astronomical unit (150,000,000 km). For comparison, the radius of the Sun is 700,000 km (0.0047 AU). Thus, the Sun occupies 0.00001% (10 %) of the volume of a sphere with a radius the size of the Earth's orbit, while the Earth's volume is roughly one million (10) times smaller than that of the Sun. Jupiter, the main planet, is 5.2 astronomical units (780,000,000 km) from the Sun and has a radius of 71,000 km (0.00047 AU), while the mainly distant planet, Neptune, is 30 AU (4.5×10 km) from the Sun.

With a few exceptions, the farther a planet or belt is from the Sun, the superior the aloofness flanked by it and the previous orbit. For instance, Venus is almost 0.33 AU farther out from the Sun than Mercury, while Saturn is 4.3 AU out from Jupiter, and Neptune lies 10.5 AU out from Uranus. Attempts have been made to determine a connection flanked by these orbital distances (for instance, the Titius–Bode law), but no such theory has been accepted.

A number of Solar System models on Earth effort to convey the relative levels involved in the Solar System on human conditions. Some models are mechanical — described orreries — while others extend crossways municipalities or local regions. The main such level model, the Sweden Solar System, uses the 110-metre Ericsson Globe in Stockholm as its substitute Sun, and, following the level, Jupiter is a 7.5 meter sphere at Arlanda International Airport, 40 km absent, while the farthest current substance, Sedna, is a 10-cm sphere in Lulea, 912 km absent.

If the Sun–Neptune aloofness is scaled to the length of a football or soccer pitch of in relation to the 100 meter, then the Sun is in relation to the 3 cm in diameter (roughly two-thirds the diameter of a golf ball) at one goal row with the gas giants all smaller than in relation to the 3 mm and Neptune establish at the opposite goal row. Earth's diameter beside with the other terrestrial planets would be smaller than a flea (0.3 mm) at this level.

Formation and Development

The Solar System shaped 4.568 billion years ago from the gravitational collapse of a region within a big molecular cloud. This initial cloud was likely many light-years crossways and almost certainly birthed many stars. As is typical of molecular clouds, this one consisted mostly of hydrogen, with some helium, and small amounts of heavier elements fused by previous generations of stars. As the region that would become the Solar System, recognized as the pre-solar nebula, collapsed, conservation of angular momentum caused it to rotate faster. The centre, where mainly of the mass composed, became increasingly hotter than the nearby disc. As the contracting nebula rotated faster, it began to flatten into a protoplanetary disc with a diameter of roughly 200 AU and a hot, thick protostar at the centre. The planets shaped by accretion from this disc, in which dust and gas gravitationally attracted each other, coalescing to form ever superior bodies. Hundreds of protoplanets may have lived in the early Solar System, but they either merged or were destroyed, leaving the planets, dwarf planets, and leftover minor bodies.

Due to their higher boiling points, only metals and silicates could exist in the warm inner Solar System secure to the Sun, and these would form the rocky planets of Mercury, Venus, Earth, and Mars. Since metallic elements only comprised a very small fraction of the solar nebula, the terrestrial planets could not grow very big. The gas giants (Jupiter, Saturn, Uranus, and Neptune) shaped further out, beyond the frost row, the point flanked by the orbits of Mars and Jupiter where material is cool enough for volatile icy compounds to remain solid. The ices that shaped these planets were more plentiful than the metals and silicates that shaped the terrestrial inner planets, allowing them to grow huge enough to capture big atmospheres of hydrogen and helium, the lightest and mainly abundant elements. Leftover debris that never became planets congregated in regions such as the asteroid belt, Kuiper belt, and Oort cloud. The Nice model is an explanation for the creation of these regions, and how the outer planets could have shaped in dissimilar positions and migrated to their current orbits through several gravitational interactions.

Within 50 million years, the pressure and density of hydrogen in the centre of the protostar became great enough for it to begin thermonuclear fusion. The temperature, reaction rate, pressure, and density increased until hydrostatic equilibrium was achieved: the thermal pressure equaled the force of gravity. At this point the Sun became a main-sequence star. Solar wind from the Sun created the heliosphere and swept absent the remaining gas and dust from the protoplanetary disc into interstellar legroom, ending the planetary formation procedure.

The Solar System will remain roughly as we know it today until the hydrogen in the core of the Sun has been entirely converted to helium, which will happen roughly 5.4 billion years from now. This will spot the end of the Sun's main-sequence life. At this time, the core of the Sun will collapse, and the power output will be much greater than at present. The outer layers of the Sun will expand too roughly up to 260 times its current diameter and the Sun will become a red giant. Because of its vastly increased surface region, the surface of the Sun will be considerably cooler (2600 K at its coolest) than it is on the main sequence. The expanding Sun is expected to vaporize Mercury and Venus and render the Earth uninhabitable, as the habitable zone moves out to the orbit of Mars. Eventually, the core will be hot enough for helium fusion; the Sun will burn helium for a fraction of the time it burned hydrogen in the core. The Sun is not huge enough to commence fusion of heavier elements, and nuclear reactions in the core will dwindle. Its outer layers will move absent into legroom, leaving a white dwarf, an extraordinarily thick substance, half the original mass of the Sun but only the size of the Earth. The ejected outer layers will form what is recognized as a planetary nebula, returning some of the material that shaped the Sun—but now enriched with heavier elements like carbon—to the interstellar medium.

Sun

The Sun is the Solar System's star, and by distant its chief component. Its big mass (332,900 Earth masses) produces temperatures and densities in its core high enough to sustain nuclear fusion, which releases enormous amounts of power, mostly radiated into legroom as electromagnetic radiation, peaking in the 400–700 nm group of visible light.

The Sun is classified as a kind G2 yellow dwarf, but this name is misleading as, compared to the majority of stars in our galaxy, the Sun is rather big and bright. Stars are classified by the Hertzsprung–Russell diagram, a graph that plots the brightness of stars with their surface temperatures. Usually, hotter stars are brighter. Stars following this pattern are said to be on the main sequence, and the Sun lies right in the middle of it. Though, stars brighter and hotter than the Sun are unusual, whereas considerably dimmer and cooler stars, recognized as red dwarfs, are general, creation up 85% of the stars in the galaxy.

Proof suggests that the Sun's location on the main sequence puts it in the "prime of life" for a star, in that it has not yet exhausted its store of hydrogen for nuclear fusion. The Sun is rising brighter; early in its history its brightness was 70% of that of what it is today.

The Sun is a population I star; it was born in the later stages of the universe's development, and thus contains more elements heavier than hydrogen and helium ("metals" in astronomical parlance) than the older population II stars. Elements heavier than hydrogen and helium were shaped in the cores of ancient and exploding stars, so the first generation of stars had to die before the universe could be enriched with these atoms. The oldest stars contain few metals, whereas stars born later have more. This high metallic is thought to have been crucial to the Sun's development of a planetary system, because the planets form from the accretion of "metals".

Interplanetary Medium

The vast majority of the volume of the Solar System consists of a close to-vacuum recognized as the interplanetary medium. Though, beside with light, the Sun radiates a continuous stream of charged particles (a plasma) recognized as the solar wind. This stream of particles spreads outwards at roughly 1.5 million kilometers per hour, creating a tenuous atmosphere (the heliosphere) that permeates the interplanetary medium out to at least 100 AU. Action on the Sun's surface, such as solar flares and coronal mass ejections, disturb the heliosphere, creating legroom weather and causing geomagnetic storms. The main structure within the heliosphere is the heliospheric current sheet, a spiral form created by the actions of the Sun's rotating magnetic field on the interplanetary medium.

Earth's magnetic field stops its atmosphere from being stripped absent by the solar wind. Venus and Mars do not have magnetic meadows, and as a result, the solar wind causes their atmospheres to slowly bleed absent into legroom. Coronal mass ejections and similar events blow a magnetic field and vast quantities of material from the surface of the Sun. The interaction of this magnetic field and material with Earth's magnetic field funnels charged particles into the Earth's upper atmosphere, where its interactions make aurorae seen close to the magnetic poles.

The heliosphere and planetary magnetic meadows (for those planets that have them) partially shield the Solar System from high-power interstellar particles described cosmic rays. The density of cosmic rays in the interstellar medium and the strength of the Sun's magnetic field change on very extensive timescales, so the stage of cosmic-ray penetration in the Solar System varies, though by how much is strange.

The interplanetary medium is house to at least two disc-like regions of cosmic dust. The first, the zodiacal dust cloud, lies in the inner Solar System and causes the zodiacal light. It was likely shaped by collisions within the asteroid belt brought on by interactions with the planets. The second dust cloud extends from in relation to the 10 AU to in relation to the 40 AU, and was almost certainly created by similar collisions within the Kuiper belt.

Inner Solar System

The inner Solar System is the traditional name for the region comprising the terrestrial planets and asteroids. Composed mainly of silicates and metals, the objects of the inner Solar System are relatively secure to the Sun; the radius of this whole region is shorter than the aloofness flanked by the orbits of Jupiter and Saturn.

Inner Planets

The four inner or terrestrial planets have thick, rocky compositions, few or no moons, and no ring systems. They are composed mainly of refractory minerals, such as the silicates, which form their crusts and mantles, and metals such as iron and nickel, which form their cores. Three of the four inner planets (Venus, Earth and Mars) have atmospheres substantial enough to generate weather; all have impact craters and tectonic surface characteristics such as rift valleys and volcanoes. The term *inner planet* should not be confused with *inferior planet*, which designates those planets that are closer to the Sun than Earth is (i.e. Mercury and Venus).

- ***Mercury:*** Mercury (0.4 AU from the Sun) is the closest planet to the Sun and the negligible planet in the Solar System (0.055 Earth masses). Mercury has no natural satellites, and it's only recognized geological characteristics besides impact craters are lobed ridges or rupees, almost certainly produced by an era of contraction early in its history. Mercury's approximately negligible atmosphere consists of atoms blasted off its surface by the solar wind. Its relatively big iron core and thin mantle have not yet been adequately explained. Hypotheses contain that its outer layers were stripped off by a giant impact, and that it was prevented from fully accreting by the young Sun's power.
- ***Venus :*** Venus (0.7 AU from the Sun) is secure in size to Earth (0.815 Earth masses), and, like Earth, has a thick silicate mantle approximately an iron core, a substantial atmosphere and proof of internal geological action. Though, it is much drier than Earth and its atmosphere is ninety times as thick. Venus has no natural satellites. It is the hottest planet, with surface temperatures in excess of 400 °C, mainly likely due to the amount of greenhouse gases in the atmosphere. No definitive proof of current geological action has been detected on Venus, but it has no magnetic field that would prevent depletion of its substantial atmosphere, which suggests that its atmosphere is regularly replenished by volcanic eruptions.
- ***Earth:*** Earth (1 AU from the Sun) is the main and densest of the inner planets, the only one recognized to have current geological action, and

is the only lay where life is recognized to exist. Its liquid hydrosphere is unique in the middle of the terrestrial planets, and it is also the only planet where plate tectonics have been observed. Earth's atmosphere is radically dissimilar from those of the other planets, having been altered by the attendance of life to contain 21% free oxygen. It has one natural satellite, the Moon, the only big satellite of a terrestrial planet in the Solar System.

- ***Mars:*** Mars (1.5 AU from the Sun) is smaller than Earth and Venus (0.107 Earth masses). It possesses an atmosphere of mostly carbon dioxide with a surface pressure of 6.1 millibars (roughly 0.6% of that of the Earth). Its surface, peppered with vast volcanoes such as Olympus Mons and rift valleys such as Valles Marineris, shows geological action that may have persisted until as recently as 2 million years ago. Its red color comes from iron oxide (rust) in its soil. Mars has two tiny natural satellites (Deimos and Phobos) thought to be captured asteroids.

Asteroid Belt

Asteroids are small Solar System bodies composed mainly of refractory rocky and metallic minerals, with some ice. The asteroid belt occupies the orbit flanked by Mars and Jupiter, flanked by 2.3 and 3.3 AU from the Sun. It is thought to be remnants from the Solar System's formation that failed to coalesce because of the gravitational interference of Jupiter. Asteroids range in size from hundreds of kilometers crossways to microscopic. All asteroids except the main, Ceres, are classified as small Solar System bodies.

The asteroid belt contains tens of thousands, perhaps millions, of objects in excess of one kilometer in diameter. Despite this, the total mass of the asteroid belt is unlikely to be more than a thousandth of that of the Earth. The asteroid belt is very sparsely populated; spacecraft routinely pass through without incident. Asteroids with diameters flanked by 10 and 10 m are described meteoroids.

- ***Ceres:*** Ceres (2.77 AU) is the main asteroid, a protoplanet, and a dwarf planet. It has a diameter of slightly less than 1000 km, and a mass big enough for its own gravity to pull it into a spherical form. Ceres was measured a planet when it was exposed in the 19th century, but was reclassified to asteroid in the 1850s as further observations revealed additional asteroids. It was classified as a dwarf planet in 2006.
- ***Asteroid groups:*** Asteroids in the asteroid belt are divided into asteroid groups and families based on their orbital features. Asteroid moons are asteroids that orbit superior asteroids. They are not as clearly distinguished as planetary moons, sometimes being approximately as big as their partners. The asteroid belt also contains main-belt comets, which may have been the source of Earth's water. Jupiter trojans are situated in either of Jupiter's L_4 or L_5 points (gravitationally stable regions leading and trailing a planet in its orbit); the term "Trojan" is also used for small bodies in any other planetary or satellite Lagrange point. Hilda asteroids are in a 2:3 resonance with Jupiter; that is, they go approximately the Sun three times for every two Jupiter orbits. The inner Solar System is also dusted with rogue asteroids, several of which cross the orbits of the inner planets.

Outer Solar System

The outer region of the Solar System is house to the gas giants and their big moons. Several short-era comets, including the centaurs, also orbit in this region. Due to their greater aloofness from the Sun, the solid objects in the outer Solar System contain a higher proportion of volatiles such as water, ammonia and methane, than the rocky denizens of the inner Solar System, as the colder temperatures allow these compounds to remain solid.

Outer Planets

The four outer planets, or gas giants (sometimes described Jovian planets), collectively create up 99% of the mass recognized to orbit the Sun. Jupiter and Saturn are each several tens of times the mass of the Earth and consist overwhelmingly of hydrogen and helium; Uranus and Neptune are distant less huge (<20 Earth masses) and possess more ices in their makeup. For these reasons, some astronomers suggest they belong in their own category, "ice giants". All four gas giants have rings, although only Saturn's ring system is easily observed from Earth. The term *outer planet* should not be confused with *superior planet*, which designates planets outside Earth's orbit and thus comprises both the outer planets and Mars.

- ***Jupiter:*** Jupiter (5.2 AU), at 318 Earth masses, is 2.5 times the mass of all the other planets put jointly. It is composed mainly of hydrogen and helium. Jupiter's strong internal heat makes a number of semi-permanent characteristics in its atmosphere, such as cloud bands and the Great Red Spot. Jupiter has 67 recognized satellites. The four main, Ganymede, Callisto, Io, and Europa, illustrate similarities to the terrestrial planets, such as volcanism and internal heating. Ganymede, the main satellite in the Solar System, is superior to Mercury.
- ***Saturn:*** Saturn (9.5 AU), distinguished by its extensive ring system, has many similarities to Jupiter, such as its atmospheric composition and magnetosphere. Although Saturn has 60% of Jupiter's volume, it is less than a third as huge, at 95 Earth masses, creation it the least thick planet in the Solar System. The rings of Saturn are made up of small ice and rock particles. Saturn has 62 confirmed satellites; two of which, Titan and Enceladus, illustrate signs of geological action, though they are mainly made of ice. Titan, the second-main moon in the Solar System, is superior to Mercury and the only satellite in the Solar System with a substantial atmosphere.

- ***Uranus:*** Uranus (19.6 AU), at 14 Earth masses, is the lightest of the outer planets. Uniquely in the middle of the planets, it orbits the Sun on its face; its axial tilt is in excess of ninety degrees to the ecliptic. It has a much colder core than the other gas giants, and radiates very little heat into legroom. Uranus has 27 recognized satellites, the main ones being Titania, Oberon, Umbriel, Ariel and Miranda.
- ***Neptune:*** Neptune (30 AU), though slightly smaller than Uranus, is more huge (equivalent to 17 Earths) and therefore more thick. It radiates more internal heat, but not as much as Jupiter or Saturn. Neptune has 13 recognized satellites. The main, Triton, is geologically active, with geysers of liquid nitrogen. Triton is the only big satellite with a retrograde orbit. Neptune is accompanied in its orbit by a number of minor planets, termed Neptune trojans that are in 1:1 resonance with it.

Centaurs

The centaurs are icy comet-like bodies with a semi-major axis greater than Jupiter's (5.5 AU) and less than Neptune's (30 AU). The main recognized centaur, 10199 Chariklo, has a diameter of in relation to the 250 km. The first centaur exposed, 2060 Chiron, has also been classified as comet (95P) because it develops a coma just as comets do when they approach the Sun.

Comets

Comets are small Solar System bodies, typically only a few kilometers crossways, composed mainly of volatile ices. They have highly eccentric orbits, usually a perihelion within the orbits of the inner planets and an aphelion distant beyond Pluto. When a comet enters the inner Solar System, its proximity to the Sun causes its icy surface to sublimate and ionise, creating a coma: an extensive tail of gas and dust often visible to the naked eye.

Short-era comets have orbits lasting less than two hundred years. Extensive-era comets have orbits lasting thousands of years. Short-era comets are whispered to originate in the Kuiper belt, while extensive-era comets, such as Hale–Bopp, are whispered to originate in the Oort cloud. Several comet groups, such as the Kreutz Sungrazers, shaped from the breakup of a single parent. Some comets with hyperbolic orbits may originate outside the Solar System, but determining their precise orbits is hard. Old comets that have had mainly of their volatiles driven out by solar warming are often categorized as asteroids.

Trans-Neptunian Region

The region beyond Neptune, or the "trans-Neptunian region", is still mainly unexplored. It appears to consist overwhelmingly of small worlds (the main having a diameter only a fifth that of the Earth and a mass distant smaller than that of the Moon) composed mainly of rock and ice. This region is sometimes recognized as the "outer Solar System", though others use that term to mean the region beyond the asteroid belt.

Kuiper Belt

The Kuiper belt is a great ring of debris similar to the asteroid belt, but consisting mainly of objects composed primarily of ice. It extends flanked by 30 and 50 AU from the Sun. Though it is thought to contain dozens of dwarf planets, it is composed mainly of small Solar System bodies. Several of the superior Kuiper belt objects, such as Quaoar, Varuna, and Orcus, may be recognized as dwarf planets with further data. There are estimated to be in excess of 100,000 Kuiper belt objects with a diameter greater than 50 km, but the total mass of the Kuiper belt is thought to be only a tenth or even a hundredth the mass of the Earth. Several Kuiper belt objects have multiple satellites, and mainly have orbits that take them outside the plane of the ecliptic.

The Kuiper belt can be roughly divided into the "classical" belt and the resonances. Resonances are orbits connected to that of Neptune (e.g. twice for every three Neptune orbits, or once for every two). The first resonance begins within the orbit of Neptune itself. The classical belt consists of objects having no resonance with Neptune, and extends from roughly 39.4 AU to 47.7 AU. Members of the classical Kuiper belt are classified as Cebuano's, after the first of their type to be exposed, (15760) 1992 QB_1, and are still in close to primordial, low-eccentricity orbits.

Pluto and Charon

The dwarf planet Pluto (39 AU average) is the main recognized substance in the Kuiper belt. When exposed in 1930, it was measured to be the ninth planet; this changed in 2006 with the adoption of a formal definition of planet. Pluto has a relatively eccentric orbit inclined 17 degrees to the ecliptic plane and ranging from 29.7 AU from the Sun at perihelion (within the orbit of Neptune) to 49.5 AU at aphelion.

Pluto has a 3:2 resonance with Neptune, meaning that Pluto orbits twice round the Sun for every three Neptunian orbits. Kuiper belt objects whose orbits share this resonance are described plutinos.

Makemake and Haumea

Makemake (45.79 AU average), while smaller than Pluto, is the main recognized substance in the *classical* Kuiper belt (that is, it is not in a confirmed resonance with Neptune). Makemake is the brightest substance in the Kuiper belt after Pluto. It was named and designated a dwarf planet in 2008. Its orbit is distant more inclined than Pluto's, at 29°.

Haumea (43.13 AU average) is in an orbit similar to Makemake except that it is caught in a 7:12 orbital resonance with Neptune. It is in relation to the similar size as Makemake and has two natural satellites. A rapid, 3.9-hour rotation provides it a flattened and elongated form. It was named and designated a dwarf planet in 2008.

Scattered Disc

The scattered disc, which overlaps the Kuiper belt but extends much further outwards, is thought to be the source of short-era comets. Scattered disc objects are whispered to have been ejected into erratic orbits by the gravitational power of Neptune's early outward migration. Mainly scattered disc objects (SDOs) have perihelia within the Kuiper belt but aphelia distant beyond it (some have aphelia farther than 150 AU from the Sun). SDOs' orbits are also highly inclined to the ecliptic plane, and are often approximately perpendicular to it. Some astronomers consider the scattered disc to be merely another region of the Kuiper belt, and describe scattered disc objects as "scattered Kuiper belt objects". Some astronomers also classify centaurs as inward-scattered Kuiper belt objects beside with the outward-scattered residents of the scattered disc.

Eris

Eris (68 AU average) is the main recognized scattered disc substance, and caused a debate in relation to the what constitutes a planet, since it is 25% more huge than Pluto and in relation to the similar diameter. It is the mainly huge of the recognized dwarf planets. It has one recognized moon, Dysnomia. Like Pluto, its orbit is highly eccentric, with a perihelion of 38.2 AU (roughly Pluto's aloofness from the Sun) and an aphelion of 97.6 AU, and steeply inclined to the ecliptic plane.

Farthest Regions

The point at which the Solar System ends and interstellar legroom begins is not precisely defined, since its outer boundaries are shaped by two separate forces: the solar wind and the Sun's gravity. The outer limit of the solar wind's power is roughly four times Pluto's aloofness from the Sun; this *heliopause* is measured the beginning of the interstellar medium. Though, the

Sun's Hill sphere, the effective range of its gravitational dominance, is whispered to extend up to a thousand times farther.

Heliopause

The heliosphere is divided into two separate regions. The solar wind travels at roughly 400 km/s until it collides with the interstellar wind; the flow of plasma in the interstellar medium. The collision occurs at the termination shock, which is roughly 80–100 AU from the Sun upwind of the interstellar medium and roughly 200 AU from the Sun downwind. Here the wind slows dramatically, condenses and becomes more turbulent, forming a great oval structure recognized as the heliosheath. This structure is whispered to seem and behave very much like a comet's tail, extending outward for a further 40 AU on the upwind face but tailing several times that aloofness downwind; but proof from the Cassini and Interstellar Boundary Explorer spacecraft has suggested that it is in information forced into a bubble form by the constraining action of the interstellar magnetic field. Both *Voyager 1* and *Voyager 2* are accounted to have passed the termination shock and entered the heliosheath, at 94 and 84 AU from the Sun, respectively. The outer boundary of the heliosphere, the heliopause, is the point at which the solar wind finally terminates and is the beginning of interstellar legroom.

The form and form of the outer edge of the heliosphere is likely affected by the fluid dynamics of interactions with the interstellar medium as well as solar magnetic meadows prevailing to the south, e.g. it is bluntly shaped with the northern hemisphere extending 9 AU farther than the southern hemisphere. Beyond the heliopause, at approximately 230 AU, lies the bow shock, a plasma "wake" left by the Sun as it travels through the Milky Method.

No spacecraft have yet passed beyond the heliopause, so it is impossible to know for sure the circumstances in local interstellar legroom. It is expected that NASA's Voyager spacecraft will pass the heliopause some time in the after that decade and transmit valuable data on radiation stages and solar wind back to the Earth. How well the heliosphere shields the Solar System from cosmic rays is poorly understood. A NASA-funded team has urbanized a concept of a "Vision Mission" dedicated to sending a probe to the heliosphere.

Detached Objects

90377 Sedna (520 AU average) is a big, reddish substance with a gigantic, highly elliptical orbit that takes it from in relation to the 76 AU at perihelion to 940 AU at aphelion and takes 11,400 years to complete. Mike Brown, who exposed the substance in 2003, asserts that it cannot be part of the scattered disc or the Kuiper belt as its perihelion is too distant to have been affected by Neptune's migration. He and other astronomers consider it to be the first in an entirely new population, which also may contain the substance 2000 CR_{105}, which has a perihelion of 45 AU, an aphelion of 415 AU, and an orbital era of 3,420 years. Brown conditions this population the "inner Oort cloud", as it may have shaped through a similar procedure, although it is distant closer to the Sun, whereas Jewitt believes these bodies were scattered outward and then had their perihelia lifted through interaction with planets besides Neptune. Sedna is very likely a dwarf planet, though its form has yet to be determined.

Oort Cloud

The Oort cloud is a hypothetical spherical cloud of up to a trillion icy objects that is whispered to be the source for all extensive-era comets and to surround the Solar System at roughly 50,000 AU (approximately 1 light-year (ly)), and perhaps to as distant as 100,000 AU (1.87 ly). It is whispered to be composed of comets that were ejected from the inner Solar System by gravitational interactions with the outer planets. Oort cloud objects move very slowly, and can be perturbed by infrequent events such as collisions, the gravitational effects of a passing star, or the galactic tide, the tidal force exerted by the Milky Method.

Boundaries

Much of the Solar System is still strange. The Sun's gravitational field is estimated to control the gravitational forces of nearby stars out to in relation to the two light years (125,000 AU). Lower estimates for the radius of the Oort cloud, by contrast, do not lay it farther than 50,000 AU. Despite discoveries such as Sedna, the region flanked by the Kuiper belt and the Oort cloud, and region tens of thousands of AU in radius, is still virtually unmapped. There are also ongoing studies of the region flanked by Mercury and the Sun. Objects may yet be exposed in the Solar System's uncharted regions.

In November 2012 NASA announced that as Voyager I approached the transition zone to the outer limit of the Solar System its instruments detected a sharp intensification of the magnetic field. No change in the direction of the magnetic field had occurred, which NASA scientists then interpreted to indicate that Voyager I had not yet left the Solar System.

Galactic Context

The Solar System is situated in the Milky Method galaxy, a barred spiral galaxy with a diameter of in relation to the 100,000 light-years containing in relation to the 200 billion stars. The Sun resides in one of the Milky Method's outer spiral arms, recognized as the Orion–Cygnus Arm or Local Spur. The Sun lies flanked by 25,000 and 28,000 light years from the Galactic Centre, and its speed within the galaxy is in relation to the 220 kilometers per second, so that it completes one revolution every 225–250 million years. This revolution is recognized as the Solar System's galactic year. The solar apex, the direction of the Sun's path through interstellar legroom, is close to the constellation of Hercules in the direction of the current site of the bright star Vega. The plane of the ecliptic lies at an angle of in relation to the 60° to the galactic plane.

The Solar System's site in the galaxy is a factor in the development of life on Earth. Its orbit is secure to circular, and orbits close to the Sun are at roughly the similar speed as that of the spiral arms. Therefore, the Sun passes through arms only rarely. Since spiral arms are house to a distant superior concentration of supernovae, gravitational instabilities, and radiation which could disrupt the Solar System, this has given Earth extensive eras of stability for life to evolve. The Solar System also lies well outside the star-crowded environs of the galactic centre. Close to the centre, gravitational tugs from nearby stars could perturb bodies in the Oort Cloud and send several comets into the inner Solar System, producing collisions with potentially catastrophic implications for life on Earth. The intense radiation of the galactic centre could also interfere with the development of intricate life. Even at the Solar System's current site, some scientists have hypothesized that recent supernovae may have adversely affected life in the last 35,000 years by flinging pieces of expelled stellar core towards the Sun as radioactive dust granules and superior, comet-like bodies.

Neighborhood

The immediate galactic neighborhood of the Solar System is recognized as the Local Interstellar Cloud or Local Fluff, and region of denser cloud in an otherwise sparse region recognized as the Local Bubble, an hourglass-shaped cavity in the interstellar medium roughly 300 light years crossways. The bubble is suffused with high-temperature plasma that suggests it is the product of many recent supernovae.

There are relatively few stars within ten light years (95 trillion km) of the Sun. The closest is the triple star system Alpha Centauri, which is in relation to the 4.4 light years absent. Alpha Centauri A and B are a closely tied pair of Sun-like stars, while the small red dwarf Alpha Centauri C (also recognized as Proxima Centauri) orbits the pair at a aloofness of 0.2 light years. The stars after that closest to the Sun are the red dwarfs Barnard's Star (at 5.9 light years), Wolf 359 (7.8 light years) and Lalande 21185 (8.3 light years). The main star within ten light years is Sirius, a bright main-sequence star roughly twice the Sun's mass and orbited by a white dwarf described Sirius B. It lies 8.6 light years absent. The remaining systems within ten light years are the binary red-dwarf system Luyten 726-8 (8.7 light years) and the solitary red dwarf Ross 154 (9.7 light years). The Solar System's closest solitary sun-like star is Tau Ceti, which lies 11.9 light years absent. It has roughly 80% of the Sun's mass, but only 60% of its luminosity. The closest recognized extrasolar planet to the Sun lies approximately Alpha Centauri B. Its one confirmed planet, Alpha Centauri Bb, is at least 1.1 times Earth's mass and orbits its star every 3.236 days.

REVIEW QUESTIONS

- Explain the major observations that radically altered the perceptions of the universe prevailing at various times in human history.
- Describe our current knowledge of the stars-their distances, brightness, temperature, motion etc.
- What wavelengths of the electromagnetic radiation reach the surface of the Earth?
- Explain how the formation of the Solar System may have taken place.
- Describe the myths and misconceptions about the effect of planetary motion on human lives.

CHAPTER 4

Origin and Evolution of Life

STRUCTURE

- Learning objectives
- Origin and evolution of life
- Evolution of man
- Review questions

LEARNING OBJECTIVES

After studying this chapter you should be able to:

- Describe the various theories regarding the origin of life, and Pasteur's contribution in this context,
- Discuss the concept of life cycles and aging,
- Analyze the possibility of life beyond the Earth.
- List various stages of human evolution,
- State evidences from different sources for the processes of human evolution like paleontology, archaeology, anthropology and biochemistry,

ORIGIN AND EVOLUTION OF LIFE

Origin of Life on the Earth

Man has always wondered how he came into subsistence, who created him, and why he was created. Curiosity in this connection has been so strong that every ancient thinker, philosopher or "prophet", has tried to provide some answer to this question and suggest some mechanism for the creation of life.

According to an ancient Greek thought, life was transferred from "cosmozoa" (life of outer legroom) to dissimilar planets in small units described "spores". These spores had a thick impenetrable covering which prevented loss of water and other necessary components. It was assumed that under favorable circumstances of temperature and moisture, these spores gave birth to the initial livelihood organisms on the, as yet uninhabited, planets. This thought presumes a universal and eternal store home of spores of life, and thus indeed avoids answering the question as to how life anywhere originated in the first lay. The Greeks, or anyone else at that time, of course, did not know that the traveling spores would encounter destructive radiations like the ultraviolet and gamma rays in legroom.

In addition to this, several other theories have been put forward from time to time in relation to the origin of life. Some of them were mere speculations, whereas others have some scientific foundation.

Special Creation

One belief, general in the middle of people of all cultures, is that all the dissimilar shapes of life, including human beings were suddenly created by a divine order in relation to the 10,000 years ago. These innumerable shapes of life have always been the similar and will last without change from generation to generation until the end of the world. Such a theory of 'special creation' is unsound, because fossils of plants and animals which necessity have existed a hundred thousand or more years ago have been exposed. In information, researches illustrate that life lived on the Earth even 3.5 billion years ago. It appears that easy shapes of life came into being from non-livelihood matter, and that these shapes grew more intricate in excess of an era of time.

Spontaneous Generation

If we seem approximately at our everyday environment, we observe that straw, soil, mud, dirt, indeed any sort of refuse or rotting matter is infested with a wriggling, moving multitude of livelihood organisms. Such observations led people to consider that life originated spontaneously from non-livelihood matter. Aristotle (384-322 B.C.), recognized as the father of biology, maintained that not only worms and insects, but also fish, frogs and mice could spring from appropriate breeding materials like filth and moist soil. Even man might have had a similar origin! This theory of spontaneous generation was disproved by the experiments of the French microbiologist Louis Pasteur as late as 1862. It was not easy to dislodge Aristotelian thoughts. It took all the ingenuity and experimental ability of Louis Pasteur to disprove the theory of spontaneous generation. Pasteur performed his experiment before a gathering of well-recognized biologists of the time, who were commissioned by the Academy of Sciences of France to test his hypothesis, that only “life begets life”.

For his experiment, Pasteur took two flasks, half filled them with yeast infusion containing a little bit of sugar and heated them so as to kill any livelihood organisms. He sealed the mouth of one of the flasks and left the other open to the air. After a few days, he invited His friends to observe what had happened. To their surprise, they establish that the closed flask was still free of any livelihood organism while the open one was infested with livelihood organisms. In information one of these sealed flasks is still kept at the Academy of Sciences in Paris. Even after more than a hundred years, there are no livelihood organisms in it. Though, to further remove any doubt that organisms did not grow in the sealed flask due to lack of oxygen, Pasteur repeated the experiment with swan necked flasks which were left open. The gooswan-neck would enable the air to get in, but would prevent any livelihood organisms from getting into the infusion. Again no organisms grew in these flasks.

Pasteur had, thus, shown by these easy experiments that livelihood organisms do not arise spontaneously. Pasteur’s studies helped to solve several troubles related to brewing of wines. Wine creation was a significant industry in France at the time and ‘souring of wine’ or wine going bad was threatening this industry at that time. Pasteur showed that if sure harmful organisms could be kept out throughout the brewing procedure, wine would not sour. These studies had a profound effect in another region also, namely that of surgery.

Surgical wounds and injuries used to get infected invariably. So much so, that if one did not die of injury, one would certainly die of infections caught from surgical instruments, bandages etc. Taking Pasteur's work as the foundation, it was postulated that if the wounds could be kept 'clean', i.e. if disease producing germs could be prevented from getting into a wound, it would not get infected and would heal better.

Chemical Evolution

The question of how life came into being in the first lay still remained unanswered. To discover an answer to this question means looking back billions of years in time and trying to imagine what the circumstances on the earth could have been like, when life first appeared. Soviet biochemist, Oparin, and the British biologist, Haldane, tried to do just that. They proposed that "life could have arisen from non-livelihood organic molecules".

In other words, to understand the problem of origin of life one necessity has knowledge of the origin of 'organic molecules' on the earth. In the early stages of its evolution, with the hot gases condensing and molten matter which was solidifying to form what are rocks, today, the Earth acted as the vast factory, producing several types of compounds. The sources of power accessible for the formation of numerous kinds of molecules were cosmic rays, ultraviolet radiations, electrical discharges such as lightning, radioactivity, and heat from volcanoes and hot springs. Molecules of all sorts were being continuously created and destroyed due to their state of agitation. The lighter gases of the atmosphere such as hydrogen, helium, oxygen, nitrogen, etc., escaped into legroom unless they could combine with other elements to form liquids or solids. In such cases they remained on the earth. In scrupulous, oxygen could not remain as free oxygen. It combined with other elements to form compounds. For instance, hydrogen and oxygen combined to form water vapor, and remained in the Earth's atmosphere. Likewise, oxygen combined with calcium and carbon to form calcium carbonate, i.e. limestone.

Again, nitrogen, hydrogen, and oxygen combined jointly to form ammonium nitrate. Compounds of carbon and hydrogen were also shaped sometimes beside with nitrogen or oxygen. These compounds are, today, described "organic compounds".

The Earth had at the similar time started cooling down. As the Earth cooled sufficiently, torrential and prolonged rains were caused due to condensation of steam. The rains began to accumulate in the depressions on the earth and so the oceans were shaped. These hot bodies of water contained abundant and varied organic compounds washed down from the atmosphere. Sustained interaction in the middle of these compounds in the warm waters resulted in the formation of yet more compounds. The waters of this stage of the Earth's evolution have been referred to as "hot dilute soup", which amongst other things also contained "amino acids" having a composition of carbon, hydrogen, nitrogen, and oxygen. The molecules of amino acids combined jointly to form big intricate molecules, the "proteins" which are the structure blocks of life.

It is from this accumulation of intricate organic molecules that the first very easy self-replicating molecular systems accidentally originated. Because of the property of self-replication, they are described livelihood organisms. The Sun's deadly ultraviolet (UV) radiations would have killed any exposed livelihood molecules unless they were under the protective cover of water. Such primitive life also had a very limited food supply, since it depended on the slow sinking of organic materials synthesized by radiation in the upper layers of water. Thus, for millions of years, life necessity has lived under these special circumstances. Again, random combinations may have led to the formation of chlorophyll containing organisms which could produce their own food by procedure described photosynthesis. Such organisms had a better chance of survival. Throughout the procedure of photosynthesis, light from the Sun helps to synthesize carbohydrates like sugar and starch out of carbon dioxide and water. Oxygen is given off in the procedure.

As such organisms grew and photosynthesis proceeded, the atmosphere grew richer in free oxygen. This had a profound effect on the course of subsequent events. Oxygen when acted upon by ultraviolet radiation shapes ozone, a gas through which ultraviolet radiation cannot pass. This happens at a height of in relation to the 25 km above the surface of the earth, giving a protective 'ozone layer'. We have, therefore, the happy chain of events—more photosynthesis, more oxygen produced. And in its turn, more ozone produced out of oxygen in the atmosphere, screens the earth from the ultraviolet radiation of the Sun. This allowed livelihood organisms to come to the surface of water and to survive even on land, if they got thrown out of the swirling and splashing water. The oxygenation of Earth's atmosphere was very important from biological point of view, as organisms of greater complexity and even intelligence could eventually arise.

Miller's Experiment

The theory could be tested by recreating in the laboratory on a small level, the circumstances which necessity has lived when life originated on the earth. Miller, an American biologist subjected a gaseous mixture of methane, ammonia, water vapor, and hydrogen in a closed flask at 80°C to electric sparking, for a week. This mixture, with its temperature, and electric discharge through it, represented a situation that might have prevailed on the earth before life came into subsistence. When the contents of the flask were examined a week later, they were establishing to have amino acids which are essential for the formation of proteins. As we have said before, proteins are the essential structure blocks for livelihood organisms.

With the creation, in the laboratory, of molecules related to life, the credibility of the Oparin-Haldane theory of chemical evolution greatly increased. Several amino acids have been obtained, since by this way. So also some sugars and nitrogenous bases which are otherwise establish in the nucleus of a cell, which is a unit of livelihood organisms. Similar experiments have led to the manufacture of several compounds which form several types of fats and significant natural pigments. Miller's experiment thus shapes a turning point in our approach to the problem of the origin of life.

The proof, we get from Miller's experiment, is supported by proof of similar chemical reactions occurring in legroom even today. Chemical analysis of a meteorite which fell close to Murchi Murchison in Australia, in 1969, shewed the attendance of organic molecules. The kinds and relative proportions of these molecules were very similar to the products shaped in Miller's experiment. The attendance of organic molecules like methane, ethane, formaldehyde, acetylene etc. has been shown in interstellar legroom by radio astronomy also.

Biological Evolution

As the circumstances on the Earth changed, more and more intricate life shapes evolved. We can presume that biological evolution began with the formation of the first true cells. These necessities have been shapes that did not require free oxygen and existed at the expense of organic molecules accessible in the waters that bounded them. Eventually, as nutrients were depleted, the first cells capable of using carbon dioxide and power from light, to create their own food through photosynthesis necessity have arisen. Today, the diversity of plant and animal shapes we have ranges from easy single celled organisms to several types of plants on one face and animals including man on the other. Today, we have millions of 'species' of livelihood shapes on our planet. There is proof, that all the life shapes are inter-related and also that the higher shapes have evolved from the lower ones. We will study more in relation to the in the after that unit—Evolution of Man. The study of these millions of species individually would be a cumbersome task. Therefore, it is necessary to classify them in groups according to their evolutionary relationships and similarities in form and function.

The first category, Monera, consists of the mainly primitive single celled organisms. These alone were present in the beginning for in relation to the 2 billion years. These cells do not have a nucleus and are represented today by the bacteria and cynobacteria (formerly recognized as blue green algae). The second, Protista evolved in relation to the 1.5 billion years ago and consists of single celled organisms containing a nucleus. Algae, protozoans, and slime moulds belong to this kingdom.

You necessity have seen mushrooms sprouting under the trees throughout the rainy season. These and the unicellular yeast are members of the Kingdom Fungi. They are placed in a separate kingdom because they are one of the mainly intricate organisms that feed on decaying organic matter. Some fungi are also parasitic causing serious diseases in plants, animals and human beings while some fungi have given us the mainly useful group of medicines—antibiotics. You necessity have heard in relation to the penicillin, streptomycin etc., these are produced by fungi. The after that two kingdoms, Plants and Animals, evolved later as a result of adaptations to the changing environment of the earth. Plants began to evolve in relation to the 600 million years ago and mainly of these organisms possess a green pigment, chlorophyll, which helps them in manufacturing their own food by the procedure of photosynthesis. They first appeared in the seas as unicellular algae. The green algae are whispered to be ancestral links to the land plants like gymnosperms, i.e. non-flowering plants sand angiosperms or flowering plants. Today, these plants have diversified and increased in numbers tremendously.

While plants are multi-cellular organisms which synthesize their food through photosynthesis, animals are multi cellular organisms that survive on food produced by the plants. The animals are divided into invertebrates or animals without a backbone and vertebrates, i.e. animals with a backbone. It is possible to arrange the several animal groups so that one can see an augment in their complexity. The insects and worms are invertebrates, while the fishes, frogs, toads, snakes, birds, and mammals like cows, deer, horses, elephants, and even man, all belong to the group—vertebrates. Thus, we see that organic evolution proceeds slowly and in excess of these billions of years, several species have evolved and have adapted themselves to their environment.

Systems View of Life

That evolution has given rise to several kinds of life shapes from single celled bacteria to organisms as intricate as a human being. It may interest you to know, that even the simplest of these organisms is able to carry out several life procedures like, taking in food, excreting waste material, reacting to stimuli and reproducing offspring's. It is able to survive in varied environments.

The features, which we recognize as life, are in information an expression of the coordinated working of several parts in the organism. Several parts in an organism, whether plant or animal are not haphazardly put jointly but are organized into systems. A system is a set of some specific inter-related parts which are organized as one unit for some purpose. The parts work jointly and the whole combination shapes one unit. A car producing company, which is organized to produce transport vehicles, can be viewed as a system too. For the effective functioning of the company, all of its parts, such as the department that purchases raw materials, the factory, the management, and the sales department necessity work in unison. An animal or a plant is also made up of numerous parts which symbolize a well defined system. For instance, in an animal body, the parts concerned with the in-take of food and digesting it, the bones arranged as a skeleton to support the body, the heart circulating blood to dissimilar parts of the body through the arteries and veins and the brain getting signals and giving orders of several types jointly compose the system.

The assemblage of all plants and animals in an environment provided by each other as well as by the land, air, and water works collectively. The method these diverse shapes of life depend on each other creates one imagine this planet itself as a vast system. Looking at it in another method, the life and environment of the earth are a well coordinated system, within which there are sub-systems like individual organisms. And within each of these sub-systems, a single plant, or animal, one would discover an intricate multi cellular system. Likewise, industrial, agricultural, or educational systems can be visualized as the sub-systems in the society.

Organic systems uphold themselves in a given composite form and function. For instance, cat remnants a cat, it prowls for food, it may lay kittens, but its internal system functions on the foundation of physical principles with stability. How is this stability maintained by a system? Let us take a specific instance; how does a man or woman uphold this internal stability while the environment approximately them changes. For instance, how do they uphold a fixed temperature of 37°C, or the composition of their blood or the blood pressure? It has been establish that all organisms possess a type of information and manage network which directs them to adjust to several situations for survival, e.g., if you touch a snail, it withdraws into its shell. This is a type of information and manage device for protecting its life. If you sit in the Sun and you feel hot, a signal which is internally generated causes perspiration and produces cooling by evaporation of the sweat. This is another instance of information and manages for maintaining a fixed body temperature.

You will discover that all organisms possess a network of information and manage which may be very easy or at times quite complicated. Without it, neither the survival of an organism nor its subsistence in a stable physical condition is possible. A whole science of “cybernetics” has urbanized to study information and manage in a common method. This is because, even machines have to be so intended as to work with stability. You necessity be well-known with a device described a voltage regulator which is used with a television set or a refrigerator. If at any time the voltage becomes higher than a fixed value the voltage regulator brings it back to that value. Thus, the voltage supplied to the TV or refrigerator remnants stable.

Another instance is prevention of fire in structures particularly offices, hotels, etc. Here a technique is used to measure the temperature of the rooms and in case of a sudden rise in temperature in a scrupulous room a valve opens to sprinkle water from the ceiling. This is automatic protection against fire. If we just think in relation to the foundation of information and manage is that any deviation or “variation” from some “normal” value is detected and this generates a signal to correct the variation. Thus, variation, deviation or error being used to correct the error, is at the heart of all stable systems. One can also call it a “feedback” arrangement, which means, feeding the error back into manage so as to reduce or correct the error.

Livelihood organisms have extra ordinary capability to regulate their own lives according to the changes approximately them. They uphold a normal external and internal structure and environment in spite of the change in the outside surroundings. This state of constancy which is vital for life is recognized as ‘homeostasis. We will provide you just one instance of the feedback system in the human body which maintains the right amount of water in the blood. Kidneys are able to manage or check the loss of water from our body. For this, water is reabsorbed by the collecting tubes in the kidneys so as to prevent its undue loss in the form of urine. This absorption of water is under the manage of a chemical described anti-diuretic hormone - (ADH), which is produced by dedicated nerve cells in one of the parts of the fore brain. If more water begins to be lost by the body due to greater evaporation throughout summer, a decrease of water in the blood will take lay, changing its internal environment for which our body is very sensitive. At the time of need a positive signal to the brain causes the manufacture of this scrupulous chemical (ADH) which increases the absorption of water in the kidneys and reduces excretion of urine. The absorbed water gets back into the blood to uphold the normal concentration of the fluid.

Life Cycle

The thought that an organism is a system, consisting of several parts that function to uphold its internal environment throughout its life time is a significant concept in biology. But how is this system shaped? In its life time an organism passes through sure recognizable stages like birth, growth, reproduction, and death. We see approximately us plants sprouting from seeds, rising, bearing fruit, and ultimately drying up. Children are born, grow to adulthood, marry, have children of their own, grow old, and die. The series of events which happen from the time an organism is born to the time it dies constitute a life cycle.

The parents die and disappear but the progenies continue to repeat the life cycle, generation after generation. This stability of generations is made possible by reproduction. Primitive organisms like bacteria, algae, protozoa, etc. reproduce by easy division of the unicellular parent into smaller cells of almost equal size, each of which then grows to the size of the parent. Some organisms develop a small outgrowth or 'bud' which gets separated from the parent body and develops into an individual. In some lower animals, the body of the parent breaks into many parts and each part develops into a complete organism.

The general characteristic of all the procedures is that only a single parent is involved and as such all the offspring's produced are alike. This way of reproduction is described 'asexual reproduction'. Interestingly, asexual reproduction prevails only in the lower animals and in some plant groups. Man has used this to his advantage in plant breeding or horticulture. For instance, one can get a new rose plant by basically cutting a branch and raising it separately. This way is extensively used in raising some economically significant plants, like much diversity of citrus fruits, lemons, oranges etc. It has been establish, that plants produced in this method mature faster and bear fruit earlier than those grown from seeds.

Evolution, as we now know, is dependent upon individual variations due to interaction of heredity with environment. These variations are inherited by the procedure of sexual reproduction which involves two parents. Mainly animals and plants reproduce by this way. The male parent produces a highly dedicated cell described ‘sperm’ and the female produces ‘ovum’ or ‘egg’. These cells also described ‘gametes’ are dissimilar from other body cells in having half the number of ‘chromosomes’. Chromosomes are the chemical structures which carry information for all the life procedures. These two cells, sperm and ovum, unite by procedure described fertilization; to form a new cell described ‘zygote’. The common pattern of evolution from zygote to several celled organism is basically the satne for every animal and plant. In the first stage of evolution the single-celled zygote divides and the subsequent cells continue to divide repeatedly while adhering to one another. These cells finally become dedicated for the formation of several organs. For instance throughout the course of evolution, a few cells become dedicated for the formation of liver. These cells begin to multiply and provide birth to millions of cells so as to form a liver. Likewise, differentiated brain cells provide birth to complicated structure of brain in an organism. Other organs are also shaped in a similar method and become dissimilar parts of the organism. After the organism obtains maturity, aging starts with the passing of time.

Aging

Aging basically means the procedure of rising old or the procedure of progressive deterioration in the structure and function of the cells and organs of the body. Aging is an integral part of the life cycle of an organism. Even if an individual meets no fatal accident, or is not eaten up by other organisms or does not suffer a killing disease, death still comes as the natural final result of old age. We are all well-known with the symptoms of aging in man, some of which are arid and wrinkled skin, brittle bones, reduced blood circulation, and thin shriveled body. These outward signs of aging are the result of changes taking lay within the cells and the loss of skill of cells to divide.

Throughout a life time, millions of cells are destroyed and replaced rapidly by the procedure of cell division. When more cells are destroyed than are replaced, aging takes lay. The skill of cells to divide is fixed and is always featuring of an organism. This explains why some animals age more rapidly than others and have shorter life span than others.

The division rate of dissimilar body cells is also specific. In human beings, the cells forming the skin are continually destroyed and rebuilt, while the cells constituting the brain undergo no division at all from a time in relation to the 5-6 years after birth.

In recent years, much attention has been paid to study the procedure of aging, and how to slow it down. If this could be done and we could remain active physically and mentally for longer eras of life span, it would be wonderful. Wouldn't it? Physical exercises which counter sluggish blood circulation and other body procedures are recognized to be of some help. Some drugs, which can slow down aging, are also being experimented with.

Extra-Terrestrial Life

Just as we have been curious in relation to the how life originated on the Earth, we have also tried to explore whether there is life on any other planet in the Solar System or elsewhere in the universe. Explorations of outer legroom accepted out by spacecraft and ground based observatories, in recent years, have led us to the conclusion that in the whole Solar System, the planet Earth is, perhaps, the only lay where there is life. The other planets are at such an aloofness from the Sun that they are either too hot or too cold for life to exist. The one secure possibility is the planet Mars. Legroom probe Viking composed and analyzed samples of rock and soil from Mars to detect the attendance of life. But so distant no conclusive proof of any life, present or past, has been establish on this planet.

Man is also looking for life beyond the Solar System. Two approaches are currently accessible to him; either to send a man or an instrument to a scrupulous star in the Universe and look at local surface for life or to listen to the signals from outer legroom which may come in the form of radio waves. With our present technology, the first approach does not take us beyond the Solar System. The second approach is based on the assumption that there may be civilizations technically as advanced as or even more advanced than our own. So we can exchange radio messages with them. We have drawn a blank so distant on this front. But it is quite possible that our galaxy, the whole system of dust, gases, and stars within which the Sun moves, is already filled with chatter flanked by the distant older and more advanced civilizations! These signals may have been transmitted by a technique still undiscovered on Earth, so we may be missing them altogether! Recently it has been accounted that astronomers have establish some other stars, like our Sun, which have planets. If this is proved to be true, there may be millions of planetary systems in the Universe, raising the likelihood of life existing on some of them.

EVOLUTION OF MAN

Theories of Evolution

Towards the beginning of the nineteenth century, scientists had already started doubting the theory of special creation and several attempts were made to explain how dissimilar life shapes could have evolved. Lamarck, a French naturalist, for instance, whispered that all livelihood things adapted to their environment, by using and developing their organs and features that suit their environment best. If environment changed, their organs too changed accordingly to suit the needs and these changes were passed on from one generation to another. Accordingly, as the giraffe existed in an environment of high trees and had to stretch its neck to eat the leaves, its neck became extensive, and this trait was inherited by its descendants. This theory has won little support with the scientists. There is no proof that a dog trained to do sure things would pass on the skill to the after that generation, or a scientist's ability is passed on to his children.

Darwin and Natural Selection

The English naturalist Charles Darwin explained how biological evolution took laid, in his extra ordinary "The Origin of Species" in 1859. Darwin began his observations at the age of 22, as a naturalist on H.M.S. Beagle, which was a sail ship going round the world. He spent five adventurous years on the voyage. Throughout this era, he visited May islands of the Atlantic Ocean, some parts of the coasts of South America, and some islands of the South Pacific, of which the Galapagos is the mainly significant. This journey gave Darwin a prolonged exposure to a region of the world, radically dissimilar in its plant and animal life from his native lay. He composed and preserved a lot of material and took extensive notes throughout the voyage.

Once back in England, he spent almost 22 years examining his collection and pondering in excess of the question of how evolution of species could have taken lay. He drew the proof from three significant regions: the record of the rocks, in which he exposed fossils and imprints of creatures of the past ages; the sharing of animals and plants in the world; and finally from the study of the breeding experiments that were going on in the nineteenth century to improve life stock or to breed dogs and pigeons.

Darwin's great innovative step was to introduce the theory of 'natural selection' as the mechanism for evolution. Though the credit for giving this theory is usually given to Darwin, another English naturalist—Alfred Russell Wallace had conceived the theory of evolution independently at the similar time. The work of the two scientists was presented jointly at the meeting of the Linnean Society in London in 1858. The theory began with two observations. First, more organisms are born than can survive to reproduce; themselves, because the environment has limited means of survival. This overproduction results in a thrash about for subsistence and ultimate survival of the fittest. Plant and animal species compete within and in the middle of themselves for food, water, air, light—everything that enables organisms to survive and reproduce. The second observation is that offspring's, i.e. children differ slightly from their parents and from each other in features which they inherit. This we now call genetic difference. Darwin held the view that these variations are a source of evolutionary change. According to him in any group, individuals with features which enable them to adapt best to their environment survive and reproduce, while those who lack these features have a poor chance of survival. Thus, Nature selects and preserves the useful variations in a changing environment, Darwin described this natural selection.

Darwin's theory of evolution through natural selection is a scientific theory. Darwin urbanized it taking into explanation his own observations as well as the other existing information. Through his analysis, he not only postulated the theory of evolution, but was able to provide us a mechanism for evolutionary change. Though, like all scientific theories, Darwin's theory of evolution through natural selection has been enriched and extended as more facts have been exposed in relation to the livelihood beings. In his own time, Darwin's Theory of biological evolution was unacceptable to mainly people, especially the Church; as it spoke against special creation. In information, Darwin was very severely criticized for his views. Though, he got support from scientific circles. The debate went on for quite a few years, and continues even today flanked by the men of science and those of religion.

Human Evolution

Charles Darwin in the 'Origin of Species' gave a mechanism for the evolution of plants and animals in common, even though he had speculated in relation to the origin of man. Four years later, he published the "Descent of

Man”, in which he speculated that like other animals, man too had evolved form pre-existing livelihood shapes.

Darwin was greatly impressed by the similarities in the bodily structure of man and the great African apes, the Chimpanzee and the Gorilla. From this, he speculated oh the site of man’s origins. In his own words, “In each great region of the world, the livelihood mammals are closely related to the extinct species of the similar region. It is, therefore, probable that Africa was formerly inhabited by extinct apes, closely allied to the gorilla and chimpanzee; and as these two species are now man’s adjacent allies, it is somewhat more than probable, that our early ancestors existed on the African continent than elsewhere”.

Darwin had noted that embryos, i.e. early unborn young ones, of dissimilar organisms pass through very similar stages. Though, small alterations in the timings of events in early evolution might produce a substantial change in the mature organism; for instance in several methods adult humans are like juvenile apes, their small faces and globular cranium bones enclosing the brain are indicative of this. A crucial step in human evolution, enlargement of the brain, can be seen as a result of the slowing down of evolution in the embryo of an ape-like ancestor. Instead of stopping at birth, brain growth continues well into childhood, eventually producing a much superior and more complicated piece of mental machinery.

Primate Heritage

Man belongs to a group of animals described mammals which are dissimilar from other animal groups in possessing hair, and milk producing mammary glands, in the middle of other things. Mammals can be further divided into smaller groups or ‘orders’ on the foundation of differences within the group. ‘Primates’, the order to which man belongs, beside with apes and monkeys, were active throughout the night, that is, they were nocturnal in the beginning of their evolution. These animals were insect-eaters and existed on trees. This combination of feeding on insects, while being suspended on branches and twigs, led the primates to develop some significant adaptations. The hand underwent many changes. The thumb became opposable, that is, it closes to meet the finger tips which aided in holding the prey. Sensitive fingers urbanized, having nails rather than claws. Eye sockets were shifted to the front of the head, providing the primates a better vision and keen skill for judging aloofness.

These striking adaptations in the primates gave rise to big sized shapes, which adopted a diurnal life approach, i.e. they were active throughout the day. Their diet incorporated plant food like leaves and fruits. The origin of monkeys and apes took these adaptations to even higher stages. Possession of sensitive finger tips became of even greater importance, as the ripeness of fruits could be judged better by touch than by sight.

Apes move beneath the branches, suspended by extensive agile arms rather than walking beside them. This involves a relatively upright posture, and their hips became a part of this type of movement. Even when they move on the ground, apes occasionally walk as bipeds, i.e., on two feet. It may be an awkward walk with short steps and swaying motion, but it are two footed nonetheless. Changes in the skull and backbone help in the upright posture. And the method the Heart, lungs and other body organs are suspended in the abdomen differs from that of conventionally four footed animals.

Evidences of Human Evolution

The several adaptations associated with bipedal locomotion in the early primates. Several more changes were yet to take lay before the first human shapes were to emerge. You may like to know, what were these several changes, what evidences we have in support of the evolution of contemporary man—'Homo sepiens'. You would appreciate that, whenever a theory is postulated, we seem for evidences which support that row of thinking. This is true for the common theory of evolution and also for the evolution of our own species. Let us attempt to reconstruct this theory from the evidences that are provided from dissimilar sources, such as the fossil records of animals which existed in the past, the archaeological remnants of the past and their dating and more recently from biochemical studies. Cave paintings and other artifacts left by the early human beings speak of their social and cultural life.

Palaeontological Proof

Palaeontology is a branch of earth sciences, which is essentially a study of plant and animal life in the past geological eras, millions of years ago. It deals with the successive plants and animals which have inhabited the earth since the earliest times. Proof of their subsistence is left in the form of skeletons and bones buried in the rocks. These are recognized as fossils. Crucial proof of human evolution is provided by the study of these fossils.

Sometimes, the buried body and the skeleton of an animal disintegrate entirely. If the nearby material is sufficiently firm, a cavity may remain, having the exact outlines of the structures that disappeared. Such a cavity is described mold, Similar to molds are the impressions. These are left by extinct objects or parts of the body upon the nearby material. The impression is made while the nearby material is soft, like footprints in clay or lava. Footprints of extinct animals are also impressions affording valuable information in relation to the animals that made them.

This is because only throughout the last 50,000 years or so, man started burying his dead. These later fossils are better preserved and, therefore, provide us more information. For the earlier era, parts of bones are often the foundation of imagining the re-construction of the whole skeleton. The finding of fossils deposits is both a matter of chance and of deliberate excavation in sure regions of the earth.

The First Hominids: The First Human Fossil

The earliest human like or hominid remnants come from two separate East African sites. Ethiopia has acquiesced many hundred fossil fragments of individuals that existed and died flanked by 3.0 and 3.6 million years ago. The second location is in Tanzania where three hominids left a 20m trail of footprints some 3.75 million years ago. It is concluded that these earliest hominids were built with an ape's head on top of a man-like body. They illustrate hominid features to lay them firmly within human ancestry. There is proof that they walked on two feet. Though, enough primitive characteristics still remained, so as to put them secure to an ape-like ancestor with tree climbing habits.

Australopithecus—The Middle Human Shapes

By in relation to the two million years ago, there were many well recognized hominid ancestors in Africa. One of the earliest of these is Australopithecus. Fossils of Australopithecus, which have been recovered from South and East Africa, illustrate that their brains were relatively small, the bones enclosing the brain, therefore, were rather ape like, but the face was shorter than in apes. The enamel of the teeth indicated that Australopithecus ate essentially fruits. The proof for two-footed posture in Australopithecus is strong as the back bone shows the typical hominid curvature. Also the hip bone, which is the skeletal frame to which the legs are attached is shorter than in apes, although it is not as short as in contemporary humans.

Homo Habilis—The First Tool Makers

One of the mainly significant growths in human evolution was the dramatic expansion in brain size which, according to the fossil data accessible so distant, began in relation to the two million years ago. Sure specimens recovered from deposits in East Africa apparently have brain capacities in excess of 650 cm3 and secure to 800 cm3. These specimens were taken to symbolize the first appearance of our own type and were termed Homo habilis. The species name Homo habilis, means, literally, handy man. Homo habilis walked upright. The bones of the hand, while displaying several features of contemporary humans, are somewhat curved in spaces and more robust than in contemporary man, i.e. Homo sapiens. The leg and foot bones have features that are both ape-like and human-like, but overall, they are much closer to those of contemporary humans than to apes. The leg and foot were those of a habitual two-footed animal. The simultaneous occurrence of Homo habilis fossils and crude flakes and stone apparatus indicate that they used apparatus. There is no proof that this early form of homonids ate meat. Homo habilis

Homo Erectus

Homo erectus or the erect man first arose at least 1.6 million years ago and sustained to live for more than a million years before the transition to Homo sapiens occurred. Homo erectus had a big brain measuring 800 to 900 cm3. Fossils of Homo erectus have been exposed throughout Africa, Europe, and Asia. Signs that Homo erectus hunted animals and ate meat, are accessible from the stone apparatus he used and the marks which these apparatus left on the bones of animals which have been recovered close to their own dwelling regions.

There is proof , that the life of Homo erectus necessity has been fairly intricate; placing great demands on these individuals as intelligent, socially interacting beings. One can even imagine that a relatively intricate spoken language may have evolved. The prehistoric record is, of course, silent on this point.

The Neanderthals

These were the first human like fossils establish. The Neanderthals lived throughout western Europe and crossways into the close to east and central Asia from in relation to the 100,000 years ago 40,000 or 35,000 years ago, depending on the precise locality. There are, striking structural distinctions flanked by Neanderthals and contemporary humans. Although, the posture, range of movements and manipulation skills were the similar in Neanderthals as in modem humans, the skeleton was considerably more robust. Neanderthal's brain was on average slightly superior to normal for contemporary humans, measuring in relation to the 1400 cm3. The big brain size could be corresponding to the more robust musculature. Neanderthals were proficient hunters, skilled tool makers and they used hides for protecting their bodies. For the first time in human history, ritual burial became general.

Homo Sapiens—Contemporary Human Beings

Discoveries of number of fossils of Homo sapiens suggest that contemporary humans arose in Africa and migrated to the rest of the old world via the Middle East. It should be noted that these contemporary humans of the early upper stone age years ago, were distinctly more robust or sturdy as compared with the population today.

Archaeological Proof

The study of human antiquities, especially of prehistoric era is recognized as archaeology. The biological and cultural evolution of man proceeded face by face and the two influenced each other. Like the physical remnants of man, his cultural remnants also lie buried in the ancient deposits. Often, the two categories of proof are establish jointly in the similar layers of the rock. With the passage of time, and the rising capability of his brain and evolution in other bodily organs, man's culture became more and more varied and intricate. He learnt the use of new materials for creation apparatus and urbanized new techniques for improving them. The use of apparatus had a tremendous impact on increased access to food and therefore on cooperative livelihood in colonies. In several regions, archaeological remnants illustrate reindeer to be the principal source of meat they ate.

Anthropological Proof

Contemporary humans arose at a time when the Earth was going through a very cold and icy era described the Ice Age, which began in relation to the 75,000 years ago and ended in relation to the years ago. The Ice Age was at its mainly severe in relation to the 18,000 years ago, a point which coincides with the evolution of prehistoric art, represented by colorful images painted on cave walls and rock shelters, Several thousands of carved and engraved pieces of bone and ivory have been exposed from the similar era. A great majority of images are, indeed, of animals we can recognize, especially images of reindeer and bisons are plentiful; while paintings of people are strangely absent.

The common view in relation to the agriculture is that, at the end of the last Ice Age, i.e. in relation to the years ago, there was a dramatic global shift in the human pattern of livelihood from itinerant hunting and food gathering to settlements producing food. The detection that sprinkling of grain could lead to crops and hence to lot of food, necessity have had a big impact on social livelihood. Settled livelihood almost certainly led to augment of population, as also to evolution of music and dance to inhabit the leisure. Language and communication necessity have urbanized, as also a capability to wonder and to reflect in relation to the nature.

Biochemical Proof

Darwin had recognized that humans and the great apes shared several physical features. This led him to conclude, that humans and apes descended from a general stock. Darwin's conclusions were based on the study of fossils and the physical similarities that he had observed. Now, a century later biochemical studies of proteins and the genetic material—DNA illustrate how good his guess was. Biochemical studies illustrate us that, as evolution proceeds and the species get differentiated, they accumulate changes in the structure of their proteins and DNA. Longer the separation time, greater the changes. These changes are expressed in conditions of percent genetic aloofness which designates the proportional variation flanked by the DNA of the two species. Relative studies of the proteins of the African apes and humans showed that chimpanzees, gorillas, and humans are closely related to one another, while the Asian apes, i.e. the gibbon and orangutan were the more distant cousins of this trio.

Once the Asian and African apes were measured to be closely related and it was thought that the hominids urbanized from apes prior to 15 million years ago. Biochemical proof , though, designates that the ape-human divergence may have been much closer to five million years and that the gorilla split off first, leaving the chimpanzees and the human-like creatures to share a general ancestor briefly before separating. Ramapithecus—a fossil specimen establishes in Asia, Europe, and Africa was at one time thought to be closely related to the species of modem man. Though, on the foundation of biochemical proof , it has now been shown that it cannot be measured a homonid, because it existed before the Asian apes diverged from hominids. Similar is true for Sivapithecus indices, a fine fossil specimen of which was exposed in 1980 from the foothills of the western Himalayas in Pakistan.

Dating the Past

You would be wondering how we can tell, today, that a scrupulous rock is a million years old, or a fossil is 50 thousand years old. For instance, how do we estimate the duration of several geological eras on a time level of billions of years? Initially, such estimates were based on the rate at which geological procedures such as depositions of stones and rocks happen. Several layers of rock originated as deposits in the sea and at the mouths of rivers. Therefore, one method to get a thought of the length of time required to produce a deposit of a given thickness, is to measure the rate at which rivers are depositing sediments in the sea today.

With the developing knowledge of radioactivity, more accurate dating of fossils and sure kinds of rocks has become possible. Radioactive substances can be easily detected using sure instruments. They have built-in “clocks” in the form of ‘radioactive isotopes’ that change or decay at a constant rate into non-radioactive form. If this rate is recognized, the length of time since the fossil or the rock was shaped can be estimated by measuring the quantities in the rock, of the radioactive isotopes and the non-radioactive ones into which they have changed. For instance, Uranium is transformed into sure isotopes of lead which are not radioactive. So, the age of uranium-containing rocks can be determined by comparison of the proportions of undecided Uranium and that of the corresponding lead isotopes present in the rock. The way mainly commonly used, now, for estimating the age of fossils is radio-carbon dating. Radioactive isotope of carbon is commonly recognized as carbon-14. Since carbon-14 is chemically the similar as ordinary carbon, both are absorbed by plant and animal tissues in the similar proportion as they are present in the atmosphere as carbor dioxide. Plants use this carbon dioxide in creation their food. Animals eat the plants. Hence, the proportion of carbon-14 in the tissues of plants and animals is the similar as in the atmosphere, as extensive as the plant or the animal is livelihood. But as soon as it dies, no more carbon can enter its body as photosynthesis or food intake stops. Following death, the carbon-14, already present in the body, decays steadily into ordinary carbon. So the smaller the number of carbon-14 atoms remaining, the older is the fossil. Thus, if we take a piece of ancient wood or bone and measure the amount of carbon-14 present in it, we can estimate the age of the material. This technique has been applied to materials of recognized age, and thus its accuracy was tested giving confidence in the age determinations of strange samples.

The carbon-14 way is applicable only to organic materials which still contain carbon. It cannot be used for fossils in which all organic matter has decayed. In that case the age of the fossil can be estimated by determining the attendance of other radioactive elements like fluorine, or phosphorus.

REVIEW QUESTIONS

- Explain the theory of chemical evolution and its scientific basis,

- Discuss the theory of biological evolution and the diversity of life forms,
- Describe systems view of life, the mechanism of feedback, information, and control,
- Describe Darwin's theory of evolution through natural selection.
- Explain how the age of fossils of plants and animals etc. is determined.

CHAPTER 5

Environment and Natural Resources

STRUCTURE

- Learning objectives
- Ecosystem
- Components of environment
- The changing environment
- Natural resources
- Resource utilization, planning and management
- Food and agriculture
- Review questions

LEARNING OBJECTIVES

After studying this chapter you would be able to:

- Discuss the interdependence of life, and how its sustaining processes are delicately balanced in nature.
- Describe three components of the earth's environment that are: oceans, atmosphere and forests; and compare their features.
- Realize how technology, over the years, has contributed to the degradation of environment
- Understand the reasons for tremendous increase in population in our country and the role education can play in finding a solution.
- Define renewable and non-renewable resources.
- Describe types of natural resources available on our earth.
- Describe various aspects of conservation of water and mineral resources
- Discuss the various agro-techniques

ECOSYSTEM

An ecosystem is a society of livelihood organisms (plants, animals and microbes) in conjunction with the nonliving components of their environment (things like air, water and mineral soil), interacting as a system. These biotic and abiotic components are regarded as connected jointly through nutrient cycles and power flows. As ecosystems are defined by the network of interactions in the middle of organisms, and flanked by organisms and their environment, they can come in any size but usually encompass specific, limited spaces (although some scientists say that the whole planet is an ecosystem).

Power, water, nitrogen, and soil minerals are other essential abiotic components of an ecosystem. The power that flows through ecosystems is obtained primarily from the sun. It usually enters the system through photosynthesis, a procedure that also captures carbon from the atmosphere. By feeding on plants and on one another, animals play a significant role in the movement of matter and power through the system. They also power the quantity of plant and microbial biomass present. By breaking down dead organic matter, decomposers release carbon back to the atmosphere and facilitate nutrient cycling by converting nutrients stored in dead biomass back to a form that can be readily used by plants and other microbes.

Ecosystems are controlled both by external and internal factors. External factors such as climate, the parent material which shapes the soil and topography, manage the overall structure of an ecosystem and the method things work within it, but are not themselves influenced by the ecosystem. Other external factors contain time and potential biota. Ecosystems are dynamic entities—invariably, they are subject to periodic disturbances and are in the procedure of recovering from some past disturbance. Ecosystems in similar environments that are situated in dissimilar parts of the world can end up doing things very differently basically because they have dissimilar pools of species present. The introduction of non-native species can cause substantial shifts in ecosystem function. Internal factors not only manage ecosystem procedures but are also controlled by them and are often subject to feedback loops. While the resource inputs are usually controlled by external procedures like climate and parent material, the availability of these resources within the ecosystem is controlled by internal factors like decomposition, root competition, or shading. Other internal factors contain disturbance, succession and the kinds of species present. Although humans exist and operate within ecosystems, their cumulative effects are big enough to power external factors like climate.

Biodiversity affects ecosystem function, as do the procedures of disturbance and succession. Ecosystems give a diversity of goods and services upon which people depend; the principles of ecosystem management suggest that rather than managing individual species, natural resources should be supervised at the stage of the ecosystem itself. Classifying ecosystems into ecologically homogeneous units is a significant step towards effective ecosystem management, but there is no single, agreed-upon method to do this.

History and Development

Arthur Tansley, a British ecologist, was the first person to use the term "ecosystem" in a published work. Tansley devised the concept to draw attention to the importance of transfers of materials flanked by organisms and their environment. He later refined the term, describing it as "The whole system, ... including not only the organism-intricate, but also the whole intricate of physical factors forming what we call the environment". Tansley regarded ecosystems not basically as natural units, but as mental isolates. Tansley later defined the spatial extent of ecosystems using the term ecotope.

G. Evelyn Hutchinson, a pioneering limnologist who was a modern of Tansley's, combined Charles Elton's thoughts in relation to the trophic ecology with those of Russian geochemist Vladimir Vernadsky to suggest that mineral nutrient availability in a lake limited algal manufacture which would, in turn, limit the abundance of animals that feed on algae. Raymond Lindeman took these thoughts one step further to suggest that the flow of power through a lake was the primary driver of the ecosystem. Hutchinson's students, brothers Howard T. Odum and Eugene P. Odum, further urbanized a "systems approach" to the study of ecosystems, allowing them to study the flow of power and material through ecological systems.

Ecosystem Procedures

Power and carbon enter ecosystems through photosynthesis, are incorporated into livelihood tissue, transferred to other organisms that feed on the livelihood and dead plant matter, and eventually released through respiration. Mainly mineral nutrients, on the other hand, are recycled within ecosystems.

Ecosystems are controlled both by external and internal factors. External factors, also described state factors, manage the overall structure of an ecosystem and the method things work within it, but are not themselves influenced by the ecosystem. The mainly significant of these is climate. Climate determines the biome in which the ecosystem is embedded. Rainfall patterns and temperature seasonality determine the amount of water accessible to the ecosystem and the supply of power accessible (by influencing photosynthesis). Parent material, the underlying geological material that provides rise to soils, determines the nature of the soils present, and powers the supply of mineral nutrients. Topography also controls ecosystem procedures by affecting things like microclimate, soil development and the movement of water through a system. This may be the variation flanked by the ecosystem present in wetland situated in a small depression on the landscape, and one present on an adjacent steep hillside.

Other external factors that play a significant role in ecosystem functioning contain time and potential biota. Ecosystems are dynamic entities—invariably, they are subject to periodic disturbances and are in the procedure of recovering from some past disturbance. Time plays a role in the development of soil from bare rock and the recovery of a society from disturbance. Likewise, the set of organisms that can potentially be present in a region can also have a major impact on ecosystems. Ecosystems in similar environments that are situated in dissimilar parts of the world can end up doing things very differently basically because they have dissimilar pools of species present. The introduction of non-native species can cause substantial shifts in ecosystem function.

Unlike external factors, internal factors in ecosystems not only manage ecosystem procedures, but are also controlled by them. Consequently, they are often subject to feedback loops. While the resource inputs are usually controlled by external procedures like climate and parent material, the availability of these resources within the ecosystem is controlled by internal factors like decomposition, root competition, or shading. Other factors like disturbance, succession or the kinds of species present are also internal factors. Human behaviors are significant in approximately all ecosystems. Although humans exist and operate within ecosystems, their cumulative effects are big enough to power external factors like climate.

Primary Manufacture

Primary manufacture is the manufacture of organic matter from inorganic carbon sources. Overwhelmingly, this occurs through photosynthesis. The power incorporated through this procedure supports life on earth, while the carbon creates up much of the organic matter in livelihood and dead biomass, soil carbon and fossil fuels. It also drives the carbon cycle, which powers global climate via the greenhouse effect.

Through the procedure of photosynthesis, plants capture power from light and use it to combine carbon dioxide and water to produce carbohydrates and oxygen. The photosynthesis accepted out by all the plants in an ecosystem is described the gross primary manufacture (GPP). In relation to the 48–60% of the GPP is consumed in plant respiration. The remainder, that portion of

GPP that is not used up by respiration, is recognized as the net primary manufacture (NPP). Total photosynthesis is limited by a range of environmental factors. These contain the amount of light accessible, the amount of leaf region a plant has to capture light (shading by other plants is a major limitation of photosynthesis), rate at which carbon dioxide can be supplied to the chloroplasts to support photosynthesis, the availability of water, and the availability of appropriate temperatures for carrying out photosynthesis.

Power Flow

The carbon and power incorporated into plant tissues (net primary manufacture) is either consumed by animals while the plant is alive, or it remnants uneaten when the plant tissue dies and becomes detritus. In terrestrial ecosystems, roughly 90% of the NPP ends up being broken down by decomposers. The remainder is either consumed by animals while still alive and enters the plant-based trophic system, or it is consumed after it has died, and enters the detritus-based trophic system. In aquatic systems, the proportion of plant biomass that gets consumed by herbivores is much higher. In trophic systems photosynthetic organisms are the primary producers. The organisms that consume their tissues are described primary consumers or secondary producers—herbivores. Organisms which feed on microbes (bacteria and fungi) are termed microbivores. Animals that feed on primary consumers—carnivores—are secondary consumers. Each of these constitutes a trophic stage. The sequence of consumption—from plant to herbivore, to carnivore—shapes a food chain. Real systems are much more intricate than this—organisms will usually feed on more than one form of food, and may feed at more than one trophic stage. Carnivores may capture some prey which is part of a plant-based trophic system and others that are part of a detritus-based trophic system (a bird that feeds both on herbivorous grasshoppers and earthworms, which consume detritus). Real systems, with all these complexities, form food webs rather than food chains.

Decomposition

The carbon and nutrients in dead organic matter are broken down by a group of procedures recognized as decomposition. This releases nutrients that can then be re-used for plant and microbial manufacture, and returns carbon dioxide to the atmosphere (or water) where it can be used for photosynthesis. In the absence of decomposition, dead organic matter would accumulate in an ecosystem and nutrients and atmospheric carbon dioxide would be depleted. Almost 90% of terrestrial NPP goes directly from plant to decomposer.

Decomposition procedures can be separated into three categories—leaching, fragmentation, and chemical alteration of dead material. As water moves through dead organic matter, it dissolves and carries with it the water-soluble components. These are then taken up by organisms in the soil, react with mineral soil, or are transported beyond the confines of the ecosystem (and are measured "lost" to it). Newly shed leaves and newly dead animals have high concentrations of water-soluble components, and contain sugars, amino acids and mineral nutrients. Leaching is more significant in wet environments, and much less significant in arid ones.

Fragmentation procedures break organic material into smaller pieces, exposing new surfaces for colonization by microbes. Freshly shed leaf litter may be inaccessible due to an outer layer of cuticle or bark, and cell contents are protected by a cell wall. Newly dead animals may be sheltered by an exoskeleton. Fragmentation procedures, which break through these protective layers, accelerate the rate of microbial decomposition. Animals fragment detritus as they hunt for food, as doe's passage through the gut. Freeze-thaw cycles and cycles of wetting and drying also fragment dead material.

The chemical alteration of dead organic matter is primarily achieved through bacterial and fungal action. Fungal hyphae produce enzymes which can break through the tough outer structures nearby dead plant material. They also produce enzymes which break down lignin, which allows to them access to both cell contents and to the nitrogen in the lignin. Fungi can transfer carbon and nitrogen through their hyphal networks and thus, unlike bacteria, are not dependent solely on in the vicinity accessible resources.

Decomposition rates vary in the middle of ecosystems. The rate of decomposition is governed by three sets of factors—the physical environment (temperature, moisture and soil properties), the quantity and excellence of the dead material accessible to decomposers, and the nature of the microbial society itself. Temperature controls the rate of microbial respiration; the higher the temperature, the faster microbial decomposition occurs. It also affects soil moisture, which slows microbial growth and reduces leaching. Freeze-thaw cycles also affect decomposition—freezing temperatures kill soil microorganisms, which allow leaching to play a more significant role in moving nutrients approximately. This can be especially significant as the soil thaws in the Spring, creating a pulse of nutrients which become accessible.

Decomposition rates are low under very wet or very arid circumstances. Decomposition rates are highest in wet, moist circumstances with adequate stages of oxygen. Wet soils tend to become deficient in oxygen (this is especially true in wetlands), which slows microbial growth. In arid soils, decomposition slows as well, but bacteria continue to grow (albeit at a slower rate) even after soils become too arid to support plant growth. When the rains return and soils become wet, the osmotic gradient flanked by the bacterial cells and the soil water causes the cells to gain water quickly. Under these circumstances, several bacterial cells burst, releasing a pulse of nutrients. Decomposition rates also tend to be slower in acidic soils. Soils which are rich in clay minerals tend to have lower decomposition rates, and thus, higher stages of organic matter. The smaller particles of clay result in a superior surface region that can hold water. The higher the water contents of a soil, the lower the oxygen content and consequently, the lower the rate of decomposition. Clay minerals also bind particles of organic material to their surface, creation them less accessibly to microbes.

The excellence and quantity of the material accessible to decomposers is another major factor that powers the rate of decomposition. Substances like sugars and amino acids decompose readily and are measured "labile". Cellulose and hemicellulose, which are broken down more slowly, are "moderately labile". Compounds which are more resistant to decay, like lignin or cutin, are measured "recalcitrant". Litter with a higher proportion of labile compounds decomposes much more rapidly than does litter with a higher proportion of recalcitrant material. Consequently, dead animals decompose more rapidly than dead leaves, which themselves decompose more rapidly than fallen branches. As organic material in the soil ages, its excellence decreases. The more labile compounds decompose quickly, leaving and rising proportion of recalcitrant material. Microbial cell walls also contain a recalcitrant materials like chitin, and these also accumulate as the microbes die, further reducing the excellence of older soil organic matter.

Nutrient Cycling

Ecosystems continually exchange power and carbon with the wider environment; mineral nutrients, on the other hand, are mostly cycled back and forth flanked by plants, animals, microbes, and the soil. Mainly nitrogen enters ecosystems through biological nitrogen fixation, is deposited through precipitation, dust, gases, or is applied as fertilizer. Since mainly terrestrial ecosystems are nitrogen-limited, nitrogen cycling is a significant manage on ecosystem manufacture.

Until contemporary times, nitrogen fixation was the major source of nitrogen for ecosystems. Nitrogen fixing bacteria either live symbiotically with plants, or live freely in the soil. The energetic cost is high for plants which support nitrogen-fixing symbionts—as much as 25% of GPP when measured in controlled circumstances. Several members of the legume plant family support nitrogen-fixing symbionts. Some cyan bacteria are also capable of nitrogen fixation. These are phototrophs, which carry out photosynthesis. Like other nitrogen-fixing bacteria, they can either be free-livelihood or have symbiotic relationships with plants. Other sources of nitrogen contain acid authentication produced through the combustion of fossil fuels, ammonia gas which evaporates from agricultural meadows which have had fertilizers applied to them, and dust. Anthropogenic nitrogen inputs explanation for in relation to the 80% of all nitrogen fluxes in ecosystems.

When plant tissues are shed or are eaten, the nitrogen in those tissues becomes accessible to animals and microbes. Microbial decomposition releases nitrogen compounds from dead organic matter in the soil, where plants, fungi, and bacteria compete for it. Some soil bacteria use organic nitrogen-containing compounds as a source of carbon, and release ammonium ions into the soil. This procedure is recognized as nitrogen mineralization. Others convert ammonium to nitrite and nitrate ions, a procedure recognized as nitrification. Nitric oxide and nitrous oxide are also produced throughout nitrification. Under nitrogen-rich and oxygen-poor circumstances, nitrates and nitrites are converted to nitrogen gas, a procedure recognized as gentrification.

Other significant nutrients contain phosphorus, sulfur, calcium, potassium, magnesium, and manganese. Phosphorus enters ecosystems through weathering. As ecosystems age this supply diminishes, creation phosphorus-limitation more general in older landscapes (especially in the tropics). Calcium and sulfur are also produced by weathering, but acid authentication is a significant source of sulfur in several ecosystems. Potassium is primarily cycled flanked by livelihood cells and soil organic matter.

Function and Biodiversity

Ecosystem procedures are broad generalizations that actually take lay through the actions of individual organisms. The nature of the organisms—the species, functional groups and trophic stages to which they belong—dictates the sorts of actions these individuals are capable of carrying out, and the relative efficiency with which they do so. Thus, ecosystem procedures are driven by the number of species in an ecosystem, the exact nature of each individual species, and the relative abundance organisms within these species. Biodiversity plays a significant role in ecosystem functioning.

Ecological theory suggests that in order to coexist, species necessity have some stage of limiting parallel—they necessity be dissimilar from one another in some fundamental method, otherwise one species would competitively exclude the other. Despite this, the cumulative effect of additional species in an ecosystem is not linear—additional species may enhance nitrogen retention, for instance, but beyond some stage of species richness, additional species may have little additive effect. The addition (or loss) of species which are ecologically similar to those already present in an ecosystem tends to only have a small effect on ecosystem function. Ecologically separate species, on the other hand, have a much superior effect. Likewise, dominant species have a big impact on ecosystem function, while unusual species tend to have a small effect. Keystone species tend to have an effect on ecosystem function that is disproportionate to their abundance in an ecosystem.

Ecosystem Goods and Services

Ecosystems give a diversity of goods and services upon which people depend. Ecosystem goods contain the "tangible, material products" of ecosystem procedures—food, construction material, medicinal plants—in addition to less tangible items like tourism and recreation, and genes from wild plants and animals that can be used to improve domestic species. Ecosystem services, on the other hand, are usually "improvements in the condition or site of things of value". These contain things like the maintenance of hydrological cycles, cleaning air and water, the maintenance of oxygen in the atmosphere, crop pollination, and even things like beauty, inspiration, and opportunities for research. While ecosystem goods have traditionally been recognized as being the foundation for things of economic value, ecosystem services tend to be taken for granted. While Gretchen Daily's original definition distinguished flanked by ecosystem goods and ecosystem services, Robert Costanza and colleagues' later work and that of the Millennium Ecosystem Assessment lumped all of these jointly as ecosystem services.

Ecosystem Management

When natural resource management is applied to whole ecosystems, rather than single species, it is termed ecosystem management. A diversity of definitions exist: F. Stuart Chapin and coauthors describe it as "the application of ecological science to resource management to promote extensive-term sustainability of ecosystems and the delivery of essential ecosystem goods and services", while Norman Christensen and coauthors defined it as "management driven by explicit goals, executed by policies, protocols, and practices, and made adaptable by monitoring and research based on our best understanding of the ecological interactions and procedures necessary to sustain ecosystem structure and function" and Peter Brussard and colleagues defined it as "managing regions at several levels in such a method that ecosystem services and biological resources are preserved while appropriate human use and options for livelihood are sustained".

Although definitions of ecosystem management abound, there is a general set of principles which underlie these definitions. A fundamental principle is the extensive-term sustainability of the manufacture of goods and services by the ecosystem; "intergenerational sustainability [is] a precondition for management, not an afterthought". It also requires clear goals with respect to future trajectories and behaviors of the system being supervised. Other significant necessities contain a sound ecological understanding of the system, including connectedness, ecological dynamics, and the context in which the system is embedded. Other significant principles contain an understanding of the role of humans as components of the ecosystems and the use of adaptive management. While ecosystem management can be used as part of a plan for wilderness conservation, it can also be used in intensively supervised ecosystems.

Ecosystem Dynamics

Ecosystems are dynamic entities—invariably, they are subject to periodic disturbances and are in the procedure of recovering from some past disturbance. When an ecosystem is subject to some sort of perturbation, it responds by moving absent from its initial state. The tendency of a system to remain secure to its equilibrium state, despite that disturbance, is termed its resistance. On the other hand, the speed with which it returns to its initial state after disturbance is described its resilience.

From one year to another, ecosystems experience difference in their biotic and abiotic environments. A drought, an especially cold winter, and a pest outbreak all constitute short-term variability in environmental circumstances. Animal populations vary from year to year, structure up throughout resource-rich eras and crashing as they overshoot their food supply. These changes play out in changes in NPP, decomposition rates, and other ecosystem procedures. Longer-term changes also form ecosystem procedures—the forests of eastern North America still illustrate legacies of farming which ceased 200 years ago, while methane manufacture in eastern Siberian lakes is controlled by organic matter which accumulated throughout the Pleistocene.

Disturbance also plays a significant role in ecological procedures. F. Stuart Chapin and coauthors describe disturbance as "a relatively discrete event in time and legroom that alters the structure of populations, societies and ecosystems and causes changes in resources availability or the physical environment". This can range from tree falls and insect outbreaks to hurricanes and wildfires to volcanic eruptions and can cause big changes in plant, animal and microbe populations, as well soil organic matter content. Disturbance is followed by succession, a "directional change in ecosystem structure and functioning resulting from biotically driven changes in resources supply."

The frequency and severity of disturbance determines the method it impacts ecosystem function. Ecosystems that experience disturbances that sever undergo primary succession. Less severe disturbance like forest fires, hurricanes or farming result in secondary succession. More severe disturbance and more frequent disturbance result in longer recovery times. Ecosystems recover more quickly from less severe disturbance events.

The early stages of primary succession are dominated by species with small propagules (seed and spores) which can be dispersed extensive distances. The early colonizers—often algae, cyan bacteria and lichens—stabilize the substrate. Nitrogen supplies are limited in new soils, and nitrogen-fixing species tend to play a significant role early in primary succession. Unlike in primary succession, the species that control secondary succession are usually present from the start of the procedure, often in the soil seed bank. In some systems the successional pathways are fairly constant, and thus, are easy to predict. In others, there are several possible pathways—for instance, the introduced nitrogen-fixing legume, *Myrica faya*, alters successional trajectories in Hawai'ian forests.

The theoretical ecologist Robert Ulanowicz has used information theory apparatus to describe the structure of ecosystems, emphasizing mutual information (correlations) in studied systems. Drawing on this methodology and prior observations of intricate ecosystems, Ulanowicz depicts approaches to determining the stress stages on ecosystems and predicting system reactions to defined kinds of alteration in their settings (such as increased or reduced power flow, and eutrophication.

Ecosystem Ecology

Ecosystem ecology studies "the flow of power and materials through organisms and the physical environment". It seeks to understand the procedures which govern the stocks of material and power in ecosystems, and the flow of matter and power through them. The study of ecosystems can cover 10 orders of magnitude, from the surface layers of rocks to the surface of the planet.

There is no single definition of what constitutes an ecosystem. German ecologist Ernst-Detlef Schulze and coauthors defined an ecosystem as a region which is "uniform concerning the biological turnover, and contains all the fluxes above and below the ground region under consideration." They explicitly reject Gene Likens' use of whole river catchments as "too wide a demarcation" to be a single ecosystem, given the stage of heterogeneity within such a region. Other authors have suggested that an ecosystem can encompass a much superior region, even the whole planet. Schulze and coauthors also rejected the thought that a single rotting log could be studied as an ecosystem because the size of the flows flanked by the log and its surroundings are too big, relative to the proportion cycles within the log. Philosopher of science Spot Sagoff considers the failure to describe "the type of substance it studies" to be an obstacle to the development of theory in ecosystem ecology.

Ecosystems can be studied through a diversity of approaches—theoretical studies, studies monitoring specific ecosystems in excess of extensive eras of time, those that seem at differences flanked by ecosystems to elucidate how they work and direct manipulative experimentation. Studies can be accepted out at a diversity of levels, from microcosms and mesocosms which serve as simplified symbols of ecosystems, through whole-ecosystem studies. American ecologist Stephen R. Carpenter has argued that microcosm experiments can be "irrelevant and diversionary" if they are not accepted out in conjunction with field studies accepted out at the ecosystem level, because microcosm experiments often fail to accurately predict ecosystem-stage dynamics.

The Hubbard Brook Ecosystem Study, recognized in the White Mountains, New Hampshire in 1963, was the first successful effort to study a whole watershed as an ecosystem. The study used stream chemistry as a means of monitoring ecosystem properties, and urbanized a detailed biogeochemical model of the ecosystem. Extensive-term research at the location led to the detection of acid rain in North America in 1972, and was able to document the consequent depletion of soil cations (especially calcium) in excess of the after that many decades.

Classification

Classifying ecosystems into ecologically homogeneous units is a significant step towards effective ecosystem management. A diversity of systems exist, based on vegetation cover, remote sensing, and bioclimatic classification systems. American geographer Robert Bailey defines a hierarchy of ecosystem units ranging from micro ecosystems (individual homogeneous sites, on the order of 10 square kilometers (4 sq mi) in region), through mesoecosystems (landscape mosaics, on the order of 1,000 square kilometers (400 sq mi)) to macroecosystems (ecoregions, on the order of 100,000 square kilometers (40,000 sq mi)).

Bailey outlined five dissimilar ways for identifying ecosystems: *gestalt* ("a whole that is not derived through considerable of its parts"), in which regions are recognized and boundaries drawn intuitively; a map overlay system where dissimilar layers like geology, landforms and soil kinds are overlain to identify ecosystems; multivariate clustering of location attributes; digital image processing of remotely sensed data grouping regions based on their appearance or other spectral properties; or by a "controlling factors way" where a subset of factors (like soils, climate, vegetation physiognomy or the sharing of plant or animal species) are selected from a big array of possible ones are used to delineate ecosystems. In contrast with Bailey's methodology, Puerto Rico ecologist Ariel Lugo and coauthors recognized ten features of an effective classification system: that it be based on georeferenced, quantitative data; that it should minimize subjectivity and explicitly identify criteria and assumptions; that it should be structured approximately the factors that drive ecosystem procedures; that it should reflect the hierarchical nature of ecosystems; that it should be flexible enough to conform to the several levels at which ecosystem management operates; that it should be tied to reliable events of climate so that it can "anticipat[e] global climate change; that it be applicable worldwide; that it should be validated against independent data; that it take into explanation the sometimes intricate connection flanked by climate, vegetation and ecosystem functioning; and that it should be able to adapt and improve as new data become accessible".

Kinds of Ecosystems

- Aquatic ecosystem
- Marine ecosystems
- Freshwater ecosystems
- River ecosystem
- Terrestrial ecosystem
- Forest
- Greater Yellowstone Ecosystem
- Big marine ecosystem
- Littoral zone
- Riparian zone
- Subsurface litho autotrophic microbial ecosystem
- Urban ecosystem
- Movile Cave
- Desert

COMPONENTS OF ENVIRONMENT

The Ocean

An ocean; the World Ocean of classical antiquity) is a body of saline water that composes a big part of a planet's hydrosphere. In the context of Earth, it refers to one or all of the major divisions of the planet's World Ocean – they are, in descending order of region, the Pacific, Atlantic, Indian, Southern (Antarctic), and Arctic Oceans. The word "sea" is often used interchangeably with "ocean", but strictly speaking a sea is a body of saline water (perhaps a division of the World Ocean) partly or fully enclosed by land.

Earth is the only planet recognized to have an ocean (or any big amounts of open liquid water). Almost 72% of the planet's surface (~3.6x10 km) is sheltered by saline water that is customarily divided into many principal oceans and smaller seas, with the ocean covering almost 71% of the Earth's surface. In conditions of the hydrosphere of the Earth, the ocean contains 97% of the Earth's water. Oceanographers have stated that out of 97%, only 5% of the ocean as a whole on Earth has been explored. Because it is the principal component of Earth's hydrosphere, the world ocean is integral to all recognized life, shapes part of the carbon cycle, and powers climate and weather patterns. The total volume is almost 1.3 billion cubic kilometers (310 million cu mi) with an average depth of 3,682 meters (12,080 ft). It is the habitat of 230,000 recognized species, although much of the ocean's depths remain unexplored and it is estimated that in excess of two million marine species exist. The origin of Earth's oceans is still strange, but oceans are whispered to have shaped in the Hadean era and may have been the impetus for the emergence of life.

Extraterrestrial oceans may be composed of a wide range of elements and compounds. The only confirmed big stable bodies of extraterrestrial surface liquids are the lakes of Titan, although there is proof for the subsistence of oceans elsewhere in the Solar System. Early in their geologic histories, Mars and Venus are theorized to have had big water oceans. The Mars ocean hypothesis suggests that almost a third of the surface of Mars was once sheltered by water, though the water on Mars is no longer oceanic, and a runaway greenhouse effect may have boiled absent the global ocean of Venus. Compounds such as salts and ammonia dissolved in water lower its freezing point, so that water might exist in big quantities in extraterrestrial environments as brine or convicting ice. Unconfirmed oceans are speculated beneath the surface of several dwarf planets and natural satellites; notably, the ocean of Europa is whispered to have in excess of twice the water volume of Earth. The Solar System's gas giant planets are also whispered to possess liquid atmospheric layers of yet to be confirmed compositions. Oceans may also exist on exoplanets and exomoons, including surface oceans of liquid water within a circumstellar habitable zone. Ocean planets are a hypothetical kind of planet with a surface totally sheltered with liquid.

Earth's Global Ocean

Divisions

Though usually described as many separate oceans, these waters comprise one global, interconnected body of salt water sometimes referred to as the World Ocean or global ocean. This concept of a continuous body of water with relatively free interchange in the middle of its parts is of fundamental importance to oceanography. The major oceanic divisions are defined in part by the continents, several archipelagos, and other criteria.

Physical Properties

The total mass of the hydrosphere is in relation to the 1,400,000,000,000,000,000 metric tons (1.5 × 10 short tons) or 1.4 × 10 kg, which is in relation to the 0.023 percent of the Earth's total mass. Less than 3 percent is fresh water; the rest is saltwater, mostly in the ocean. The region of the World Ocean is 361 million square kilometers (139 million square miles), and its volume is almost 1.3 billion cubic kilometers (310 million cu mi). This can be thought of as a cube of water with an edge length of 1,111 kilometers (690 mi). Its average depth is 3,790 meters (12,430 ft), and its maximum depth is 10,923 meters (6.787 mi). Almost half of the world's marine waters are in excess of 3,000 meters (9,800 ft) deep. The vast expanses of Deep Ocean (anything below 200 meters (660 ft) cover in relation to the 66% of the Earth's surface. This does not contain seas not linked to the World Ocean, such as the Caspian Sea.

The bluish color of water is a composite of many contributing mediators. Prominent contributors contain dissolved organic matter and chlorophyll.

Sailors and other mariners have accounted that the ocean often emits a visible glow, or luminescence, which extends for miles at night. In 2005, scientists announced that for the first time, they had obtained photographic proof of this glow. It is mainly likely caused by bioluminescence.

Zones and Depths

Oceanographers divide the ocean into dissimilar zones depending on the present physical and biological circumstances. The pelagic zone comprises all open ocean regions, and can be divided into further regions categorized by depth and light abundance. The photic zone covers the oceans from surface stage to 200 meters down. This is the region where photosynthesis can happen and therefore is the mainly biodiversity. Since plants require photosynthesis, life establish deeper than this necessity either rely on material sinking from above or discover another power source; hydrothermal vents are the primary option in what is recognized as the aphotic zone (depths exceeding 200 m). The pelagic part of the photic zone is recognized as the epipelagic. The pelagic part of the aphotic zone can be further divided into regions that succeed each other vertically according to temperature. The mesopelagic is the uppermost region. Its lowermost boundary is at a thermocline of 12 °C (54 °F), which, in the tropics usually lies at 700–1,000 meters (2,300–3,300 ft). After that is the bathypelagic lying flanked by 10 and 4 °C (50 and 39 °F), typically flanked by 700–1,000 meters (2,300–3,300 ft) and 2,000–4,000 meters (6,600–13,000 ft) Lying beside the top of the abyssal plain is the abyss pelagic, whose lower boundary lies at in relation to the 6,000 meters (20,000 ft). The last zone comprises the deep trenches, and is recognized as the hadalpelagic. This lies flanked by 6,000–11,000 meters (20,000–36,000 ft) and is the deepest oceanic zone.

Beside with pelagic aphotic zones there are also benthic aphotic zones. These correspond to the three deepest zones of the deep-sea. The bathyal zone covers the continental slope down to in relation to the 4,000 meters (13,000 ft). The abyssal zone covers the abyssal plains flanked by 4,000 and 6,000 m. Lastly, the hadal zone corresponds to the hadalpelagic zone which is established in the oceanic trenches. The pelagic zone can also be split into two sub regions, the neritic zone and the oceanic zone. The neritic encompasses the water mass directly above the continental shelves, while the oceanic zone comprises all the totally open water. In contrast, the littoral zone covers the region flanked by low and high tide and symbolizes the middle region flanked by marine and terrestrial circumstances. It is also recognized as the intertidal zone because it is the region where tide stage affects the circumstances of the region.

Exploration

Ocean travel by boat dates back to prehistoric times, but only in contemporary times has extensive underwater travel become possible.

The deepest point in the ocean is the Mariana Trench, situated in the Pacific Ocean close to the Northern Mariana Islands. Its maximum depth has been estimated to be 10,971 meters (35,994 ft) The British naval vessel, *Challenger II* surveyed the trench in 1951 and named the deepest part of the trench, the "Challenger Deep". In 1960, the Trieste successfully reached the bottom of the trench, manned by a crew of two men.

Much of the ocean bottom remnants unexplored and unmapped. A global image of several underwater characteristics superior than 10 kilometers (6.2 mi) was created in 1995 based on gravitational distortions of the nearby sea surface.

Climate

Ocean currents greatly affect the Earth's climate by transferring heat from the tropics to the Polar Regions, and transferring warm or cold air and precipitation to coastal regions, where winds may carry them inland. Surface heat and freshwater fluxes make global density gradients that drive the thermohaline circulation part of big-level ocean circulation. It plays a significant role in supplying heat to the Polar Regions, and thus in sea ice regulation. Changes in the thermohaline circulation are thought to have important impacts on the Earth's radiation budget. Insofar as the thermohaline circulation governs the rate at which deep waters reach the surface, it may also significantly power atmospheric carbon dioxide concentrations.

It is often stated that the thermohaline circulation is the primary cause that the climate of Western Europe is so temperate. An alternate hypothesis claims that this is mainly incorrect, and that Europe is warm mostly because it lies downwind of an ocean basin, and because atmospheric waves bring warm air north from the subtropics.

The Antarctic Circumpolar Current encircles that continent, influencing the region's climate and connecting currents in many oceans. One of the mainly dramatic shapes of weather occurs in excess of the oceans: tropical cyclones (also described "typhoons" and "hurricanes" depending upon where the system shapes).

Biology

The ocean has an important effect on the biosphere. Oceanic evaporation, as a stage of the water cycle, is the source of mainly rainfall, and ocean temperatures determine climate and wind patterns that affect life on land. Life within the ocean evolved 3 billion years prior to life on land. Both the depth and the aloofness from shore strongly power the biodiversity of the plants and animals present in each region.

Life forms native to the ocean contain:

- Fish;
- Radiata, such as jellyfish (Cnidaria);
- Cetacea, such as whales, dolphins, and porpoises;
- Cephalopods, such as octopus and squid;
- Crustaceans, such as lobsters, clams, shrimp, and krill;
- Marine worms;
- Plankton; and
- Echinoderms, such as brittle stars, starfish, sea cucumbers, and sand dollars.

Economic Value

The oceans are essential to transportation. This is because mainly of the world's goods move by ship flanked by the world's seaports. Oceans are also the major supply source for the fishing industry. Some of the more major ones are shrimp, fish, crabs, and lobster.

Extraterrestrial Oceans

While Earth is the only recognized planet with big stable bodies of liquid water on its surface and the only one in our Solar System, other celestial bodies are whispered to possess big oceans.

Planets

The gas giants, Jupiter and Saturn, are thought to lack surfaces and instead have a stratum of liquid hydrogen, though their planetary geology is not well understood. Likewise the ice giants of Uranus and Neptune may also possess vast oceans of liquid water under their thick atmospheres, though their internal structure has not been confirmed.

There is currently much debate in excess of whether Mars once had an ocean in its northern hemisphere, and in excess of what happened to it; recent findings by the Mars Exploration Rover mission indicate Mars had extensive-term standing water in at least one site, but its extent is not recognized.

Astronomers consider that Venus had liquid water and perhaps oceans in its very early history. If they lived, all later vanished via resurfacing.

Natural Satellites

A global layer of liquid water thick enough to decouple the crust from the mantle is whispered to be present on Titan, Europa and, with less certainty, Callisto, Ganymede, and Triton. A magma ocean is thought to be present on Io. Geysers have been established on Saturn's moon Enceladus, though their origins are not well understood. Other icy moons may also have internal oceans, or have once had internal oceans that have now frozen.

Big bodies of Liquid hydrocarbons are thought to be present on the surface of Titan, though they are not big enough to be described as oceans and are sometimes referred to as *lakes* or seas. The Cassini–Huygens legroom mission initially exposed only what appeared to be arid lakebeds and empty river channels, suggesting that Titan had lost what surface liquids it might have had. Cassini's more recent fly-by of Titan offers radar images that strongly suggest hydrocarbon lakes exist close to the colder polar regions. Titan is thought to have a subterranean water ocean under the ice and hydrocarbon mix that shapes its outer crust.

Dwarf Planets and Trans-Neptunian Objects

Ceres appears to be differentiated into a rocky core and icy mantle and may harbor a liquid water ocean under its surface. Not enough is recognized of the superior Trans-Neptunian objects to determine whether they are differentiated bodies capable of possessing oceans, although models of radioactive decay suggest that Pluto, Eris, Sedna, and Orcus have oceans beneath solid icy crusts at the core-boundary almost 100 to 180 km thick.

Extra Solar

Some planets and natural satellites beyond the Solar System are likely to possess oceans, including possible water ocean planets similar to Earth in the habitable zone or "Liquid Water belt". The discovery of oceans, even through the spectroscopy way, though is likely to prove very hard and inconclusive.

Theoretical models have been used to predict with high probability that GJ 1214 b, detected by transit, is composed of exotic form of ice VII, creation up 75% of its mass.

Other possible candidates are merely speculated based on their mass and location in the habitable zone contain planet though little is actually recognized of their composition. Some scientists have speculated Kepler-22b to be an "ocean-like" planet. Models have been proposed for Gliese 581 d that could contain surface oceans. Gliese 436 b is speculated to have an ocean of "hot ice". Extrasolar moons orbiting planets, particularly gas giants within their parent star's habitable zone may theoretically possess surface oceans.

The Atmosphere

The atmosphere of Earth is a layer of gases nearby the planet Earth that is retained by Earth's gravity. The atmosphere protects life on Earth by absorbing ultraviolet solar radiation, warming the surface through heat retention (greenhouse effect), and reducing temperature extremes flanked by day and night (the diurnal temperature difference).

The general name given to the atmospheric gases used in breathing and photosynthesis is air. Arid air contains roughly (by volume) 78.09% nitrogen, 20.95% oxygen, 0.93% argon, 0.039% carbon dioxide, and small amounts of other gases. Air also contains a variable amount of water vapor, on average approximately 1%. While air content and atmospheric pressure vary at dissimilar layers, air appropriate for the survival of terrestrial plants and terrestrial animals currently is only recognized to be establishing in Earth's troposphere and artificial atmospheres.

The atmosphere has a mass of in relation to the 5×10 kg, three quarters of which is within in relation to the 11 km (6.8 mi; 36,000 ft) of the surface. The atmosphere becomes thinner and thinner with rising altitude, with no definite boundary flanked by the atmosphere and outer legroom. The Kármán row, at 100 km (62 mi), or 1.57% of the Earth's radius, is often used as the border flanked by the atmosphere and outer legroom. Atmospheric effects become noticeable throughout atmospheric reentry of spacecraft at an altitude of approximately 120 km (75 mi). Many layers can be distinguished in the atmosphere, based on features such as temperature and composition.

The study of Earth's atmosphere and its procedures is described Atmospheric science or aerology. Early pioneers in the field contain Léon Teisserenc de Bort and Richard Assmann.

Composition

Air is mainly composed of nitrogen, oxygen, and argon, which jointly constitute the major gases of the atmosphere. Water vapor accounts for roughly 0.25% of the atmosphere by mass. The concentration of water vapor (a greenhouse gas) varies significantly from approximately 10 ppmv in the coldest portions of the atmosphere to as much as 5% ppmv in hot, humid air masses, and concentrations are typically provided for arid air without any water vapor. The remaining gases are often referred to as trace gases, in the middle of which are the greenhouse gases such as carbon dioxide, methane, nitrous oxide, and ozone. Filtered air comprises trace amounts of several other chemical compounds. Several substances of natural origin may be present in small amounts as aerosol in an unfiltered air example, including dust of mineral and organic composition, pollen and spores, sea spray, and volcanic ash. Several industrial pollutants also may be present as gases or aerosol, such as chlorine (elemental or in compounds), fluorine compounds and elemental mercury vapor. Sulfur compounds such as hydrogen sulfide and sulfur dioxide [SO_2] may be derived from natural sources or from industrial air pollution.

Structure of the Atmosphere

Principal Layers

In common, air pressure and density decrease with altitude in the atmosphere. Though, temperature has a more complicated profile with altitude, and may remain relatively constant or even augment with altitude in some regions. Because the common pattern of the temperature/altitude profile is constant and recognizable through means such as balloon soundings, the temperature behavior gives a useful metric to distinguish flanked by atmospheric layers. In this method, Earth's atmosphere can be divided (described atmospheric stratification) into five main layers. From highest to lowest, these layers are:

Exosphere

The exosphere is the outermost layer of Earth's atmosphere, extending beyond the exobase at an altitude of in relation to the 600 km. It is mainly composed of hydrogen, helium and some heavier molecules such as nitrogen, oxygen, and carbon dioxide closer to the exobase. These free-moving particles follow ballistic trajectories and may migrate in and out of the magnetosphere or the solar wind.

Thermosphere

Temperature increases with height in the thermosphere from the mesopause up to the thermo pause, then is constant with height. Unlike in the stratosphere, where a temperature inversion is caused by absorption of radiation by ozone, in the thermosphere the inversion is a result of the very low density of molecules. The temperature of this layer can raise to 1,500 °C (2,700 °F), though the gas molecules are so distant separately that temperature in the usual sense is not well defined. The air is so rarefied that an individual molecule (of oxygen, for instance) travels an average of 1 kilometer flanked by collisions with other molecules. The International Legroom Station orbits in this layer, flanked by 320 and 380 km (200 and 240 mi). Because of the relative infrequency of molecular collisions, air above the mesopause is poorly mixed compared with air below. While the composition from the troposphere to the mesosphere is fairly constant, above a sure point, air is poorly mixed and becomes compositionally stratified. The point dividing these two regions is recognized as the turbo pause. The region below is the homosphere, and the region above is the hydrosphere. The top of the thermosphere is the bottom of the exosphere, described the exobase. Its height varies with solar action and ranges from in relation to the 350–800 km (220–500 mi; 1,100,000–2,600,000 ft).

Mesosphere

The mesosphere extends from the stratopause at in relation to the 50 km (31 mi; 160,000 ft) to 80–85 km (50–53 mi; 260,000–280,000 ft). It is the layer where mainly meteors burn up upon entering the atmosphere. Temperature decreases with height in the mesosphere. The mesopause, the temperature minimum that marks the top of the mesosphere, is the coldest lay on Earth and has an average temperature approximately −85 °C (−120 °F; 190 K). At the mesopause, temperatures may drop to −100 °C (−150 °F; 170 K). Due to the cold temperature of the mesosphere, water vapor is frozen, forming ice clouds (or Noctilucent clouds). A kind of lightning referred to as either sprites or ELVES, form several miles above thunderclouds in the troposphere.

Stratosphere

The stratosphere extends from the tropopause at in relation to the 12 km (7.5 mi; 39,000 ft) to in relation to the 51 km (32 mi; 170,000 ft). Temperature increases with height due to increased absorption of ultraviolet radiation by the ozone layer, which restricts turbulence and mixing. While the temperature may be −60 °C (−76 °F; 210 K) at the tropopause, the top of the stratosphere is much warmer, and may be close to freezing. The pressure here is 1/1000 sea stage.

Troposphere

The troposphere begins at the surface and extends to flanked by 9 km (30,000 ft) at the poles and 17 km (56,000 ft) at the equator, with some difference due to weather. The troposphere is mostly heated by transfer of power from the surface, so on average the lowest part of the troposphere is warmest, and temperature decreases with altitude. This promotes vertical mixing (hence the origin of its name in the Greek word, *trope*, meaning turn or overturn). The troposphere contains roughly 80% of the mass of the atmosphere. The tropopause is the boundary flanked by the troposphere and stratosphere.

Other Layers

Separately from the five principal layers which are mainly determined by temperature, many layers may be distinguished by other properties:

- The ozone layer is contained within the stratosphere. In this layer ozone concentrations are in relation to the 2 to 8 parts per million, which is much higher than in the lower atmosphere but still very small compared to the main components of the atmosphere. It is mainly situated in the lower portion of the stratosphere from in relation to the

15–35 km (9.3–22 mi; 49,000–110,000 ft), though the thickness varies seasonally and geographically. In relation to the 90% of the ozone in our atmosphere is contained in the stratosphere.

The ionosphere is a region of the atmosphere that is ionized by solar radiation. It stretches from 50 to 1,000 km (31 to 620 mi; 160,000 to 3,300,000 ft) and comprises parts of the exosphere and the thermosphere. It shapes the inner edge of the magnetosphere. It has practical importance because it powers, for instance, radio propagation on the Earth. It is responsible for auroras.

The homosphere and heterosphere are defined by whether the atmospheric gases are well mixed. In the homosphere the chemical composition of the atmosphere does not depend on molecular weight because the gases are mixed by turbulence. The homosphere comprises the troposphere, stratosphere, and mesosphere. Above the *turbopause* at in relation to the 100 km (62 mi; 330,000 ft) (essentially corresponding to the mesopause), the composition varies with altitude. This is because the aloofness that particles can move without colliding with one another is big compared with the size of motions that cause mixing. This allows the gases to stratify by molecular weight, with the heavier ones such as oxygen and nitrogen present only close to the bottom of the heterosphere. The upper part of the heterosphere is composed approximately totally of hydrogen, the lightest element.

The planetary boundary layer is the part of the troposphere that is adjacent the Earth's surface and is directly affected by it, mainly through turbulent diffusion. Throughout the day the planetary boundary layer usually is well-mixed, while at night it becomes stably stratified with weak or intermittent mixing. The depth of the planetary boundary layer ranges from as little as in relation to the 100 m on clear, calm nights to 3000 m or more throughout the afternoon in arid regions.

The average temperature of the atmosphere at the surface of Earth is 14 °C (57 °F; 287 K) or 15 °C (59 °F; 288 K), depending on the reference.

Physical Properties

Pressure and Thickness

The average atmospheric pressure at sea stage is 1 average atmosphere (atm)=101.3 kPa (kilopascals)=14.7 psi (pounds per square inch)=760 torr=29.92 inches of mercury (symbol Hg). Total atmospheric mass is 5.1480×10 kg (1.135×10 lb), in relation to the 2.5% less than would be inferred from the average sea stage pressure and the Earth's region of 51007.2 mega hectares, this portion being displaced by the Earth's mountainous terrain.

If the atmosphere had a uniform density, it would terminate abruptly at an altitude of 8.50 km (27,900 ft). It actually decreases exponentially with altitude, dropping by half every 5.6 km (18,000 ft) or by a factor of 1/e every 7.64 km (25,100 ft), the average level height of the atmosphere below 70 km (43 mi; 230,000 ft). Though, the atmosphere is more accurately modeled with a customized equation for each layer that takes gradients of temperature, molecular composition, solar radiation, and gravity into explanation.

In summary, the mass of Earth's atmosphere is distributed almost as follows:

- 50% is below 5.6 km (18,000 ft).
- 90% is below 16 km (52,000 ft).
- 99.99997% is below 100 km (62 mi; 330,000 ft), the Kármán row. By international convention, this marks the beginning of legroom where human travelers are measured astronauts.

By comparison, the summit of Mt. Everest is at 8,848 m (29,029 ft); commercial airliners typically cruise flanked by 10 km (33,000 ft) and 13 km (43,000 ft) where the thinner air improves fuel economy; weather balloons reach 30.4 km (100,000 ft) and above; and the highest X-15 flight in 1963 reached 108.0 km (354,300 ft).

Even above the Kármán row, important atmospheric effects such as auroras still happen. Meteors begin to glow in this region though the superior ones may not burn up until they penetrate more deeply. The several layers of Earth's ionosphere, significant to HF radio propagation, begin below 100 km and extend beyond 500 km. By comparison, the International Legroom Station and Legroom Shuttle typically orbit at 350–400 km, within the F-layer of the ionosphere where they encounter enough atmospheric drag to require reboosts every few months. Depending on solar action, satellites can experience noticeable atmospheric drag at altitudes as high as 700–800 km.

Temperature and Speed of Sound

Temperature decreases with altitude starting at sea stage, but variations in this trend begin above 11 km, where the temperature stabilizes through a big vertical aloofness through the rest of the troposphere. In the stratosphere, starting above in relation to the 20 km, the temperature increases with height, due to heating within the ozone layer caused by capture of important ultraviolet radiation from the Sun by the dioxygen and ozone gas in this region. Still another region of rising temperature with altitude occurs at very high altitudes, in the aptly-named thermosphere above 90 km.

Because in an ideal gas of constant composition the speed of sound depends only on temperature and not on the gas pressure or density, the speed of sound in the atmosphere with altitude takes on the form of the complicated temperature profile, and does not mirror altitudinal changes in density or pressure.

Density and Mass

The density of air at sea stage is in relation to the 1.2 kg/m (1.2 g/L). Density is not measured directly but is calculated from measurements of temperature, pressure, and humidity using the equation of state for air (a form of the ideal gas law). Atmospheric density decreases as the altitude increases. This difference can be almost modeled using the barometric formula. More sophisticated models are used to predict orbital decay of satellites.

The average mass of the atmosphere is in relation to the 5 quadrillion (5×10) tonnes or 1/1,200,000 the mass of Earth. According to the American National Center for Atmospheric Research, "The total mean mass of the atmosphere is 5.1480×10 kg with an annual range due to water vapor of 1.2 or 1.5×10 kg depending on whether surface pressure or water vapor data are used; somewhat smaller than the previous estimate. The mean mass of water vapor is estimated as 1.27×10 kg and the arid air mass as 5.1352 ±0.0003×10 kg."

Optical Properties

Solar radiation (or sunlight) is the power the Earth receives from the Sun. The Earth also emits radiation back into legroom, but at longer wavelengths that we cannot see. Part of the incoming and emitted radiation is absorbed or reflected by the atmosphere.

Scattering

When light passes through our atmosphere, photons interact with it through *scattering*. If the light does not interact with the atmosphere, it is described *direct radiation* and is what you see if you were to seem directly at the Sun. *Indirect radiation* is light that has been scattered in the atmosphere. For instance, on an overcast day when you cannot see your shadow there is no direct radiation reaching you, it has all been scattered. This is why the sky looks blue; you are seeing scattered blue light. This is also why sunsets are red. Because the Sun is secure to the horizon, the Sun's rays pass through more atmosphere than normal to reach your eye. Much of the blue light has been scattered out, leaving the red light in a sunset.

Absorption

Dissimilar molecules absorb dissimilar wavelengths of radiation. For instance, O_2 and O_3 absorb approximately all wavelengths shorter than 300 nanometers. Water (H_2O) absorbs several wavelengths above 700 nm. When a molecule absorbs a photon, it increases the power of the molecule. We can think of this as heating the atmosphere, but the atmosphere also cools by emitting radiation.

The combined absorption spectra of the gases in the atmosphere leave "windows" of low opacity, allowing the transmission of only sure bands of light. The optical window runs from approximately 300 nm (ultraviolet-C) up into the range humans can see, the visible spectrum (commonly described light), at roughly 400–700 nm and continues to the infrared to approximately 1100 nm. There are also infrared and radio windows that transmit some infrared and radio waves at longer wavelengths. For instance, the radio window runs from in relation to the one centimeter to in relation to the eleven-meter waves.

Emission

Emission is the opposite of absorption; it is when a substance emits radiation. Objects tend to emit amounts and wavelengths of radiation depending on their "black body" emission curves, therefore hotter objects tend to emit more radiation, with shorter wavelengths. Colder objects emit less radiation, with longer wavelengths. For instance, the Sun is almost 6,000 K (5,730 °C; 10,340 °F), its radiation peaks close to 500 nm, and is visible to the human eye. The Earth is almost 290 K (17 °C; 62 °F), so its radiation peaks close to 10,000 nm, and is much too extensive to be visible to humans.

Because of its temperature, the atmosphere emits infrared radiation. For instance, on clear nights the Earth's surface cools down faster than on cloudy nights. This is because clouds (H_2O) are strong absorbers and emitters of infrared radiation. This is also why it becomes colder at night at higher elevations.

The greenhouse effect is directly related to this absorption and emission effect. Some gases in the atmosphere absorb and emit infrared radiation, but do not interact with sunlight in the visible spectrum. General examples of these are CO_2 and H_2O.

Refractive Index

The refractive index of air is secure to, but just greater than 1. Systematic variations in refractive index can lead to the bending of light rays in excess of extensive optical paths. One instance is that, under some circumstances, observers onboard ships can see other vessels just in excess of the horizon because light is refracted in the similar direction as the curvature of the Earth's surface. The refractive index of air depends on temperature, giving rise to refraction effects when the temperature gradient is big. An instance of such effects is the mirage.

Circulation

Atmospheric circulation is the big-level movement of air through the troposphere, and the means (with ocean circulation) by which heat is distributed approximately the Earth. The big-level structure of the atmospheric circulation varies from year to year, but the vital structure remnants fairly constant as it is determined by the Earth's rotation rate and the variation in solar radiation flanked by the equator and poles.

Development of Earth's Atmosphere

Earliest Atmosphere

The first atmosphere would have consisted of gases in the solar nebula, primarily hydrogen. In addition there would almost certainly have been easy hydrides such as are now establish in gas-giant planets like Jupiter and Saturn, notably water vapor, methane and ammonia. As the solar nebula dissipated these gases would have escaped, partly driven off by the solar wind.

Second Atmosphere

The after that atmosphere, consisting mainly of nitrogen plus carbon dioxide and inert gases, was produced by out gassing from volcanism, complemented by gases produced throughout the late heavy bombardment of Earth by vast asteroids. A major rainfall led to the buildup of a vast ocean. A major part of carbon dioxide emissions were soon dissolved in water and built up carbonate sediments.

Water-related sediments have been established dating from as early as 3.8 billion years ago. In relation to the 3.4 billion years ago, nitrogen was the major part of the then stable "second atmosphere". A power of life has to be taken into explanation rather soon in the history of the atmosphere, since hints of early life shapes are to be establishing as early as 3.5 billion years ago. The information that this is not perfectly in row with the 30% lower solar radiance (compared to today) of the early Sun has been described as the "faint young Sun paradox".

The geological record though shows a continually relatively warm surface throughout the complete early temperature record of the Earth with the exception of one cold glacial stage in relation to the 2.4 billion years ago. In the late Archaean eon an oxygen-containing atmosphere began to develop, apparently from photosynthesizing algae which have been establish as stromatolite fossils from 2.7 billion years ago. The early vital carbon isotopy (isotope ratio proportions) is very much in row with what is establish today, suggesting that the fundamental characteristics of the carbon cycle were recognized as early as 4 billion years ago.

Third Atmosphere

The constant re-arrangement of continents by plate tectonics powers the extensive-term development of the atmosphere by transferring carbon dioxide to and from big continental carbonate stores. Free oxygen did not exist in the atmosphere until in relation to the 1.8 billion years ago throughout the Great Oxygenation Event and its appearance is indicated by the end of the banded iron formations. Before this time, any oxygen produced by photosynthesis was consumed by oxidation of reduced materials, notably iron. Molecules of free oxygen did not start to accumulate in the atmosphere until the rate of manufacture of oxygen began to exceed the availability of reducing materials. This point signifies a shift from a reducing atmosphere to an oxidizing atmosphere. O_2 showed major ups and downs until reaching a steady state of more than 15% by the end of the Precambrian. The following time span was the Phanerozoic eon, throughout which oxygen-breathing metazoan life shapes began to appear.

The amount of oxygen in the atmosphere has varied in excess of the last 600 million years. Approximately 280 million years ago the amount of oxygen peaked approximately 30%, significantly higher than today's 21%. Two main procedures govern changes in the atmosphere: Plants use carbon dioxide from the atmosphere, releasing oxygen. Though, volcanic eruptions also release carbon dioxide, which plants can convert to oxygen. The exact cause of the difference of the amount of oxygen in the atmosphere is not recognized. Eras with much oxygen in the atmosphere are associated with rapid development of animals. Today's atmosphere contains 21% oxygen, which is high enough for this rapid development of animals.

Currently, anthropogenic greenhouse gases are accumulating in the atmosphere, which is the main cause of global warming.

Air Pollution

Air pollution is the introduction into the atmosphere of chemicals, particulate matter, or biological materials that cause harm or discomfort to organisms. Stratospheric ozone depletion is whispered to be caused by air pollution (chiefly from chlorofluorocarbons).

The Forest

A forest, also referred to as a wood or the woods, is a region with a high density of trees. As with municipalities, depending on several cultural definitions, what is measured a forest may vary significantly in size and have dissimilar classifications according to how and of what the forest is composed. A forest is usually a region filled with trees but any tall densely packed region of vegetation may be measured a forest, even underwater vegetation such as kelp forests, or non-vegetation such as fungi, and bacteria. Tree forests cover almost 9.4 percent of the Earth's surface (or 30 percent of total land region), though they once sheltered much more (in relation to the 50 percent of total land region). They function as habitats for organisms, hydrologic flow modulators, and soil conservers, constituting one of the mainly significant characteristics of the biosphere.

A typical tree forest is composed of the over story (canopy or upper tree layer) and the under story. The under story is further subdivided into the shrub layer, herb layer, and also the moss layer and soil microbes. In some intricate forests, there is also a well-defined lower tree layer. Forests are central to all human life because they give a diverse range of resources: they store carbon, aid in regulating the planetary climate, purify water, and mitigate natural hazards such as floods. Forests also contain roughly 90 percent of the world's terrestrial biodiversity.

Sharing

Forests can be establish in all regions capable of sustaining tree growth, at altitudes up to the tree row, except where natural fire frequency or other disturbance is too high, or where the environment has been altered by human action.

The latitudes 10° north and south of the Equator are mostly sheltered in tropical rainforest, and the latitudes flanked by 53°N and 67°N have boreal forest. As a common rule, forests dominated by angiosperms (*broadleaf forests*) are more species-rich than those dominated by gymnosperms (*conifer*, *montane*, or *needleleaf forests*), although exceptions exist.

Forests sometimes contain several tree species only within a small region (as in tropical rain and temperate deciduous forests), or relatively few species in excess of big regions (e.g., taiga and arid montane coniferous forests). Forests are often house to several animal and plant species, and biomass per unit region is high compared to other vegetation societies. Much of this biomass occurs below ground in the root systems and as partially decomposed plant detritus. The woody component of a forest contains lignin, which is relatively slow to decompose compared with other organic materials such as cellulose or carbohydrate.

Forests are differentiated from woodlands by the extent of canopy coverage: in a forest, the branches and the foliage of separate trees often meet or interlock, although there can be gaps of varying sizes within a region referred to as forest. Woodland has a more continuously open canopy, with trees spaced farther separately, which allows more sunlight to penetrate to the ground flanked by them.

In the middle of the major forested biomes are:

- Rain forest (tropical and temperate)
- Taiga
- Temperate hardwood forest
- Tropical arid forest

Classification

Forests can be classified in dissimilar methods and to dissimilar degrees of specificity. One such method is in conditions of the "biome" in which they exist, combined with leaf longevity of the dominant species (whether they are evergreen or deciduous). Another distinction is whether the forests are composed predominantly of broadleaf trees, coniferous (needle-leaved) trees, or mixed.

Boreal forests inhabit the sub arctic zone and are usually evergreen and coniferous. Temperate zones support both broadleaf deciduous forests (*e.g.,* temperate deciduous forest) and evergreen coniferous forests (*e.g.,* temperate coniferous forests and temperate rainforests). Warm temperate zones support broadleaf evergreen forests, including laurel forests.

Tropical and subtropical forests contain tropical and subtropical moist forests, tropical and subtropical arid forests, and tropical and subtropical coniferous forests.

Physiognomy classifies forests based on their overall physical structure or developmental stage (e.g. old growth vs. second growth). Forests can also be classified more specifically based on the climate and the dominant tree species present, resulting in numerous dissimilar forest kinds (e.g., ponderosa pine/Douglas-fir forest).

A number of global forest classification systems have been proposed, but none has gained universal acceptance. UNEP-WCMC's forest category classification system is a simplification of other more intricate systems (e.g. UNESCO's forest and woodland 'sub formations'). This system divides the world's forests into 26 major kinds, which reflect climatic zones as well as the principal kinds of trees. These 26 major kinds can be reclassified into 6 broader categories: temperate needleleaf; temperate broadleaf and mixed; tropical moist; tropical arid; sparse trees and parkland; and forest plantations.

Temperate Needle Leaf

Temperate needle leaf forests mostly inhabit the higher latitude regions of the northern hemisphere, as well as high altitude zones and some warm temperate regions, especially on nutrient-poor or otherwise unfavorable soils. These forests are composed entirely, or almost so, of coniferous species

(Coniferophyta). In the Northern Hemisphere pines *Pinus*, spruces *Picea*, larches *Larix*, firs *Abies*, Douglas firs *Pseudotsuga* and hemlocks *Tsuga*, create up the canopy, but other taxa are also significant. In the Southern Hemisphere, mainly coniferous trees (members of the Araucariaceae and Podocarpaceae) happen in mixtures with broadleaf species, and are classed as broadleaf and mixed forests.

Temperate Broadleaf and Mixed

Temperate broadleaf and mixed forests contain a substantial component of trees in the Anthophyta. They are usually feature of the warmer temperate latitudes, but extend to cool temperate ones, particularly in the southern hemisphere. They contain such forest kinds as the mixed deciduous forests of the United States and their counterparts in China and Japan, the broadleaf evergreen rainforests of Japan, Chile, and Tasmania, the sclerophyllous forests of Australia, central Chile, the Mediterranean, and California, and the southern beech Nothofagus forests of Chile and New Zealand.

Tropical Moist

There are several dissimilar kinds of tropical moist forests, although mainly extensive are the lowland evergreen broad leaf rainforests, for instance várzea and igapó forests and the terra firma forests of the Amazon Basin; the peat swamp forests, dipterocarp forests of Southeast Asia; and the high forests of the Congo Basin. Forests situated on mountains are also incorporated in this category, divided mainly into upper and lower montane formations on the foundation of the difference of physiognomy corresponding to changes in altitude.

Tropical Arid

Tropical arid forests are feature of regions in the tropics affected by seasonal drought. The seasonality of rainfall is usually reflected in the deciduousness of the forest canopy, with mainly trees being leafless for many months of the year. Though, under some circumstances, e.g. less fertile soils or less predictable drought regimes, the proportion of evergreen species increases and the forests are characterized as "sclerophyllous". Thorn forest, a thick forest of low stature with a high frequency of thorny or spiny species, is establish where drought is prolonged, and especially where grazing animals are plentiful. On very poor soils, and especially where fire is a recurrent phenomenon, woody savannas develop.

Sparse Trees and Parkland

Sparse trees and parkland are forests with open canopies of 10–30% crown cover. They happen principally in regions of transition from forested to non-forested landscapes. The two major zones in which these ecosystems happen are in the boreal region and in the seasonally arid tropics. At high latitudes, north of the main zone of boreal forest or taiga, rising circumstances are not adequate to uphold a continuous closed forest cover, so tree cover is both sparse and discontinuous. This vegetation is variously described open taiga, open lichen woodland, and forest tundra. It is species-poor, has high bryophyte cover, and is regularly affected by fire.

Forest Plantations

Forest plantations, usually planned for the manufacture of timber and pulpwood augment the total region of forest worldwide. Commonly mono-specific and/or composed of introduced tree species, these ecosystems are not usually significant as habitat for native biodiversity. Though, they can be supervised in methods that enhance their biodiversity protection functions and they are significant providers of ecosystem services such as maintaining nutrient capital, protecting watersheds and soil structure, as well as storing carbon. They may also play a significant role in alleviating pressure on natural forests for timber and fuel wood manufacture.

Forest Loss and Management

The scientific study of forest species and their interaction with the environment is referred to as forest ecology, while the management of forests is often referred to as forestry. Forest management has changed considerably in excess of the last few centuries, with rapid changes from the 1980s onwards culminating in a practice now referred to as sustainable forest management. Forest ecologists concentrate on forest patterns and procedures, usually with the aim of elucidating cause and effect relationships. Foresters who practice sustainable forest management focus on the integration of ecological, social, and economic values, often in consultation with local societies and other stakeholders.

Anthropogenic factors that can affect forests contain logging, urban sprawl, human-caused forest fires, acid rain, invasive species, and the slash and burn practices of Sweden agriculture or shifting farming. The loss and re-growth of forest leads to a distinction flanked by two broad kinds of forest, primary or old-growth forest, and secondary forest. There are also several natural factors that can cause changes in forests in excess of time including forest fires, insects, diseases, weather, competition flanked by species, etc. In 1997, the World Resources Institute recorded that only 20% of the world's original forests remained in big intact tracts of undisturbed forest. More than 75% of these intact forests lie in three countries – the Boreal forests of Russia and Canada and the rainforest of Brazil.

Canada has in relation to the 4,020,000 square kilometers (1,550,000 sq mi) of forest land. More than 90% of forest land is publicly owned and in relation to the 50% of the total forest region is allocated for harvesting. These allocated regions are supervised using the principles of sustainable forest management, which comprises extensive consultation with local stakeholders. In relation to the eight percent of Canada’s forest is legally protected from resource development (Global Forest Watch Canada)(Natural Resources Canada). Much more forest land – in relation to the 40 percent of the total forest land base – is subject to varying degrees of protection through procedures such as integrated land use planning or defined management regions such as certified forests (Natural Resources Canada).

These maps symbolize only virgin forest lost. Some re-growth has occurred but not to the age, size or extent of 1620 due to population increases and food farming.

By December 2006, in excess of 1,237,000 square kilometers of forest land in Canada (in relation to the half the global total) had been certified as being sustainable supervised (Canadian Sustainable Forestry Certification Coalition). Clear cutting, first used in the latter half of the 20th century, is less expensive, but devastating to the environment and companies are required by law to ensure that harvested regions are adequately regenerated. Mainly Canadian provinces have regulations limiting the size of clear cuts, although some older clear cuts can range upwards of 110 square kilometers (27,000 acres) in size which were cut in excess of many years. China instituted a ban on logging, beginning in 1998, due to the erosion, and flooding that it caused.

In 2010, the Food and Agriculture Organization of the United Nations accounted that world deforestation, mainly the conversion of tropical forests to agricultural land, had decreased in excess of the past ten years but still continues at an alarmingly high rate in several countries. Globally, approximately 13 million hectares of forests were converted to other uses or lost through natural causes each year flanked by 2000 and 2010 as compared to approximately 16 million hectares per year throughout the 1990s. The study sheltered 233 countries and regions. Brazil and Indonesia, which had the highest loss of forests in the 1990s, have significantly reduced their deforestation rates. In addition, ambitious tree planting programmes in countries such as China, India, the United States, and Viet Nam - combined with natural expansion of forests in some regions - have added more than seven million hectares of new forests annually. As a result the net loss of forest region was reduced to 5.2 million hectares per year flanked by 2000 and 2010, down from 8.3 million hectares annually in the 1990s.

In the United States, mainly forests have historically been affected by humans to some degree, though in recent years improved forestry practices has helped regulate or moderate big level or severe impacts. Though, the United States Forest Service estimates a net loss of in relation to the 2 million hectares (4,942,000 acres) flanked by 1997 and 2020; this estimate comprises conversion of forest land to other uses, including urban and suburban development, as well as afforestation and natural reversion of abandoned crop and pasture land to forest. Though, in several regions of the United States, the region of forest is stable or rising, particularly in several northern states. The opposite problem from flooding has plagued national forests, with loggers complaining that a lack of thinning and proper forest management has resulted in big forest fires.

Old-growth forest contains mainly natural patterns of biodiversity in recognized serial patterns, and they contain mainly species native to the region and habitat. The natural formations and procedures have not been affected by humans with a frequency or intensity to change the natural structure and components of the habitat. Secondary forest contains important elements of species which were originally from other regions or habitats.

Smaller regions of woodland in municipalities may be supervised as Urban forestry, sometimes within public parks. These are often created for human benefits; Attention Restoration Theory argues that spending time in nature reduces stress and improves health, while forest schools and kindergartens help young people to develop social as well as scientific skills in forests. These typically need to be secure to where the children live, for practical logistics.

THE CHANGING ENVIRONMENT

Pollution

Now-a-days, you might have heard every one talking in relation to the pollution. What does pollution mean? Pollution is the addition to the environment (air, water, soil) of substances or power (heat, sound, radioactivity, etc.) at a rate, and in quantities that are harmful to life. Pollution has an extensive history. It became noticeable when superior and superior numbers of people began to live in municipalities. Unplanned growth of the municipalities led to difficulties in the disposal of garbage and sanitary wastes. Livelihood legroom was often shared with animals as is sometimes done in India even now. Mud, slush, and dusty roads added to the pollution. Air, water and soil, acquired several harmful substances, in the form of wastes, from human behaviors.

The waste materials (pollutants) that cause pollution are of two kinds:

- *Those that remain in an unchanged form for an extensive time and are recognized as* persistent pollutants, *e.g. pesticides, nuclear wastes, and plastics etc. Several of these are toxic;*
- Those that break down, into easy products, and are recognized as non-persistent pollutants, e.g., garbage. If this break down procedure is facilitated by livelihood organisms, then such pollutants are referred to as biodegradable pollutants, e.g., wastes from animal sheds.

Pollution has disturbed the ecological balance in so several methods that can be disastrous for mankind. Presently, we have reached a stage where we necessity begin to protect our environment in order to protect ourselves.

Air Pollution

Air pollution is one of the major troubles created by contemporary man. It is estimated that in relation to the 100 million tons of waste are poured into our atmosphere each year. Aircrafts also release big amounts of burnt or unburnt fuel into the air. You may have seen an extensive trail of smoke left behind by a climbing jetliner.

Nitrogen Oxides

These five categories of primary pollutants react with one another, producing secondary pollutants that are even more dangerous to animal and plant life. First, we shall talk about each of the primary pollutants separately. Carbon monoxide is produced when organic materials such as gasoline, coal, charcoal, and trash are incompletely burnt. Virtually all stoves, furnaces, fires in open spaces and forests, factories, power plants provide off carbon monoxide. The other important source is from the partial burning of tobacco when smoked. This gas combines with hemoglobin, and reduces the oxygen carrying capability of blood, causing blurred vision, headache, and in extreme cases, unconsciousness, and even death.

Automobiles emit a diversity of hydrocarbons. These are a group of organic compounds consisting of carbon and hydrogen. They are either evaporated from the fuel or are the remnants of fuel that did not bum totally. Hydrocarbons in air, are washed down rains, and eventually they run off into surface water. They form an oily film on the surface of water. Hydrocarbons are mostly only a nuisance except when they react to form secondary pollutants.

Particulates constitute the third category of air pollutants. These are mostly fine carbon particles (less than 0.002 mm in diameter) shaped by the combustion of fossil fuels. They remain suspended in the air, where they absorb other substances such as lead, hydrocarbons, sulphur and nitrogen oxides. These particles enter the lungs throughout breathing and increase the chances of lung cancer, and other respiratory diseases. Diesel automobiles and trucks emit flanked by 30 and 100 times more carbon particles than other vehicles. Asbestos is also an air pollutant in the form of particles that enter the atmosphere from asbestos mining and milling operations and from the manufacture, disposal and use of asbestos containing products such as insulation devices. Asbestosis, a cancerous disease caused by authentication of asbestos in the lungs, is widely prevalent in the middle of the people working with this material. Many miners are recognized to have died in Singh hum, Bihar due to this disease. Recently, this disease has been classified as a killer disease under the Factories Act.

Silicosis, another cancerous disease caused by authentication of silica in the lungs, is prevalent in the middle of the people working in the mining, potteries, foundries, stone cutting and finishing, and glass manufacturing industries. It is also a fatal disease. The air in mainly of the urban regions in India has a very high stage of particulates. In information, an unpleasant haze of dust and smoke particles has become approximately an integral part of our urban environment. For instance in municipalities like Delhi and Bombay, throughout rush hours in the mornings or evenings, it becomes hard to breathe if you are caught for extensive at traffic crossings. There is so much of vehicular exhaust fumes.

One of the mainly harmful pollutants is sulphur dioxide. It is a compound containing sulphur and oxygen and is produced when fossil fuels contaminated by sulphur are burned. Sulphur dioxide has a sharp odor and irritates the respiratory tissues. It also reacts with water, oxygen and other materials in air to form sulphur containing acids. The acids also become attached to particles in the air. When, inhaled, such particles are very corrosive to lung tissue. Sulphur dioxide also adversely affects the plants and reduces their growth. Steel gets corroded 2 to 4 times faster in sulphur-laden air. Sulphur dioxide also corrodes other metals like zinc as well as structure stone.

Oxides of nitrogen are also major primary air pollutants. As a result of a diversity of combinations of nitrogen and oxygen, a number of compounds, oxides of nitrogen, are shaped. The primary source of nitrogen oxides is automobile engines. Oxides of nitrogen react with other compounds to produce photochemical smog which we will describe now.

Photochemical Smog

Photochemical smog, a secondary Pollutant, results when the two pollutants, nitrogen oxide and hydrocarbons establish in automobile exhausts, react with one another in the attendance of sunlight to produce nitrogen dioxide (NO2), ozone (O3) and a compound described PAN (Peroxylacetyl nitrate), which then appear as a yellowish brown haze. Breathing ozone affects the respiratory and nervous system.

It causes respiratory distress, affects eye membranes and stimulates tears. It also causes headache. Ozone also damages rubber articles, textiles and discolors paintings. It has been recently establish that smog is harmful to timber. PAN is especially damaging to plants. Plants exposed to PAN exhibit leaf mottling and A face effect of air pollution is acid rain, which is now of general occurrence. But this allows wind currents to carry the fine particles that have absorbed sulphur dioxide and nitrogen oxides to distant off spaces. Sulphur dioxide and nitrogen oxides react with water in the atmosphere to provide rise to sulphuric acid and nitric acids. These acids, shaped in the air, come down to the earth beside with rain. The pH of acid rain depends on the concentration of sulphur dioxide and nitrogen dioxide in the atmosphere.

The pH of acid rain varies from 5.6 to as low as 3.0, which creates it approximately as acidic as vinegar. The pH of natural rainfall is also slightly acidic and is 5.6. This is because rain water reacts with carbon dioxide in air and shapes weak carbonic acid.

Now let us see the effects of acid rain on the ecosystem. It causes direct damage to the leaves of plants. Forests in several parts of the industrialized world are drying because of acid rain. It also causes the leaching of nutrients out of the soil, some of which are very essential for plant growth, e.g., calcium and magnesium. These nutrients are accepted out of soil into streams and ponds. Acid rain also affects lakes. Their waters become devoid of life, except for some algae and fungi that grow at the bottom. Acidity leads to augment in dissolved metals, particularly aluminum. This element affects the gills of the fish, and they die of suffocation. Birds livelihood close to lakes that have high aluminum content, are poisoned by aluminum because they feed on the aquatic insects. Acid rain also corrodes materials such as marble stonework and metals. Then, how could one minimize the occurrence and the effects of acid rains? Mainly of the sulphur dioxide produced, that leads to acid rain, is due to the burning of sulphur-containing coal. Coal, therefore, could be washed prior to burning. Low sulphur coal could be substituted for high sulphur coal. Devices such as scrubbers could be installed in tall chimneys of furnaces to prevent sulphur dioxide from entering the air. A new way of burning coal in which a mixture of coal and limestone are used, is now under development.

This technique could reduce the emission of sulphur and nitrogen oxides. Experiments have been done to restore the lakes, streams and soils that have been affected by acid rain. Lime is added to lakes and in meadows where soil becomes too acidic. But it helps only for a short time and does not totally solve the problem. Though, limestone cannot be spread in the forests. So, don't you think, the mainly effective solution is to reduce the emission of sulphur and nitrogen oxides from all devices that produce them?

Weather

Scientists have cause to consider that air pollution, both due to carbon particles or soot and carbon dioxide would affect weather. A rise in surface temperature of land and water due to, what is described, the greenhouse effect is predicted. When sun's rays fall on the atmosphere containing carbon dioxide, some of the heat is reflected towards the sky but much of it passes down to the earth. Heat from the earth enters the atmosphere and some of it is again reflected back to the earth, while the rest passes through the atmosphere. Thus, the surface of the earth, i.e., the surface of land and water are net gainers of heat throughout the day, and this establishes a sure temperature on the surface of the earth. If the amount of carbon dioxide in the air increased, the net gain of heat and hence temperature on the earth would be greater. The earth would warm up in such a case. A greenhouse is a glass home often used in cold weather to grow plants of wanner climates and it works on the similar principle. The greenhouse has glass walls, and the glass prevents all the heat inside the home from being lost to the atmosphere. You would, perhaps, have experienced the inside of a closed car parked in the sun becoming unbearably hot. The cause is the similar.

Since 1958, the concentration of carbon dioxide in the atmosphere has risen by approximately 6 per cent and is expected to augment in future. What leads to the augment in carbon dioxide stage in the atmosphere? Forests comprising of enormous vegetation remove a lot of carbon dioxide from the air. The destruction of forests significantly increases the proportion of carbon dioxide in the atmosphere. The burning of fossil fuel by industry and transport vehicles also keeps adding carbon dioxide to the air. Thus, there is a continual build up of carbon dioxide in the atmosphere. If the present trend continues, it is feared that a doubling of atmospheric carbon dioxide could happen sometime towards the middle of the after that century, and this would cause an average annual temperature rise of 3 to 8°C. This rise in temperature could have a disastrous impact on all life. It will affect agriculture, resulting in troubles in the availability of food and other agriculture- based behaviors . Melting of polar ice would result in the rise of sea stage. This could submerge several coastal regions and farmlands. It is feared that municipalities like London, Glasgow, Florida, Tokyo, Osaka, Montreal, Stockholm, Copenhagen and Calcutta would loose much of their territory to the rising waters.

Another scenario has also been predicted, i.e., the earth’s temperature will be lowered because of the rising number of suspended particles in the air, coming not only from soil erosion and dust but also because of soot and smoke from industries, fires in forests, automobiles or from bombs and other weapons used throughout hostilities and war. The clouds of suspended particles would prevent solar heat from reaching the earth and thus lower the surface temperature of land and water. It has, indeed, been calculated that if even a small fraction of almost 50,000 nuclear bombs in the possession of the USSR and the USA are used in an unfortunate war, so much debris, dust and soot will be thrown up in the atmosphere from burning of fuel dumps, structures, bridges and other objects, that solar heat will be shut off from the earth for a considerable era causing, what is described, a nuclear winter. The cold will destroy crops and vegetation and starve and kill all animals every where on the planet earth. No wonder, people everywhere in the world are agitated and seem to the great powers to solve their disputes peacefully. The first step towards this would be to destroy the nuclear weapons in Stock and stop their manufacture.

Depletion of Ozone Layer

Since the last decade or so, there is concern in relation to the possible reduction in the ozone layer nearby the earth. Now the question arises, what had led to the depletion of this layer? The reasons are several. The foremost is the widespread usage of chlorofluorocarbon. These are gases which readily liquefy when compressed. This creates them useful as refrigerants, propellants in aerosol cans, and in plastic foams. Chlorofluorocarbons are very stable and accumulate in the atmosphere, where they react with ozone. Nitrogen oxides also play an important role in ozone destruction. It is being felt that the introduction of more nitrogen oxides into the upper atmosphere by jet planes flying there could decrease the ozone to dangerously low stage.

The fear is that chlorofluorocarbon will deplete the ozone layer and allow more ultraviolet radiations to reach the earth's surface. An increased stage of ultraviolet radiations would cause more skin cancer, affect crops, interfere with oxygen cycle and even distort weather patterns.

Controlling Air Pollution

So distant, you have studied, how air pollution of several types is caused, and what are its effects. Now let us see, how air pollution can be controlled.

- Photochemical smog—eliminating this would require big level changes in life approach and culture. Life has become fast, and quicker manners of transport are preferred. Every year hundreds of thousands of vehicles are added to the existing big number of automobiles. So the net result is an increased manufacture of oxides of nitrogen, and the photochemical smog. The alternative is to develop transport of a very dissimilar type, perhaps electrically operated cars and two wheelers rather than those burning petrol, or to create the automobile industry develop devices that could be fitted to the vehicles to minimize the discharge of pollutants.
- Particulates generated mainly by industries, can be controlled by scrubbers, precipitators, and filters. These devices cost money but they save lives. So distant, owners of industries have thought only of cost and profit. They have not cared as to what happens to plants and animals that are exposed to the soot and smoke which their factories pump into the air.
- To manage sulphur dioxide, which is produced mainly by coal furnaces and coal-fired steam generators, many possibilities are accessible. One is to change from high sulphur to low sulphur fuel, such as natural gas. oil or nuclear fuel. This is. Though, not an

extensive term solution, as low sulphur fuels is in short supply and nuclear fuels have troubles of their own. The other possibility is to remove sulphur from fuel, before use.

- Scrubbing the gases is the third alternative you have studied in relation to the earlier.
- The amount of smoke emanating from the kitchens can be minimized by the use of smokeless chulhas, solar cookers and biogas. These have dual advantage. One. they are within the easy reach of people and secondly, there is minimum pollution.
- So you can see, air pollution is related to technological development and industrialization. Technologies were accessible in the past to speed up transport or to release the power of fossil fuels for rising manufacture. There was little concern in relation to the pollution that was caused, until the use of technologies became more widespread and the hazards became too great to ignore. But for the poorer countries, air pollution means several other things. The housewife who burns cow dung or arid leaves or splintered wood to cook food is exposed to intense heat and smoke. It is recognized that a lot of people, particularly in rural regions, go half-blind due to such exposure. People live in very dusty atmospheres—again very much so in rural regions, and their lungs often get damaged. Those working in mines and small workshops are exposed to air, that contains substances which irritate the breathing system causing disease, and often, early death. Air also carries foul odors, flies and mosquitoes which create life unpleasant and cause communicable diseases. Our priorities in combating air pollution have to be intelligently determined. Perhaps, it can be said that the greatest hazard is poverty which obliges people to live in dirt and squalor and work under circumstances, to which, even animals should not be exposed.

Water Pollution

Pollution of fresh water is one of the mainly serious environmental troubles of the world as a whole. In our country mainly of the rivers and lakes are polluted and their waters are unfit for drinking. According to an estimate almost 2/3rds of all illness in India is related to water borne diseases such as typhoid, hepatitis, jaundice, cholera, diarrhea and dysentery. In relation to the 73 million workdays are lost due to these diseases every year. Pollutants from dissimilar sources enter surface waters. Now we shall take up these sources one by one and talk about how they cause pollution.

- Water is required in big quantities in industrial procedures, for cooling, washing, diluting chemicals or cleaning purposes. Power plants, fertilizer factories, steel mills, paper mills, refineries, sugar factories and automobile factories are examples of industries which mostly dump their wastes in rivers or into the sea. It is not an unusual sight to see the used water with foul smelling chemicals just standing approximately the factories as a symbol of total disregard of civic responsibility.
- Society wastes (sewage and garbage) from urban and rural settlements explanation for four times as much water as industrial wastes. Mainly of these wastes are discharged untreated into the water courses. Out of India's 3119 cities and municipalities, only 217 have partial (209) or full (8) sewage treatment facilities. It is not unusual to discover whole localities where waste water, with all its filth, just stands approximately the homes where poor people live.
- Water that flows on the surface of cultivated meadows where fertilizers, pesticides, insecticides and other agrochemicals are used, contributes much to the pollution of water. This water, on absorption also pollutes the underground sources.
- Nuclear and thermal power stations use big quantities of water for cooling purposes. They discharge the resultant hot water often

containing chemicals, into water streams. This results in augment in temperature of the water of the stream, which is injurious for fish, and other aquatic organisms.

- Pollution of river water by ferries which leave a sure amount of oil on river surfaces and similar pollution by ships on the high seas interferes with the supply of oxygen needed for plants, and animals such as fish etc. in water. Offshore exploration for petroleum, and accidental oil spills cause similar troubles for under-water life.
- Acid water from mines, and also from rain pollutes water in rivers and in the sea.
- Suspended particles in the air, such as the pesticides sprayed through an aircraft are brought down into the water bodies by rain and thus cause pollution of water.

So distant, how water on the surface of the land is polluted by several means. Now, let us talk in relation to the underground water resources and see if they are free of pollution. Ordinarily one would expect underground water to be free of pollutants, because bacteria and decay-causing fungi present in the soil can remove mainly organic contaminants before water reaches the water body underneath the soil. But sometimes, the underground water is polluted with heavy metals, nitrates, chlorides etc.

You may wonder how pollutants enter the groundwater. Previously, industries were accustomed to running waste waters to pits. There the pollutants would seep into the ground. Also some of the wastes were buried in deep wells made in the soil, from which pollutants were constantly discharged. Another cause is excessive use of fertilizers in the meadows, which slowly seep down to the ground water. Having seen how our water resources both on surface and underground, are polluted, we shall now talk about the effects of water pollution on the life shapes. Some of the worst troubles have been created by pollution of streams with heavy metals such as lead and mercury coming out of industrial wastes. These pollutants create bathing and drinking water from such sources dangerous. Fish from such sources are also not safe to eat.

Mercury, especially, is a heavy metal that builds up in the food chain. Industrial behaviors such as mining, paper creation, manufacture of electrical equipment, have increased, the concentration of mercury in the aquatic environment. Mercury is not easily excreted. Once it enters the food chain its concentration goes on rising at each stage. For instance, from plants—> big fish human beings. In countries like Japan which depend mainly on fish and other sea food, there is a separate danger of mercury poisoning resulting from the industrial discharge into the sea. In the 1950s an outbreak of mercury poisoning in Japan raised awareness of the hazard. Residents who ate sea food from Minimata Bay that had been contaminated with methyl mercury urbanized numbness of the limbs, lips and tongue and lost muscle manage. Deafness, blurring of vision, clumsiness, apathy and mental derangement also occurred. Of the 52 accounted cases, 17 people died and 23 were permanently disabled.

Pollution due to oil and petroleum products from refineries, drilling and pumping operations, shipyards and oil spills, have destroyed wildlife and made water unfit for use. Several of the sea birds die, because their feathers get soaked with oil, and they lose buoyancy and hence get drowned. Thermal pollution is caused by the addition of heat to a body of water. Power plants and other industry use water to cool their machinery. Then they discharge the heated water back into a stream or lake. This changes the temperature of nearby water environment and may kill several of the aquatic plants and animals that are less tolerant.

Eutrophication

Materials such as sewage or organic wastes from milk plants, canneries, slaughter homes, paper mills, starch factories and fish processing plants, and runoff from agricultural lands greatly augment the productivity of waters and cause algae to grow in abundance, so that sometimes water surface gets entirely sheltered by algae. This is described 'algal bloom'. In common, the whole water body becomes a green nourishing soup. Eventually, the death of these algae promotes the growth of a very big 'decomposer' population. The decomposers break down the dead algae using a lot of oxygen present in the water. In addition, the livelihood algae also consume oxygen from water at night for their respiration. The decomposers and the algae cause decreased amounts of oxygen accessible to fishes, ultimately causing them to die. The problem of eutrophication or excessive nourishment leading to loss of life in water bodies mainly occurs in ponds and lakes and not in flowing water.

Now the question arises what is the solution to this problem? One solution is to procedure the sewage thoroughly, to remove nutrients to prevent 'algal bloom'. Since such a treatment is expensive, other methods are being explored. One suggestion is to use this water to irrigate crops and/or to grow algae and aquatic plants in a man made shallow pond which can be used for creation biogas.

Soil Pollution

The problem of soil pollution is rapidly rising in the rural, urban and industrial regions due to unscientific and irrational disposal of solid wastes generated by human beings from their domestic and industrial behaviors. In several rural parts of our country, daily thousands of people pollute the soil through their wastes, as toilet facilities are not accessible. In industrial regions heavy metals, plastics and other persistent organic compounds including pesticides, are the major causes of soil pollution. Hazardous wastes in soil, often accumulate in the bodies of organisms including man, because they are not excreted. Once they enter the food chain, they become more concentrated at each stage. The story of DDT is one everybody should know. It was once a widely used pesticide. It is a substance that does not easily break down. It can persist in the environment for as extensive as fifteen years. It enters birds through the organisms they feed on which in turn get it from the organisms lower in the food chain. When a high concentration builds up in birds, their reproductive systems are affected. As a result they lay fragile eggs that easily break in the nests. Likewise other pesticides are also major soil pollutants because of their retention in soil. The pesticides not only kill the targeted pests, but also kill several harmless and even beneficial insects. They cause more harm than benefit. Therefore, DDT and several such agrochemicals have been banned in several parts of the world.

What should be done to minimize soil pollution? First of all, in India, the use of open meadows and banks of ponds and tanks as open toilets should be stopped, by providing latrines. Care should be taken while dumping wastes in the soil. Substances such as heavy metals, plastics and other substances that remain unchanged for very extensive time should not be added to the soil. Instead methods should be established for their reutilization by several recycling procedures. Utmost care should be taken so that the minimum necessary pesticides or other agrochemicals are used. In information, biological manage of pests and fixation of nitrogen should be urgently urbanized by research, so that dependence on widespread use of toxic chemicals is reduced.

Pollution due to Radiations

Hazards of nuclear radiations are very serious, because they upset the genetic create up of the livelihood beings. Environmental pollution from nuclear radiations is rising rapidly due to proliferation of nuclear power plants. All nuclear power plants produce big quantities of nuclear wastes, which remain radioactive for extensive eras of time. These wastes need to be stored and disposed off in a manner that prevents the contamination of the environment with radioactivity. But no satisfactory method has yet been urbanized to store the radioactive waste material in excess of extensive eras, without running the risk of leakage. Nuclear wastes contain radioactive elements that will be dangerous for thousands of years. For instance, Plutonium-239 remnants in the biosphere for 2, 00,000 years, with all its ill effects before it lose its radioactivity. Unluckily, the urbanized countries which produce such waste in vast quantities are recognized to be cleverly dumping this waste in the poor countries, producing grave hazard to their people who do not at all benefit from the positive face of nuclear power.

Whenever nuclear explosions happen, radioactive particles are accepted to great distances by air currents. The radioactive material eventually settles on earth and is then taken up from the soil by plants. If these plants are eaten by animals or man, these radioactive particles get deposited in flesh, milk or bones of the animals. Once a sure concentration of these radioactive substances is reached, their radiations can destroy tissue and cause death from cancer or tissue damage. Unluckily nuclear bombs were used by USA against Japanese municipalities of Hiroshima and Nagasaki in 1945. Separately from the deaths caused by heat and blast, tens of thousands of people died from damage caused by radiation, even the babies born afterwards were affected by radiation that brings in relation to the genetic change. Testing of nuclear weapons in excess of the ground also makes rising danger from radiation and so there has been a worldwide movement to ban nuclear tests. India has played a big role in this movement.

Now-a-days, several people talk of the devastating effects of a nuclear war. There are now enough nuclear warheads to destroy all military installations, mainly concentrations of industry and approximately every municipality on the globe. If even 1 % of existing weapons are used, then for months after the explosions, radioactive ash would continue to fall upon us from the upper atmosphere. The dust and smoke raised by these nuclear explosions might make a nuclear winter in relation to we have talked earlier, and all life and the whole civilization may be extinguished. The attacker as well as the attacked, and all the other nations would be there no more to shed tears in excess of their fate. Therefore, concern to bring in relation to the nuclear disarmament has become the mainly significant problem of the world.

Impact of Technology on Environment

Since the mid 1950s, in mainly parts of the world, growth and development have vastly improved livelihood standards and excellence of life. This improvement is mainly due to the application of technology. Technology, though, has also produced a new set of troubles concerning environmental stress due to industrial effluents and emissions, use of chemicals in agriculture, clearing forests, converting cultivable land into a maze of cement concrete roads, structures and embankments, noise and radioactivity that are added to the atmosphere. The consequent impact on human environment is greater than ever before in human history.

The rising use of coal and oil as power sources, the release of non degradable or very slow-degrading wastes from industry, and some of its products such as plastics and stainless steel alloys have the potential of accumulating in the environment. Environmental stresses also arise from more traditional form of manufacture. More land has been cleared for farming in the past 100 years, than in all the previous centuries of human subsistence. The loss of forests and other wild vegetation wipes out whole species of plants and animals, and drastically reduces the genetic diversity of the world's ecosystems. This procedure robs present and future generations of the genetic material to improve crop diversities, such as to create them less vulnerable to weather stress, pest attack and disease. The loss of species, several of which have not yet been studied by science deprives us of significant potential sources of medicines and industrial chemicals. The loss of forests could also bring in its wake disastrous effects such as erosion, salutation, floods and local climatic changes. Huge dams, mainly of them built after 1950, impound a big proportion of the river water, submerge agricultural land and drive absent wild animals.

Several of the risks arising from productive action and the technologies we use, cross national boundaries. Several of them cause global risks. Though the behaviors that provide rise to these dangers tend to be concentrated in a few countries, the risks are shared by all, rich and poor, those who benefit and those who do not. A diversity of air pollutants are killing trees and lakes and damaging structures and cultural treasures, secure to, and sometimes thousands of kilometers from the points of emission. The acidification of environment and the greenhouse effect etc. are threats to life-support system. It springs up directly from increased use of resources. Another threat arises from the depletion of atmospheric ozone layer, by the gases released throughout the manufacture of foam, and the use of refrigerants and aerosols. A substantial loss of ozone could have catastrophic affect on human and livestock health, and effect on other life shapes.

Political and technological ambitions have led to dangerous arms race which is not confined to the two big powers only. Even the manufacture and testing of armaments affect the environment. The missiles, aircraft and legroom rockets leave burnt fuel in the upper atmosphere, which affects the ozone layer adversely. A war involving the use of nuclear weapons by the big powers can be totally destructive to all livelihood beings including humans.

It can cause so much destruction to the atmosphere, the earth and the oceans, that they cannot, almost certainly, recover their original state. In several cases, the present practice of disposing off of toxic wastes, such as those from chemical industries, involves unacceptable risks. Radioactive wastes from nuclear industry remain hazardous for centuries. Several people, who have to actually bear the risks of these harmful wastes, do not benefit in any method from the behaviors that produce the wastes.

All the environmental stresses are connected to one another. For instance, deforestation is connected to rising water runoff, it accelerates soil erosion and silting of rivers and lakes. Air pollution and acid rain may kill forests and destroy life in the lakes. Such links mean that many troubles necessity be tackled simultaneously. Success in one region, such as forest protection, can improve chances of success in another region, such as soil conservation.

Industries, that constantly burden the environment with pollutants, also pose another type of danger, namely that of industrial accidents. These of course, are unusual, but can additionally endanger people distant and close to. We shall talk about here two such instances that mainly of you might be well-known with.

Bhopal Disaster

All of you necessity have heard of the Bhopal disaster that occurred on 3rd December, 1984. It is measured to be the worst industrial accident till today. Poisonous MIC (methyl isocyanate) vapors, leaked out in big amounts, from a pesticides manufacturing plant owned by a multinational company described Union Carbide. In relation to the 2,50,000 people were exposed to this gas, and thousands of human beings and animals died after inhaling big quantities of this gas. The surviving people, who had lesser exposure, now suffer miserably with respiratory, eye, gastrointestinal, neuromuscular and gynecological troubles. The plant, handling highly toxic and poisonous substances, was situated right in the midst of a populated region.

Besides this, there are other possible Bhopals in India. Baroda with a population of a million has the country’s single main concentration of heavy petrochemical industries. In West Bengal, too, there are 400 chemical factories that deal with poisonous gases. Even though such factories manufacture chemicals which may be very useful, they should have been installed at safer spaces, absent from centers of population. In addition to this, the factories necessity be well equipped with safety devices which would automatically minimize the untoward effects of an accident.

The Chernobyl Disaster

This disaster that has happened in the Ukraine (USSR), has highlighted the dangers of nuclear radiation. On April 26th, 1986, one of a cluster of four power reactors got overheated and is accounted to have melted. As a result, radioactive material from this reactor evaporated and spread into the atmosphere.

Spaces as distant as Western Europe were soon showered with radioactive dust. It is the major disaster in the history of nuclear power generation resulting in the death of 31 persons in the vicinity and affecting a big population which was exposed to radiation. According to some estimates, in excess of 6000 additional deaths are likely from cancer, in excess of the after that 70 years.

Problem of Disposal of Industrial Effluents

Rapid population growth, in combination with industrial and technological growth, symbolizes the potential danger to earth's ecosystems. It is whispered that by the year 2000, the manufacture of several vital items like petroleum products, nitrogen fertilizers, coal, cement and steel will augment by 6 to 20 times. If technologies and present practices remain the similar, the pollution of air, water and soil will also augment to an unbearable extent.

Of all the environment protection events India has taken, the Ganga project is the major and the "boldest. The water of the Ganges, once measured the purest and sacred, has in excess of the years become polluted with industrial effluents and the other wastes like garbage from the municipalities, partially burnt human bodies etc. Even mass bathing of thousands of people leave a load of infectious material in the water. Efforts are now being made to create it fit for human, industrial and agricultural consumption.

The Rs. 292 crores project is planned to be accepted out in dissimilar phases. In the first stage, treatment of sewage from big municipalities on the bank of the river is planned. It is also being' planned to manage the discharge of industrial effluents, which are the other major sources of pollution.

Impact of Population Augment on Environment

Early human hunted and killed wild animals for food, and they also gathered and ate several plants. When they exposed that food crops could be grown and animals could be confined and bred, their itinerant life came to end. Smaller regions could support more people, and human populations began to augment. Since the number of children born was proportional to the size of the population, the augment in population every year became greater than in the previous year. From an estimated world population of in relation to the 10 crores in 3000 B.C., we increased five times by the year 1650 A.D., or in relation to the 4600 years. The after that augment by a factor of five took only in relation to the 300 years, or in relation to the 1950. Today world population has already exceeded 500 crores. The extra ordinary information is that much of this augments takes lay in the poorer countries such as Asia, Africa and Latin America. Population of USA or U.K. is not rising as rapidly as that of China or India. If we look at augment of population in India, we discover that family size is smaller in the middle of the well to do people than in the middle of the poor. Again, in the middle of Indian states, those with high stage of education have a lower rate of population growth than the others.

There is a high correlation flanked by rate of growth of population, poverty and lack of education. This is understandable because education would lead to better understanding of one’s own difficulties in relation to the providing food, shelter, clothing and education to children if there are too several children to share an income. Education would also lead to knowledge in relation to the how birth manage can be achieved without too much expense or trouble, overcome cultural factors which lead to big families, for instance too much importance to male children. In search of having one boy, a family may sometimes produce 3,4 more children. Education would also lead to better health care of the children, so that those who are born have a greater chance to survive. Educated population would also augment economic productivity which could lead to removal of poverty, and greater pressure to improve benefits of manufacture so that social justice is achieved.

Though, here our concern is the strain which rising population puts on the resources of the world, including the environmental resource. All the things we dig out of the earth such as coal, iron, petroleum, copper, and so on, are accessible in limited supply and all of them are going to be exhausted within a limited number of years—and if population keeps rising, world consumption of these materials will stay rising, advancing the date of resource exhaustion. Already there is a world crisis of power, and we are obliged to look at how to use renewable sources of power like solar or wind power, etc. We have to use more of nuclear power, rather than power obtained from coal, diesel or petroleum. Superior and superior population also requires more manufacture of food. Agriculture requires land and in several countries land is not accessible to grow the crops needed for the doubling or tripling population. There is tremendous strain in resources of drinking water, and on facilities to remove filth and muck. Superior population could mean shortage of housing, congestion on roads, slums going from bad to worse, and pollution—which we have described in this chapter, becoming increasingly active. Are we to stay poisoning the air we breathe, polluting the water that we drink or otherwise use, and polluting the soil at a rising pace? The rich countries have to cut down on excessive consumption of world's resources and their technologies necessity evolve so that they do not poison the air we breathe and the water in which vast resources of food and medicine flourish.

The poor countries have to create huge efforts to educate their people, to manage growth of their population and to evolve a society which does not create the rich, richer and the poor, poorer. They have also to evolve a technology that doesn't just copy what has been done in the past when pollution and limitation on resources was not a looming danger, and a technology which increases harmony flanked by environment and livelihood approach.

NATURAL RESOURCES

Natural Resources

Resources, or the wealth nature has bestowed on us are essential for civilized livelihood, and therefore, they have to be wisely used. Though, it is whispered that these resources are being used indiscriminately. This is partly because of the tremendous augment in population and partly because there is insufficient realization that these resources will one day be exhausted. Industrial and technological progress which the world has experienced has increased the rate at which these resources are being used. An important factor has been that, for centuries, the resources of some countries have been exported as raw materials to the dominant or imperial countries. The poor countries still have to export some valuable minerals to the similar countries which are now described urbanized countries. For instance, we are now a days exporting cadmium, a soft silvery metal, to foreign countries so as to earn foreign currency to meet our other necessities. The metal is very useful and is used for a diversity of purposes like creation cadmium rods for nuclear reactors and cadmium—silver cells for electronic watches etc. At present, we are not able to create much use of this metal in our country because of the low stage of technological development. If tomorrow our mineral reserve of this metal is exhausted, we may be forced to import it at a much higher cost.

Some countries which are importing this mineral may be stock-piling it and they will sell it at exorbitant price when our stocks are exhausted. We should, therefore, know what our natural resources are, what their uses are and how judiciously we can create use of these resources. Careful and planned use will no doubt augment the life span of our resources. For this it is necessary that we are able to explore our natural resources and estimate their reserves. Modem technology has made scientific exploration of natural resources possible.

Our resources are basically of two types, viz., renewable and non-renewable. Let us see what they mean. Some of the resources of the earth are replaced from time to time by natural multiplication as for instance, is vegetation. In other words, these resources are inexhaustible and are therefore described renewable resources. Forests, pastures, wild life, and aquatic life are renewable resources. Water is also a renewable resource because it recycles. There are some other resources, such as minerals which once used are lost for ever. They cannot be regenerated. Mineral deposits were shaped slowly in millions of years. Once a deposit is used, it cannot be regenerated. For instance, petrol gets burnt up and cannot be recovered.

These are recognized as non-renewable resources. Likewise, the formation of soil is a very slow and extensive term procedure and it takes thousands of years. It is, therefore, not renewable in the life span of even many generations of people. Hence it is also a non-renewable resource.

Renewable Resources

As stated earlier, renewable resources are in principle inexhaustible, because they get regenerated naturally. Though, through misuse we can interfere in this natural procedure and cause irreparable damage to these resources. Water and forests are our main renewable resources.

Water Resources

Water, as you know, is the mainly essential component of life. Our water resources are limited, though apparently, water is accessible in an abundant quantity. There is scarcity of usable excellence of water in big parts of the world. You will be quite amazed to know that only 2.7% of the total water resources of the earth consist of fresh water, fit for drinking, irrigation and such other purposes. Water flowing in the streams and rivers is only 0.0001% of the total water resource on the earth, i.e., one bucket in 10,000 buckets! Fresh water lakes contain only 0.009% of total water. Ground water upto a depth of in relation to the 150 meters accounts for only 0.625%. Water establishes in the frozen state as snow on high mountains, which cannot be directly used, accounts for in relation to the 2.15%.

The total volume of water establish in underground reservoirs, described aquifers, which can be pumped out is estimated to be 42.3 x 1010 cubic meters, of which only a quarter is being used, and the rest can be utilized in future for irrigation, industries and houses etc. That is the amount of ground water is in small quantity in these regions. We can see that water which is required for several purposes like irrigation, navigation, generation of hydro-electricity and domestic and industrial needs is rather scarce. It is, therefore, necessary that water resources should be exploited judiciously.

Forest Resources

Forests are our treasures, which give us a wide diversity of commodities we use in the form of fuel wood, fodder, fiber, fruit, timber, herbal drugs, cosmetics and several raw materials that are used in wood-based industries. A great several kinds of animals and birds, which live in the forests, serve as useful livelihood resources. Forests play a great role in maintaining oxygen supply in the air we breathe, and they affect the climate. Analysis of satellite photographs shows that in 1982, in relation to the 14% of the geographic region of our country were sheltered with forests of which almost 11% were closed forests and 3% degraded forests.

As a result of increased utilization of wood and other forest products, without putting in adequate efforts to regenerate them, the forests are recognized to be fast disappearing. This has caused an environmental imbalance. For instance, rain water flows unimpeded in excess of the mountain slopes and often causes floods. The excessive washing absent of top soil results in low fertility and decreased manufacture of crops. It is because of these evil effects of deforestation, that a strong policy has been adopted by our government to protect forests and to plant more trees.

Non-renewable Resources

After learning in relation to the renewable resources like water, forests etc., you would like to know what our non-renewable resources such as land, mineral, oceanic resources are. These resources can neither be regenerated nor expanded.

Land Resources

Land is a vital resource for us. It is, in information, the base on which the whole ecological system rests and it is the livelihood ground (habitat) for all terrestrial plants and animals. The capability of land to support life and several behaviors of man and animals is dependent both on its biological productivity, and load bearing capability of the soil and rocks.

Land is under great pressure due to augment in population. Our land mass which was, in 1901, inhabited by 238 million people, is now shared by more than 780 million people. Mismanagement of the land resource as a result of indiscriminate cutting of trees or deforestation has caused considerable damage to the excellence of the soil and landscapes.

Today, per capita land resource accessible in India is less than 0.4 hectare and it is presumed that with the present rate of population growth, it would be reduced to in relation to the 0.33 hectare by the end of twentieth century. Thus, you can realize the magnitude of the pressure on our land resources.

Soil Resources

Soil, which shapes the uppermost layer of the land, is the mainly valuable of all resources, because it supports the whole life system, gives food and fodder in the form of vegetation and stores water essential for life. It contains sand, silt and clays, mixed with air and moisture. It possesses rich organic and mineral nutrients.

The kind of soil varies from lay to lay. Those soils which are rich in organic matter are fertile. Fertility is also dependent on the capability of the soil to retain water and oxygen. The following major kinds of soil are recognizable in the Indian sub-continent.

- Deep red soil is establish on plateaux and lowland regions of Eastern Bihar, Madhya Pradesh and North Andhra Pradesh, where rainfall is 100-300 cm/year and temperature remnants above 22° C. The soil supports rain forests and grasslands and is good for farming of potatoes, bananas, pineapples and rubber etc.
- The kind of soil establish on the Deccan and Malwa plateaux of western and central India has a cover of clay and is loamy and black. It is very fertile and supports mixed grasslands, forests, crops of sugarcane, groundnut, soyabean, cotton and rice etc.

- The soils of the desert region of western India are low in organic matter and usually measured to have low fertility. Though, if water is provided they can be made very fertile. In excess of-irrigation, on the other hand, leads to salinity of these soils, thus reducing their productivity.
- Another kind of soil, shapes part of the Indo-Gangetic plain extending from Pakistan to Assam. It is establish in the delta regions on the coasts of Bengal, Orissa, Andhra Pradesh, Tamil Nadu, Kerala and Gujarat. This soil is characterized by loamy texture, arid composition and variability of thickness from lay to lay. The soil is highly productive and supports crops of all type. In the arid circumstances, it becomes in the vicinity alkaline or saline and is not very productive.
- The soil that shapes part of the low-lying wet land or marshy land in the deltas of Ganga, Godavari, Krishna, Kaveri and in the river basins of Kerala, contains rich organic matter such as decomposed farmyard manure (dung) and plant material (wood peat), and as such is very fertile.
- Another kind of soil establish on the mountainous Himalayan region, which is ash grey to pale yellow-brown in color, has low fertility and supports coniferous plants such as pines, deodar and oak etc.

The system of soil classification that you have read above is based on their common features. There are several differences within these kinds of soil which are due to differences in climate and natural vegetation.

Mineral Resources

Minerals, natural substances got from the earth by mining, are the backbone of our industries, and hence of commercial and economic use. Now-a-days, minerals such as uranium are also used for generating atomic power as an alternate source of power. A great diversity of minerals like coal, iron, copper, aluminum, petroleum etc., is indispensable to meeting our day-to-day necessities.

We are predominantly dependent on petroleum for generating power for all purposes, but the world stock of underground resources of this fuel is whispered to be exhausting. India is self-enough in 35 minerals, which are used as raw materials in vital industries. We have iron, aluminum, coal etc. in enough quantity, but for the requirement of phosphates which are used in creation fertilizers, crude oil and non-ferrous metals like cop per, zinc and lead; we are dependent, to some extent on imports from foreign countries. Our mineral producing states are Bihar, Madhya Pradesh, Bengal, Gujarat, Rajasthan and Andhra Pradesh. With the introduction of modem technology, it is now possible to locate the reserves of petroleum on the land as well as in the ocean bed. Pictures sent by the satellites, satellite imageries, help us to pin point the region where mineral deposits are likely to be establish in abundance. Earlier, before we had the satellites in legroom, this was not possible.

Oceanic Resources

Several minerals are established in the sea basins. In the middle of the minerals establish at a depth of 4000-5000 meters below sea stage are the “nodules” or lumps of manganese oxides and sulphides of cobalt, nickel, copper and iron. India is also trying to use this resource. Today more than l/5th of the world’s oil and natural gas manufacture comes from offshore wells. The Bombay High, for instance, has petroleum reserves of the order of 7,400 million tonnes. Deltas of the Kaveri, Godavari and Mahanadi are also established to have big deposits of natural gas and oil. The coastal sands of Kerala and Orissa contain several valuable minerals such as monazite (raw material used in generation of atomic power) and zircon. Several other metals like tin, gold, platinum etc. are also establish in the deposits on the coast.

The livelihood resources of the ocean such as fish and plants serve as good food to meet the needs of the people or as a source of some medicines.

Power: A Non Conventional Renewable Resource

The demand for power doubles every 14 years and is taken as one of the indicators of development of a country. India, with 16% of the world's population consumes only 1.5% of the total power produced in the world, in comparison to USA which has 6.25% of the world's population and utilizes 33% of the power produced. This provides us and thought of the low stage of our development and should be an incentive to better utilization of our resources for generating more power, so that we can meet our rising demands of power. Even today, in relation to the 80% of our population continues to depend on fuel wood, dung and agricultural wastes. We know that non-renewable reserves such as fossil fuels, coal and petroleum, are not going to last for extensive. Forests are also being depleted at a fast rate due to indiscriminate felling of trees. Therefore, it has become necessary to think of alternative, non conventional sources of power. Some of these sources of power are discussed here.

Solar Power

The power we get today from the fossil fuels like coal, is in reality sun's power, trapped in them millions of years ago. Plants create their food and grow because they use solar power for photosynthesis. Millions of years ago, vast forests got buried in the earth's crust and under great pressure and temperature; they were converted into coal or oil. Hence coal and oil are described fossil fuels. Solar power is the great source for manufacture of vegetation which serves as food and fuel for us.

Wind Power

Like solar power, wind flow can also be harnessed to obtain mechanical power for fetchin water from the wells or from rivers. Once the windmill is turning due to force of the wind, it may as well run a generator to get electrical power. In the coastal and hilly regions, where wind blows at high speed, a wind mill can be used for the supply of electricity to a small city. Windmills have been used since extensive in several countries, but in India they have only been recently introduced.

Wave and Tidal Power

Waves and tides are another source of power which is perpetual and can be converted into electric power; particularly where sea water can move into a narrow cut, such as is provided naturally where rivers flow into the sea. Power accepted by water has also been widely used in India's hilly regions, since a wheel with pedals can be made to turn when it is put in a fast flowing stream. Flour mills of small size built on this principle were used in Kashmir for extensive time. In information, big "hydroelectric" power stations work on the similar principle. A natural or artificial water fall is made to turn a contemporary type of pedal wheel, described a turbine, which rotates and causes electricity to be generated.

Geothermal Power

Hot water and superheated steam of hot springs are a natural phenomenon and can be used to, generate electricity. In our country there are 46 hydrothermal regions where the temperature of the spring water exceeds 150°C. These hot springs can be used to generate electricity for heating houses, or glass-homes to grow vegetables.

Atomic Power

In view of the fast depletion of our non-renewable resources like coal and petroleum, and because of pollution which power stations burning coal cause, there has been a move to use other means of obtaining power. Since the power of the atom had already been unleashed in the form of a bomb, efforts were made to release atomic power in a controlled manner. The device used for this purpose is described an atomic reactor.

Nuclear reactors produce heat, which is commonly used to raise steam, which rotates turbines and generators of electric power. It is estimated that 1 kg of natural uranium, written as U23, generates power equal to that produced by 35,000 kg of coal. Thus manufacture of power from nuclear fuel like uranium is efficient, and since great loads of coal or diesel are not consumed daily, this power is convenient. Nuclear reactors need to be situated at spaces distant absent from habitations. They have to be operated under strict safety manage, so that there are no accidental leakages of radioactive material. The radioactive wastes have to be cautiously disposed off. India is very short of power and all of you may have heard or experienced power cuts or load-shedding. We have plans to set up many nuclear reactors to generate a good location of our total power requirement.

Biogas

You may have heard of the use of cattle dung for manufacture of biogas which is used for cooking. Water weeds like water hyacinth, water lettuce, salvinia, hydrilla, duck weeds and algae are established to be useful supplement to cattle dung. Biogas can be used not only as cooking gas, it can also be used to raise steam, which can be used for running engines or machines in the factories or for running turbines to generate electricity. It has been establish that big biogas plants can supply the needs of a number of families or even small villages. What is left in excess of after generating the gas, can be used as manure. Hence this is also an economical method of getting more power. That is why in countries like China or India, great efforts are being made to install tens of thousands of biogas plants in rural regions.

Ways of Exploration of Resources

Exploration of resources involves intricate techniques which depend on the physical, chemical and biological properties of a scrupulous resource. Now-a-days, in our country, much of the exploration is done by analysis of photographs taken from aircraft or spacecraft (satellites) and other data supplied by the sensors mounted on these vehicle by a way described' remote sensing'. You may like to know something in relation to the ways used for exploration of resources.

Conventional Ways

In olden days, detection of minerals or of petroleum was purely accidental. People used to know in relation to the hidden treasures of the Earth, when they used to dig out land for water or for construction of homes. Sometimes, while tilling land, farmers struck luck and exposed valuable metals and minerals. Though, in this method, they could only hit upon the mineral wealth which lay secure to the surface. Now, several techniques are used for systematic exploration of the hidden resources, and drilling or digging is undertaken when preliminary surveys have clearly indicated what is underneath and how much is likely to be established.

Remote Sensing Way

Principle

Remote sensing is a way of collecting information in relation to the ground objects like soil, water, vegetation and minerals, from a remote lay, such as an aircraft or a satellite. This technique not only enables us to locate several resources, but also helps us to know in relation to the quantity and excellence. The simplest device could be a camera accepted by an aeroplane to photograph big regions of land systematically. Television cameras could be mounted on satellites and they could take pictures showing details of clouds, water, forests or structures on the earth. Both these are "optical" ways of remote sensing because visible light is used by the cameras. But one could send out radio waves from the satellites and observe how they are reflected or absorbed on the surface of the earth. Usually radio waves of wavelengths as small as a few centimeters described 'microwaves', are used for such studies, because these waves penetrate through Clouds and their reflections also go through the clouds to reach the satellite. Likewise, infra-red signals can be sent from the satellite and reflections studied to reveal the nature of the reflecting surface.

Remote Sensing of Water Resources

Radio waves of the shortest recognized wavelengths are described 'gamma rays'. These are given off by atoms of many elements. As a result, the ground soil sends out gamma rays which can be picked up by detectors in the aeroplanes or satellites. This emission is affected by the attendance of moisture or water in the soil and hence, it can be easily detected whether or not the soil holds water. Moreover, in the pictures taken from legroom, the wet soil will have altogether dissimilar appearance compared to arid or waterless soil. Due to the attendance of moisture, the water rich soil will not only illustrate day time (diurnal) difference in temperature on its surface, but will also have a cover of vegetation. Analysis of the kind, density and pattern of the vegetation rising on the wet soil helps us in locating the regions of potential ground water. Likewise, the belts of hot springs may be recognized and will illustrate up in thermal or infra-red detectors.

Survey of the Vegetation Cover

Forests of deciduous trees which shed leaves in a sure season can be easily recognized with the help of pictures taken from the spacecraft specially throughout autumn when the deciduous trees shed leaves and there is no snowfall as yet to conceal the vegetation. Vegetation cover can be surveyed by measuring and analyzing infra-red reflection, or with the help of photographs. The density of vegetation, form and size of the plants and even size, orientation and health of the leaves can be studied from afar. The pattern of seasonal growth of deciduous trees is dissimilar from that of the coniferous trees like pine and deodar and thus the variation can be detected in the photos taken by the spacecraft.

Plants absorb solar power to create carbohydrates. A part of the absorbed power is given out and therefore the leaf temperature remnants 10-15°C higher than the nearby air temperature throughout sunniest part of the day, and in relation to the 5°C below the air temperature at the coolest hour of the night. So by measuring ground temperature from aloofness, the attendance or absence of vegetation can be detected.

Search for Mineral Deposits

Aerial photos and satellite pictures illustrate very clearly if there is a break in the stability of layers of rock, or other unusual characteristics on the surface of the earth. The distinctive linear characteristics are established to be very general centers where mineral deposits and ground water are accumulated. Radio waves and magnetic measurements also give information in relation to the minerals and oil under the surface.

Kinds of Resource Maps

Usually, many kinds of maps, based on the kind of resources, are prepared. Some of these are:

- Soil Maps showing the kinds of soil, their composition and biological productivity.
- Mineral Maps showing locations of several types of mineral deposits in relation to settings of the earth's crust.
- Hydrological Maps illustrate attendance of underground water aquifers, i.e., rock formation containing water in recoverable quantity, in conditions of the depth of water table.
- Snow Cover Maps demarcate the extent of snow packs on high mountains.

Resource Mapping

Using several techniques, Resource Mapping is done to locate dissimilar resources like water, minerals, forests, vegetation as well as the kinds of land. Mapping of resources creates it possible to visualize how land use could be supervised to best advantage. The rural land use map tells us in relation to the health of forests and the state of deforestation, in relation to the pastures, and agricultural crops. It also tells us how much land and of what type is unutilized. The urban land use maps illustrate housing, commercial structures, sports facilities, essential services such as roads, water supply and disposal of waste etc. Likewise, the preparation of local land use maps will focus upon the broader characteristics of development such as land used for agriculture, industrialization and urbanization, for obtaining natural resources (forestry, mining etc.), water resource development (dams, reservoirs and canals), transportation net work (rails, road etc.) and also the zones prone to natural hazards like floods, cyclones, earthquakes, landslides and avalanches etc.

RESOURCE UTILISATION, PLANNING AND MANAGEMENT

Use of Natural Resources

Land

Land is the mainly valuable resource, because its produce supports human population and other livelihood beings on land. Almost 44% of land in India is used for agricultural purposes, of which 11-14% is sheltered with forests that contain good as well as degraded forests, and 4% of the land is used as pastures and grazing meadows. The remaining 8% is used for several other purposes such as housing, agro forestry, establishment of industries, development of roads and reservoirs etc...

In relation to the 14% of our land is barren i.e. it cannot be used for the farming of crops. Almost 1/3 of the barren land has lost its productivity due to alkalinity or salinity of the soil, and water logging etc. Soil erosion causes a great harm to productivity of our land, because in this procedure soil is broken up and washed absent by water or swept absent by wind. These facts indicate careless and unwise use of land and are a reflection of the mismanagement of our land resources.

Today, almost 24% of our population lives in urban regions. The rapid augment of urbanization and migration of population from rural to urban regions lead to two serious consequences. Migration of people to cities increases their population and expands their size, thus necessitating conversion of agricultural land to housing, office and factory structures, roads and bridges etc. Rural land, on the other hand, may remain underutilized. The circumstances of life in the municipalities often deteriorate due to increased population. Sewage and water supply come under strain; more vehicles cause more pollution; or the poor end up in unhygienic slums. Migration can be checked only if the livelihood circumstances in the villages are improved. Particularly transport and communication, health care, education, and other vital amenities like clean water and good sewage disposal should be provided in rural regions. Setting up of rural industries can lead to employment of rising numbers, so fewer people would leave their villages for urban regions.

Water

Water, used for irrigation of meadows or for drinking, is obtained from rivers and streams and from wells which provide access to the underground water reserves. In spite of the abundance of the water flowing down the rivers or stored underground, mainly of the villages, even today, do not have adequate supply of good excellence drinking water. Quite often, in rural regions, drinking water has to be brought from an aloofness of a few kilometers. Even all the cities do not have a municipal water supply system. On the other hand, a lot of water is misused or wasted. Ground water accounts for in relation to the 48% of the irrigation water. If necessary equipment and power are accessible to pump it out, it could give assured irrigation to sizable part of our land.

Forest Cover

An analysis of satellite imageries and air photos designates that in 1982 in relation to the 11%of land region in India was thick forests and the remaining 3% degraded or thin forests. The world figures are much higher than this, and a higher figure is measured necessary from the point of view of climate as well as maintenance of the composition of the air we breathe. In India, mainly of the forests resources are used as fuel by people livelihood in or approximately them. A good deal of forest trees are felled for timber, and for packing fruit and for creation paper. Besides, forests are being overgrazed by the rising number of cattle. Throughout the last 30 years, almost 4.3 million hectares of forests were converted into agricultural meadows or lost in construction of dams and roads. This is quite a good fraction of the 75 million hectares of total forest region. According to the latest information, the country is losing its forests at the rate of 0.16 million hectare every year. If the present rate of deforestation continues, a good deal of the country would become mere grassland within a hundred years, with drought and floods becoming a regular characteristic in India.

Minerals

Minerals like coal, iron, copper, steel etc. are used in all types of industries and in every-day life. The rate of consumption of minerals is rising every year. Although the per capita consumption of some minerals like lime stone and iron ore is higher than some other minerals like bauxite, clay, gypsum, silica, sulphur, coal etc. Our per capita mineral consumption is very small compared to that of the urbanized countries like USA, USSR or Japan. A major proportion of minerals produced in our country are exported to other countries as raw material to earn foreign exchange. Though, quite a few minerals, like uranium, diamond, some types of steel, copper, non-ferrous alloys, crude oil etc. is imported in one form or another.

A significant issue in the utilization of resources is how to handle waste, so as to extract the useful resources from it. Let us now consider the recycling of waste materials.

Recycling of Used Resources and Waste

Some of the materials once used need not go waste, these can be re-used. The procedure through which the waste resources are again made usable is recognized as recycling.

Scraps and Used Metals

Scrap metal is produced in big quantities in mills and factories. Old used metal of discarded vehicles, machine, aircrafts, ships, structures etc. can be melted and recycled for useful purposes. Used aluminum utensils, for instance, can be composed, melted and shaped into new utensils. We can meet the rising demand of such scarce metals as copper, zinc, lead, platinum etc. by recycling the used materials.

Waste Water

Domestic and municipal waste water is rich in organic nutrients. If this type of water is made free from disease carrying germs and poisonous elements, it can be used for irrigation of farms, gardens and other vegetations.

For the removal of germs and toxic elements, the waste water or sewage is treated in a tank or in ponds for many days. The clear liquid is then allowed to pass through filters or sand or earth and finally air is blown through it. This treatment not only removes carbon dioxide and hydrogen sulphide which is usually dissolved in waste water, but also adds oxygen to the filtered water, thus helping in purification. Treatment of water with appropriate doses of chlorine, recognized as chlorination, kills all the harmful germs and creates water usable.

Rising of algae or water hyacinth, a wild plant that grows in floating masses in rivers, lakes etc. serve a double purpose.

Solid Waste

Solid waste in some cases can be a resource. A good instance is the factory at Yokohama in Japan which is occupied in converting waste paper into toilet paper. In our country, the main street of Patna municipality is being illuminated by biogas produced from night soil of the municipality dwellers. In Delhi, the sewage treatment plant produces cooking gas. Fermentation of wastes such as cattle dung, human excreta, garbage and aquatic weeds like algae and water hyacinth, produces biogas which can be used for a diversity of purposes. Fermentation takes lay at temperatures flanked by 28° and 40°C and gases produced are predominantly methane and carbon dioxide with a small quantity of hydrogen sulphide and nitrogen.

Slag, a waste product left when the metal has been extracted from its ore, can be powdered and added to cement for construction. Flyash is another material used as a valuable cementing material.

It is clear from the above that the solid wastes can serve as very useful resource for providing raw material for our industries, for generating power and for the manufacture of manure.

Resource Planning and Management

You already know that our resources are limited and if they are not used properly they will get exhausted soon. It is, therefore, necessary for us to study, how with wise and careful planning, we can create use of our limited resources.

Land Use Planning and Management

People see land everywhere and get an impression that plenty of it is accessible. Besides, they do not care how it is being used, unless of course, it is their own property. Lack of concern on the part of the public and official agencies has led to widespread erosion, soil sickness and other damage to land resources. Land is an exhaustible resource and is very sensitive to changes in climate and physical procedures in nature like rain, sunshine, vegetation, erosion, land slides etc.

Land should be used according to its suitability and capability. Suitability and capability of land is assessed in conditions of its load bearing skill and fertility.

Since food for a rising population requires more land for farming, the encroachment of fertile agricultural lands for non-agricultural purposes like construction of roads and structures should be reduced to the minimum. Extreme care should be taken in selecting sites for development of industries, construction of dams and water reservoirs etc., so that the environment and socio-economic circumstances of the people livelihood in that region are not disturbed. In locating sites for the development of urban centers, the need for housing, water supply, disposal of waste and garbage etc. should be taken into consideration.

Hill regions, as distant as possible, should be put under forest cover because forests serve as a resource for fuel, fodder, and timber, and give legroom for animal farming. Besides, forests help in rising the ground water, since they impede the free surface runoff, thus allowing water to be absorbed by the ground. In this procedure, soil erosion is minimized and flooding can be avoided. Forests help to uphold a balance in the ecosystem, that is, in the middle of animals, plants, air and water etc.

Essential Components of Land Management

This type of map is prepared with the help of aerial photos and satellite imageries. The map can also provide information concerning the properties of rock and soil and underground potentials of water reserves.

A detailed study of several characteristics of land, such as kind of soil, physical characteristics of the earth’s crust, water resource input, its sharing, utilization, surface flow, surface storage, for instance in ponds and ground water. A programme of land use can be worked out on the foundation of such information.

Changes resulting from land use have to be monitored. This can be done by remote sensing.

Soil Management

As we have said before, soil is a valuable resource which takes millions of years to form, and hence proper management of soil is very necessary. The management of the soil is twofold, i.e.

- To minimize or check soil erosion and
- Restore productivity of the soil.

Manage of Soil Erosion

The mainly important events of erosion manage contain:

- Growth of grasses, shrubs and trees on soils and
- Construction of a drainage system which can prevent free, uncontrolled flow of water.

Water flow causes formation of narrow channels or gullies and leads to development of deep narrow valleys leading to ravine land. The well-known Chambal ravines have been shaped as a result of deep soil erosion and the procedure is still continuing. This can be controlled by constructing a series of check dams which prevent the flow of running water and widening of gullies. Formation of a broad wall of stone beside the coasts of Maharashtra, Kerala, Andhra Pradesh and Orissa has proved to be very effective in controlling erosion by sea waves and currents. Movement of sand by gusts of wind in the deserts and sandy coasts can be prevented by putting barriers of trees and shrubs crossways the path of wind. In the mountain and hilly regions, planting of stems and branches of self propagating trees and shrubs, not only strengthens the slope of the terrace but also gives fuel wood and fodder to the farmers. Alternation of beds of crops with strips of erosion resistant vegetation like grasses, shrubs, trees, maize, sugarcane, cotton and tobacco etc. brings in relation to the stabilization of the terraced meadows on mountainous and hilly regions.

The mainly effective step in controlling erosion and mass movement, such as landslides in the hills, is the construction of a network of the drainage ditches which are filled with fragments of stones or bricks so that water flows out through them. The hill slopes are stabilized by constructing walls approximately them which allows the free passage of water. On the vulnerable slopes, a cover of vegetation is provided and in the beginning, seeds are sheltered with coir netting pegged firmly to the ground. Netting checks erosion holds the soil material jointly and adds nutrients. The quick growth of grass stabilizes the soil.

Treatment of Soil Sickness

Due to overuse without rest, soil becomes deficient in the requisite nutrients and loses its fertility. Rotation of crops and vegetables, such as peas and beans, helps to remove the deficiency of nutrients. Plants such as peas add nitrogen to the soil and thus augment its binding property as well as productivity. The roots and off-shoots of the crops and their remnants are left in the field for a sure era of time to protect the soil from erosion.

It is establish that excessive irrigation causes complete saturation or water logging of the soil, which consequently loses productivity, partially or totally. As a result of in excess of irrigation in some regions, salinity and alkalinity of the soil increases, creation it “sick”. This type of soil sickness can be controlled by, first of all, sealing off all points of leakage from canals, reservoirs, tanks and ponds, and use of only the required amount of water. Alkalinity and salinity of the soil can also be reduced by application of some chemicals like:

- Gypsum (a chalk like substance, from which Plaster of Paris is made),
- Phosphogypsum (gypsum with phosphates),
- Pyrites (sulphides of copper, iron etc.) in addition to organic manures and fertilizers.

Planting of salt resistant plants such as barley, millets, soya, cotton, spinach, date palm is another method of overcoming the problem of salination of the soil.

Management of Forest Resources

Considering the ever rising demand of wood and realizing the importance of conserving our forest resources, it has become necessary to discover alternative fuels as well as raw materials to manufacture paper, sports goods, packing cases, furniture and beams used in structures. Research is going on to talk about alternate sources; in some cases, plastics and composite materials have been urbanized, though they are not widely used as yet. The other method is to cultivate quick rising trees and herbages in big numbers in selected farms of degraded or wastelands. This will give us fodder, fuel wood, timber, fruits and seeds. If deforestation has to be stopped, some necessary steps have to be taken:

adoption of a scientific way of harvesting forest stocks, developing a mechanism of monitoring forest growth rate and depletion, establishing an effective system of fighting forest fires, strictly enforcing laws to deal with unauthorized cutting of trees.

Tree Plantation

Plantation, on a mass level, of fast rising trees such as poplar, casuarinas etc. should be undertaken. The productivity of tree plantation is establish to be greater than that of natural forests. In a well irrigated tree farm, the productivity may be as high as 45 tonnes per hectare per year.

Social Forestry

A fanner can partly meet his needs of wood from the fast rising trees planted within the limits of his village, beside the footpaths, roadsides, alongside railway tracks, face roads or canala and streams, boundaries of meadows and empty spaces. The aim of social forestry is to meet the needs of fuel, fodder, fruits, timber and other necessities.

Management of Water Resources

Management of water resources means a programme to give an adequate supply of good excellence of water for several uses without endangering the life of the source or the reserve of water. In other words, efforts should be made to see that:

- Water of the right excellence is accessible for all type of uses and
- There is no misuse or wastage of this valuable resource.

Water management comprises recharging the reserves of groundwater and diverting supply from a region of surplus to the region of scarcity. Recharging of groundwater is the mainly significant aspect of the water management. In the mountains and hills, the watersheds are sheltered with vegetation. The litter-sheltered soil of the watershed allows infiltration of rain water, which discovers its method to the aquifers.

In urban and rural regions, storm water, used water or domestic drains can be fed into pits, trenches, or any depression, where it can filter underground. Flood water can be injected into aquifers through a series of deep pits or it can be spread on the meadows through a network of ditches. The excess flow of normal as well as flood water can be diverted to regions where there is scarcity of water. This will not only remove the danger of damage caused by floods but will also benefit the regions of scarcity. By proper treatment of the domestic and municipal waste water, one can obtain a supply fit for several industrial and agricultural purposes. The treatment of waste water involves removal of pollutants, germs, and toxic elements.

Desalination of Sea Water

By use of solar power, sea water can be distilled, thus fresh water of good excellence can be obtained. This way of desalination of sea water is being used in our country at spaces like Bhavanagar in Gujarat and Churu in Rajasthan.

Reducing in Excess of Consumption

Using more water than necessary is an unpardonable waste of the valuable and scarce resource. In our country, a lot of water is wasted due to leaking taps and bad plumbing. There is also need for a check on excessive irrigation. There are methods in which we can better manage our limited resources.

Conservation of Mineral Resources

At the present rate of consumption several of them will not last extensive. Conservation means that there should be judicious use with minimum wastage. One method of minimizing or reducing wastage is recovering as much as possible and leaving nothing as waste. The excellence of lower grade ore can be improved by procedures which remove undesirable materials like earth rock etc. and provide enriched ore. Scraps of used metals can be recycled or used again. This will reduce the pressure of demand on several mineral reserves. The alloys of magnesium are fast replacing steel and are also reducing the demand for copper, lead and tin which are in short supply. There is a need to discover substitutes for metals like mercury, gold, silver, platinum etc. and also for asbestos.

The dug out parts are devoid of nutrients. Hence, they remain barren and do not allow the growth of any vegetation. Such waste or damaged lands can be sheltered by fresh topsoil. Use of fertilizers, sewage water, domestic or municipal waste, farmyard manure, etc. will help in restoring the fertility of these degraded lands. Continuous recording of the changes in the excellence and quantity of several resources is as significant an element of resource planning as evaluation of original reserves.

The monitoring of resource utilization is best done through remote sensing. It involves learning the nature and size of reduction or deterioration of the forests, soil, land, mineral deposits, water bodies and snow packs. For instance monitoring of the behaviour of rivers will help us in averting or reducing the menace of floods and erosion. Monitoring has also demonstrated that in excess of-irrigation of arid or semi-arid regions causes salinity or alkalinity of the soil. Such harmful effects of in excess of-irrigation are witnessed in southern Haryana and adjoining Rajasthan.

FOOD AND AGRICULTURE

Agriculture in India

Agriculture in India has an important history. Today, India ranks second worldwide in farm output. Agriculture and allied sectors like forestry and fisheries accounted for 16.6% of the GDP in 2009, in relation to the 50% of the total workforce. The economic contribution of agriculture to India's GDP is steadily declining with the country's broad-based economic growth. Still, agriculture is demographically the broadest economic sector and plays an important role in the overall socio-economic fabric of India.

Per 2010 FAO world agriculture statistics, India is the world's main producer of several fresh fruits and vegetables, milk, major spices, select fresh meats, select fibrous crops such as jute, many staples such as millets and castor oil seed. India is the second main producer of wheat and rice, the world's major food staples. India is also the world's second or third main producer of many arid fruits, agriculture-based textile raw materials, roots and tuber crops, pulses, farmed fish, eggs, coconut, sugarcane and numerous vegetables. India ranked within the world's five main producers of in excess of 80% of agricultural produce items, including several cash crops such as coffee and cotton, in 2010. India is also one of the world's five main producers of livestock and poultry meat, with one of the fastest growth rates, as of 2011.

One statement from 2008 claimed India's population is rising faster than its skill to produce rice and wheat. Other recent studies claim India can easily feed its rising population, plus produce wheat and rice for global exports, if it can reduce food staple spoilage, improve its infrastructure and raise its farm productivity to those achieved by other developing countries such as Brazil and China.

In fiscal year ending June 2011, with a normal monsoon season, Indian agriculture accomplished an all-time record manufacture of 85.9 million tons of wheat, a 6.4 percent augment from a year earlier. Rice output in India also hit a new record at 95.3 million tons, a 7% augment from the year earlier. Lentils and several other food staples manufacture also increased year in excess of year. Indian farmers, thus produced in relation to the 71 kilograms of wheat and 80 kilograms of rice for every member of Indian population in 2011. The per capita supply of rice every year in India is now higher than the per capita consumption of rice every year in Japan.

India exported approximately 2 million metric tons of wheat and 2.1 million metric tons of rice in 2011 to Africa, Nepal, Bangladesh and other regions approximately the world.

Aquaculture and catch fishery is amongst the fastest rising industries in India. Flanked by 1990 and 2010, Indian fish capture harvest doubled, while aquaculture harvest tripled. In 2008, India was the world's sixth main producer of marine and freshwater capture fisheries, and the second main aquaculture farmed fish producer. India exported 600,000 metric tonnes of fish products to almost half of all the world's countries.

India has shown a steady average nationwide annual augment in the kilograms produced per hectare for several agricultural items, in excess of the last 60 years. These gains have come mainly from India's green revolution, improving road and power generation infrastructure, knowledge of gains and reforms. Despite these recent accomplishments, agriculture in India has the potential for major productivity and total output gains, because crop yields in India are still just 30% to 60% of the best sustainable crop yields achievable in the farms of urbanized as well as other developing countries. Additionally, losses after harvest due to poor infrastructure and unorganized retail cause India to experience some of the highest food losses in the world.

History

The invention of agriculture is one of the great revolutions of human history. It comprises the food manufacture and domestication which led to important changes in human society, population augment and biological changes. Though, this revolution is best demonstrated at Mehargarh (Era-I Neolithic era) in which the sense of the revolution ultimately set the platform for the rise of urbanization in the Indian Subcontinent. In the era of the Neolithic revolution (roughly 8000-5000 BCE.), agriculture was distant from the dominant mode of support for human societies. But those who adopted it, have survived and increased, and passed their techniques of manufacture to the after that generation. This transformation of knowledge was the base of further development in agriculture. Vedic literature gives some of the earliest written record of agriculture in India. Rigveda hymns, for instance, describes plowing, fallowing, irrigation, fruit and vegetable farming. Other historical proof suggests rice and cotton were cultivated in the Indus Valley, and plowing patterns from the Bronze Age have been exhumed at Kalibangan in Rajasthan. Bhumivargaha, another ancient Indian Sanskrit text, suggested to be 2500 years old, classifies agricultural land into twelve categories:

- Urvara (fertile),
- Ushara (barren),
- Maru (desert),
- Aprahata (fallow),
- Shadvala (grassy),
- Pankikala (muddy),
- Jalaprayah (watery),
- Kachchaha (land contiguous to water),
- Sharkara (full of pebbles and pieces of limestone),

- Sharkaravati (sandy),
- Nadimatruka (land watered from a river), and
- Devamatruka (rainfed).

Some archaeologists consider rice was a domesticated crop beside the banks of the Indian River Ganges in the sixth millennium BC. So were species of winter cereals (barley, oats, and wheat) and legumes (lentil and chickpea) grown in Northwest India before the sixth millennium BC. Other crops cultivated in India 3000 to 6000 years ago, contain sesame, linseed, safflower, mustards, castor, mung bean, black gram, horse gram, pigeonpea, field pea, grass pea (khesari), fenugreek, cotton, jujube, grapes, dates, jackfruit, mango, mulberry, and black plum. Indian peasants had also domesticated cattle, buffaloes, sheep, goats, pigs and horses thousands of years ago. Some scientists claim agriculture in India was widespread in the Indian peninsula, some 3000–5000 years ago, well beyond the fertile plains of the north. For instance, one study reports twelve sites in the southern Indian states of Karnataka and Andhra Pradesh providing clear proof of agriculture of pulses (Vigna radiata and Macrotyloma uniflorum), millet-grasses (Brachiaria ramosa and Setaria verticillata), wheats (Triticum diococcum, Triticum durum/aestivum), barley (Hordeum vulgare), hyacinth bean (Lablab purpureus), pearl millet (Pennisetum glaucum), finger millet (Eleusine coracana), cotton (Gossypium sp.), linseed (Linum sp.), as well as gathered fruits of Ziziphus and two Cucurbitaceae.

Some claim Indian agriculture began by 9000 BP as a result of early farming of plants, and domestication of crops and animals. Settled life soon followed with implements and techniques being urbanized for agriculture. Double monsoons led to two harvests being reaped in one year. Indian products soon reached the world via existing trading networks and foreign crops were introduced to India. Plants and animals—measured essential to their survival by the Indians—came to be worshiped and venerated.

The middle ages saw irrigation channels reach a new stage of sophistication in India and Indian crops affecting the economies of other regions of the world under Islamic patronage. Land and water management systems were urbanized with an aim of providing uniform growth. Despite some stagnation throughout the later contemporary era the independent Republic of India was able to develop a comprehensive agricultural program.

Agriculture and Colonialism

In excess of 2500 years ago, Indian farmers had exposed and begun farming several spices and sugarcane. It was in India, flanked by the sixth and fourth centuries BC, that the Persians, followed by the Greeks, exposed the well-known “reeds that produce honey without bees” being grown. These were in the vicinity described, pronounced as saccharum. On their return journey, the Macedonian soldiers accepted the "honey bearing reeds," thus spreading sugar and sugarcane agriculture. People in India had also invented, by in relation to the 500 BC, the procedure to produce sugar crystals. In the local language, these crystals were described *khanda*, which is the source of the word *candy*.

Prior to 18th century, farming of sugar cane was mainly confined to India. A few merchants began to deal in sugar - a luxury and an expensive spice in Europe until the 18th century. Sugar became widely popular in 18th century Europe, then graduated to becoming a human necessity in the 19th century all in excess of the world. This development of taste and demand for sugar as an essential food ingredient unleashed major economic and social changes. Sugarcane does not grow in cold, frost-prone climate; therefore, tropical and semitropical colonies were sought. Sugarcane plantations, just like cotton farms, became a major driver of big and forced human migrations in 19th century and early 20th century - of people from Africa and from India, both in millions - influencing the ethnic mix, political conflicts and cultural development of several Caribbean, South American, Indian Ocean and Pacific island nations. The history and past accomplishments of Indian agriculture thus influenced, in part, colonialism, first slavery and then slavery-like indentured labor practices in the new world, Caribbean wars and the world history in 18th and 19th centuries.

Indian Agriculture since 1947

In excess of 50 years since its independence, India has made immense progress towards food security. Indian population has tripled, but food-grain manufacture more than quadrupled: there has thus been substantial augment in accessible food-grain per capita.

Prior to the mid-1960s India relied on imports and food aid to meet domestic necessities. Though, two years of severe drought in 1965 and 1966 influenced India to reform its agricultural policy, and that India could not rely on foreign aid and foreign imports for food security. India adopted important policy reforms focused on the goal of food grain self-sufficiency. This ushered in India's Green Revolution. It began with the decision to adopt superior yielding, disease resistant wheat diversities in combination with better farming knowledge to improve productivity. The Indian state of Punjab led India's green revolution and earned itself the distinction of being the country's bread basket.

The initial augment in manufacture was centered on the irrigated regions of the Indian states of Punjab, Haryana and western Uttar Pradesh. With both the farmers and the government officials focusing on farm productivity and knowledge transfer, India's total food grain manufacture soared. A hectare of Indian wheat farms that produced an average of 0.8 tons in 1948, produced 4.7 tons of wheat in 1975 from the similar land. Such rapid growths in farm productivity enabled India to become self-enough by the 1970s. It also empowered the smallholder farmers to seek further means to augment food staples produced per hectare. By 2000, Indian farms were adopting wheat diversities capable of yielding 6 tons of wheat per hectare.

With agricultural policy success in wheat, India's Green Revolution technology spread to rice. Though, since irrigation infrastructure was very poor, Indian farmer innovated with tube-wells, to harvest ground water. When gains from the new technology reached their limits in the states of initial adoption, the technology spread in the 1970s and 1980s to the states of eastern India — Bihar,[Orissa] and West Bengal. The lasting benefits of the improved seeds and new technology extended principally to the irrigated regions which explanation for in relation to the one-third of the harvested crop region. In the 1980s, Indian agriculture policy shifted to "development of a manufacture pattern in row with the demand pattern" leading to a shift in emphasis to other agricultural commodities like oilseed, fruit and vegetables. Farmers began adopting improved ways and technologies in dairying, fisheries and livestock, and meeting the diversified food needs of India's rising population. As with Rice, the lasting benefits of improved seeds and improved farming technologies now mainly depends on whether India develops infrastructure such as irrigation network, flood manage systems, reliable electricity manufacture capability, all season rural and urban highways, cold storage to prevent food spoilage, contemporary retail, and competitive buyers of produce from the Indian farmer. This is increasingly the focus of Indian agriculture policy.

India's agricultural economy is undergoing structural changes. Flanked by 1970 and 2011, the GDP share of agriculture has fallen from 43 to 16 percent. This isn't because of reduced importance of agriculture, or a consequence of agricultural policy. This is mainly because of the rapid economic growth in services, industrial output, and non-agricultural sectors in India flanked by 2000 to 2010.

Irrigation

Irrigation in India refers to the supply of water from Indian rivers, tanks, wells, canals and other artificial projects for the purpose of farming and agricultural behaviors . In country such as India, 64% of cultivated land is dependent on monsoons. The economic significance of irrigation in India is namely, to reduce in excess of dependence on monsoons, advanced agricultural productivity, bringing more land under farming, reducing instability in output stages, creation of job opportunities, electricity and transport facilities, manage of floods and prevention of droughts.

Accomplishments

As of 2011, India had a big and diverse agricultural sector, accounting, on average, for in relation to the 16 percent of GDP and 10 percent of export earnings. India's arable land region of 159.7 million hectares (394.6 million acres) is the second main in the world, after the United States. Its gross irrigated crop region of 82.6 million hectares (215.6 million acres) is the main in the world. India has grown to become in the middle of the top three global producers of a broad range of crops, including wheat, rice, pulses, cotton, peanuts, fruits, and vegetables. Worldwide, as of 2011, India had the main herds of buffalo and cattle, is the main producer of milk, and has one of the main and fastest rising poultry industries.

Troubles

A 2003 analysis of India’s agricultural growth from 1970 to 2001, by Food and Agriculture Organization of the United Nations, recognized systemic troubles in Indian agriculture. For food staples, the annual growth rate in manufacture throughout the six-year segments 1970-76, 1976–82, 1982–88, 1988–1994, 1994-2000 were establish to be respectively 2.5, 2.5, 3.0, 2.6, and 1.8 percent per annum. Corresponding analyses for the index of total agricultural manufacture illustrate a similar pattern, with the growth rate for 1994-2000 attaining only 1.5 percent per annum. The low growth rates may constitute in part a response to inadequate returns to Indian farmers. India has very poor rural roads affecting timely supply of inputs and timely transfer of outputs from Indian farms, inadequate irrigation systems, crop failures in some parts of the country because of lack of water while in other parts because of local floods, poor seed excellence and inefficient farming practices in sure parts of India, lack of cold storage and harvest spoilage causing in excess of 30% of farmer's produce going to waste, lack of organized retail and competing buyers thereby limiting Indian farmer's skill to sell the surplus and commercial crops. The Indian farmer receives just 10 to 23 percent of the price the Indian consumer pays for exactly the similar produce, the variation going to losses, inefficiencies and middlemen traders. Farmers in urbanized economies of Europe and the United States, in contrast, receive 64 to 81 percent of the price the local consumer pays for exactly the similar produce in their supermarkets.

Even though, India has shown extra ordinary progress in recent years and has attained self-sufficiency in food staples, the productivity of Indian farms for the similar crop is very low compared to farms in Brazil, the United States, France and other nations. Indian wheat farms, for instance, produce in relation to the a third of wheat per hectare per year in contrast with wheat farms in France. Likewise, at 44 million hectares, India had the main farm region under rice manufacture in 2009; yet, the rice farm productivity in India was less than half the rice farm productivity in China. Other food staples productivity in India is likewise low, suggesting a major opportunity for growth and future agricultural prosperity potential in India. Indian total factor productivity growth remnants below 2 percent per annum; in contrast, China has shown total factor productivity growths of in relation to the 6 percent per annum, even though China too has smallholding farmers. If India could adopt technologies and improve its infrastructure, many studies suggest India could eradicate hunger and malnutrition within India, and be a major source of food for the world.

Indian farms are not poor performing for every crop. For some, Indian farms post the best yields. For instance, some of India's regions uniformly post some of the highest yields for sugarcane, cassava and tea crops every year.

Within India, average yields for several crops vary significantly flanked by Indian states. Some Indian states produce two to three times more granules per acre of land than the grain produced in similar acre of land in other Indian states. Crop yields for some farms within India are within 90% of the best achieved yields by farms in urbanized countries such as the United States and in European Union. No single state of India is best in every crop. Indian states such as Tamil Nadu achieve highest yields in rice and sugarcane, Haryana enjoys the highest yields in wheat and coarse granules, Karnataka does well in cotton, Bihar does well in pulses, while other states do well in horticulture, aquaculture, flower and fruit plantations. These differences in agricultural productivity within India are a function of local infrastructure, soil excellence, micro-climates, local resources, farmer knowledge and innovations. Though, one of the serious troubles in India is the lack of rural road network, storage, logistics network, and efficient retail to allow free flow of farm produce from mainly productive but distant Indian farms to Indian consumers. Indian retail system is highly inefficient. Movement of agricultural produce within India is heavily and overly regulated, with inter-state and even inter-district restrictions on marketing and movement of agricultural goods. The talented and efficient farms are currently unable to focus on the crops they can produce with high yields and at lowest costs.

One study suggests Indian agricultural policy should best focus on improving rural infrastructure primarily in form of irrigation and flood manage infrastructure, knowledge transfer in shapes of better yielding and more disease resistant seeds with the goal of sustainable producing as several kilograms of food staples per hectare as already produced sustainable in other nations. Additionally, cold storage, hygienic food packaging and efficient contemporary retail to reduce waste can also dramatically improve India’s agricultural output availability and rural incomes.

The low productivity in India is a result of the following factors:

- The average size of land holdings is very small (less than 2 hectares) and is subject to fragmentation due to land ceiling acts, and in some cases, family disputes. Such small holdings are often in excess of-manned, resulting in disguised unemployment and low productivity of labour. Some reports claim smallholder farming may not be cause of poor productivity, since the productivity is higher in China and several developing economies even though China smallholder farmers constitute in excess of 97 percent of its farming population. Chinese smallholder farmer is able to rent his land to superior farmers, China's organized retail and extensive Chinese highways are able to give the incentive and infrastructure necessary to its farmers for sharp increases in farm productivity.

Adoption of contemporary agricultural practices and use of technology is inadequate, hampered by ignorance of such practices, high costs and impracticality in the case of small land holdings.

According to the World Bank, Indian Branch: Priorities for Agriculture and Rural Development", India's big agricultural subsidies are hampering productivity-enhancing investment. Overregulation of agriculture has increased costs, price risks and uncertainty. Government intervenes in labour, land, and credit markets. India has inadequate infrastructure and services. World Bank also says that the allocation of water is inefficient, unsustainable and inequitable. The irrigation infrastructure is deteriorating. The overuse of water is currently being sheltered by in excess of pumping aquifers, but as these are falling by foot of groundwater each year, this is a limited resource.

Illiteracy, common socio-economic backwardness, slow progress in implementing land reforms and inadequate or inefficient finance and marketing services for farm produce.

Agricultural subsidies and taxes often changed without notice for short term political ends. Irrigation facilities are inadequate, as revealed by the information that only 52.6% of the land was irrigated in 2003–04, which result in farmers still being dependent on rainfall, specifically the Monsoon season. A good monsoon results in a robust growth for the economy as a whole, while a poor monsoon leads to a sluggish growth. Farm credit is regulated by NABARD, which is the statutory apex agent for rural development in the subcontinent. At the similar time over pumping made possible by subsidized electric power is leading to an alarming drop in aquifer stages.

A third of all food that is produced rots due to inefficient supply chains and the use of the "Walmart model" to improve efficiency is blocked by laws against foreign investment in the retail sector.

Farmer Suicides

Following the liberalizing economic reforms of 1991 the government withdrew support from the agricultural sector. These reforms, beside with other factors, led to a rise in farmer suicides. Several studies identify the significant factors as the withdrawal of government support, insufficient or risky credit systems, the difficulty of farming semi-arid regions, poor agricultural income, absence of alternative income opportunities, a downturn in the urban economy which forced non-farmers into farming, and the absence of appropriate counseling services.

Initiatives

The required stage of investment for the development of marketing, storage and cold storage infrastructure is estimated to be vast. The government has not been able to implement several schemes to raise investment in marketing infrastructure. In the middle of these schemes are *Construction of Rural Godowns*, *Market Research and Information Network*, and *Development / Strengthening of Agricultural Marketing Infrastructure, Grading and Standardization*.

The Indian Agricultural Research Institute (IARI), recognized in 1905, was responsible for the search leading to the "Indian Green Revolution" of the

1970s. The Indian Council of Agricultural Research (ICAR) is the apex body in agriculture and related allied meadows, including research and education. The Union Minister of Agriculture is the President of the ICAR. The Indian Agricultural Statistics Research Institute develops new techniques for the design of agricultural experiments, analyses data in agriculture, and specializes in statistical techniques for animal and plant breeding.

Recently Government of India has set up Farmers Commission to totally evaluate the agriculture program. In November 2011, India announced major reforms in organized retail. These reforms would contain logistics and retail of agricultural produce. The reform announcement led to major political controversy. The reforms were placed on hold by the Indian government in December 2011.

In the summer of 2012, the subsidized electricity for pumping, which has caused an alarming drop in aquifer stages, put additional strain on the country's electrical grid due to a 19 percent drop in monsoon rains, and may have helped contribute to blackout crossways much of the country. In response the state of Bihar offered farmers in excess of $100 million in subsidized diesel to operate their pumps.

Vital Resources for Agriculture

Sustainability can be understood as an ecosystem approach to agriculture. Practices that can cause extensive-term damage to soil contain excessive tillage (leading to erosion) and irrigation without adequate drainage (leading to salinization). Extensive-term experiments have provided some of the best data on how several practices affect soil properties essential to sustainability. In the United States a federal agency, USDA-Natural Resources Conservation Service, specializes in providing technological and financial assistance for those interested in pursuing natural resource conservation and manufacture agriculture as compatible goals.

The mainly significant factors for an individual location are sun, air, soil and water. Of the four, water and soil excellence and quantity are mainly amenable to human intervention through time and labour.

Although air and sunlight are accessible everywhere on Earth, crops also depend on soil nutrients and the availability of water. When farmers grow and harvest crops, they remove some of these nutrients from the soil. Without replenishment, land suffers from nutrient depletion and becomes either unusable or suffers from reduced yields. Sustainable agriculture depends on replenishing the soil while minimizing the use of non-renewable resources, such as natural gas (used in converting atmospheric nitrogen into synthetic fertilizer), or mineral ores (e.g., phosphate). Possible sources of nitrogen that would, in principle, be accessible indefinitely, contain:

- Recycling crop waste and livestock or treated human manure
- Rising legume crops and forages such as peanuts or alfalfa that form symbioses with nitrogen-fixing bacteria described rhizobia
- Industrial manufacture of nitrogen by the Haber Procedure uses hydrogen, which is currently derived from natural gas, (but this hydrogen could instead be made by electrolysis of water using electricity (perhaps from solar cells or windmills)) or
- Genetically engineering (non-legume) crops to form nitrogen-fixing symbioses or fix nitrogen without microbial symbionts.

The last option was proposed in the 1970s, but is only recently becoming feasible. Sustainable options for replacing other nutrient inputs (phosphorus, potassium, etc.) are more limited. More realistic, and often overlooked, options contain extensive-term crop rotations, returning to natural cycles that annually flood cultivated lands (returning lost nutrients indefinitely) such as the Flooding of the Nile, the extensive-term use of biochar, and use of crop and livestock landraces that are adapted to less than ideal circumstances such as pests, drought, or lack of nutrients. Crops that require high stages of soil nutrients can be cultivated in a more sustainable manner if sure fertilizer management practices are adhered to.

Water

In some regions, enough rainfall is accessible for crop growth, but several other regions require irrigation. For irrigation systems to be sustainable they require proper management (to avoid salinization) and necessity not use more water from their source than is naturally replenished, otherwise the water source becomes, in effect, a non-renewable resource. Improvements in water well drilling technology and submersible pumps combined with the development of drip irrigation and low pressure pivots have made it possible to regularly achieve high crop yields where reliance on rainfall alone previously made this stage of success unpredictable. Though, this progress has come at a price, in that in several regions where this has occurred, such as the Ogallala Aquifer, the water is being used at a greater rate than its rate of recharge.

Many steps should be taken to develop drought-resistant farming systems even in "normal" years, including both policy and management actions: 1) improving water conservation and storage events, 2) providing incentives for selection of drought-tolerant crop species, 3) using reduced-volume irrigation systems, 4) managing crops to reduce water loss, or 5) not planting at all.

Indicators for sustainable water resource development are:

- ***<u>Internal renewable water resources:</u>*** This is the average annual flow of rivers and groundwater generated from endogenous precipitation, after ensuring that there is no double counting. It symbolizes the maximum amount of water resource produced within the boundaries of a country. This value, which is expressed as an average on a yearly foundation, is invariant in time (except in the case of proved climate change). The indicator can be expressed in three dissimilar units: in absolute conditions (km3/yr), in mm/yr (it is a measure of the humidity of the country), and as a function of population (m3/person per yr).

- ***Global renewable water resources:*** This is the sum of internal renewable water resources and incoming flow originating outside the country. Unlike internal resources, this value can vary with time if upstream development reduces water availability at the border. Treaties ensuring a specific flow to be reserved from upstream to downstream countries may be taken into explanation in the computation of global water resources in both countries.
- ***Dependency ratio:*** This is the proportion of the global renewable water resources originating outside the country, expressed in percentage. It is an expression of the stage to which the water resources of a country depend on neighboring countries.
- ***Water withdrawal:*** Only gross water withdrawal can be computed systematically on a country foundation as a measure of water use. Absolute or per-person value of yearly water withdrawal provides a measure of the importance of water in the country's economy. When expressed in percentage of water resources, it shows the degree of pressure on water resources. A rough estimate shows that if water withdrawal exceeds a quarter of global renewable water resources of a country, water can be measured a limiting factor to development and, reciprocally, the pressure on water resources can have a direct impact on all sectors, from agriculture to environment and fisheries.

Soil

Soil erosion is fast becoming one of the world’s greatest troubles. It is estimated that "more than a thousand million tonnes of southern Africa's soil are eroded every year. Experts predict that crop yields will be halved within thirty to fifty years if erosion continues at present rates." Soil erosion is not unique to Africa but is occurring worldwide. The phenomenon is being described *Peak Soil* as present big level factory farming techniques are jeopardizing humanity's skill to grow food in the present and in the future. Without efforts to improve soil management practices, the availability of arable soil will become increasingly problematic.

Some Soil Management techniques:

- No-till farming
- Keyline design
- Rising wind breaks to hold the soil
- Incorporating organic matter back into meadows
- Stop using chemical fertilizers (which contain salt)
- Protecting soil from water runoff

Phosphate

Phosphate is a primary component in the chemical fertilizer which is applied in contemporary agricultural manufacture. Though, scientists estimate that rock phosphate reserves will be depleted in 50–100 years and that Peak Phosphate will happen in relation to the 2030. The phenomenon of "peak phosphate" is expected to augment food prices as fertilizer costs augment as rock phosphate reserves become harder to extract. In the extensive term, phosphate will therefore have to be recovered and recycled from human and animal waste in order to uphold food manufacture.

Land

As the global population increases and demand for food increases, there is pressure on land resources. Land can also be measured a finite resource on Earth. Expansion of agricultural land has an impact on biodiversity and contributes to deforestation. The Food and Agriculture Organisation of the United Nations estimates that in coming decades, cropland will continue to be lost to industrial and urban development, beside with reclamation of wetlands, and conversion of forest to farming, resulting in the loss of biodiversity and increased soil erosion.

Power for Agriculture

Power is used all the method down the food chain from farm to fork. In industrial agriculture, power is used in on-farm mechanization, food processing, storage, and transportation procedures. It has therefore been establish that power prices are closely connected to food prices. Oil is also used as an input in agricultural chemicals. Higher prices of non-renewable power resources are projected by the International Power Agency. Increased power prices as a result of fossil fuel resources being depleted may therefore impact negatively on the global food security unless action is taken to 'decouple' fossil fuel power from food manufacture, with a move towards 'Power-Smart' agricultural systems.

Scientific and Technological Advancements in Our Agricultural Produce

Cereal

Cereal is a grass (members of the monocot family Poaceae, also recognized as Gramineae) cultivated for the edible components of their grain (botanically, a kind of fruit described a caryopsis), composed of the endosperm, germ, and bran. Cereal granules are grown in greater quantities and give more food power worldwide than any other kind of crop; they are therefore staple crops. In their natural form (as in *whole grain*), they are a rich source of vitamins, minerals, carbohydrates, fats, oils, and protein. Though, when refined by the removal of the bran and germ, the remaining endosperm is mostly carbohydrate and lacks the majority of the other nutrients. In some developing nations, grain in the form of rice, wheat, millet, or maize constitutes a majority of daily sustenance. In urbanized nations, cereal consumption is moderate and varied but still substantial. The word *cereal* derives from *Ceres*, the name of the Roman goddess of harvest and agriculture.

Millet

The millets are a group of highly variable small-seeded grasses, widely grown approximately the world as cereal crops or granules for both human food and fodder. They do not form a taxonomic group, but rather a functional or agronomic one. Millets are significant crops in the semi-arid tropics of Asia and Africa (especially in India, Nigeria, and Niger), with 97% of millet manufacture in developing countries. The crop is favored due to its productivity and short rising season under arid, high temperature circumstances. The mainly widely grown millet is pearl millet, which is a significant crop in India and parts of Africa. Finger millet, proso millet, and foxtail millet are also significant crop species. In the urbanized world, millets are less significant. For instance, in the United States the only important crop is proso millet, which is mostly grown for bird seed. While millets are indigenous to several parts of the world, millets mainly likely had an evolutionary origin in tropical western Africa, as that is where the greatest number of both wild and cultivated shapes exist. Millets have been significant food staples in human history, particularly in Asia and Africa, and they have been in farming in East Asia for the last 10,000 years.

Pulse (Legume)

A pulse sometimes described a "grain legume", is an annual leguminous crop yielding from one to twelve seeds of variable size, form, and color within a pod. Pulses are used for food for humans and other animals. Incorporated in the pulses are: arid beans like pinto beans, kidney beans and navy beans; arid peas; lentils; and others. Pulses are significant food crops due to their high protein and essential amino acid content. Like several leguminous crops, pulses play a key role in crop rotation due to their skill to fix nitrogen.

Just like words such as "bean" and "lentil", the word "pulse" may refer to just the seed, or the whole plant.

Soybean

The soybean (US) or soya bean (UK) (*Glycine max*) is a species of legume native to East Asia, widely grown for its edible bean which has numerous uses. The plant is classed as an oilseed rather than a pulse by the UN Food and Agricultural Organization (FAO). Fat-free (defatted) soybean meal is an important and cheap source of protein for animal feeds and several prepackaged meals; soy vegetable oil is another product of processing the soybean crop. For instance, soybean products such as textured vegetable protein (TVP) are ingredients in several meat and dairy analogues. Soybeans produce significantly more protein per acre than mainly other uses of land. Traditional non-fermented food uses of soybeans contain soy milk, and from the latter tofu and tofu skin. Fermented foods contain soy sauce, fermented bean paste, natto, and tempeh, in the middle of others. The oil is used in several industrial applications. The main producers of soy are the United States (35%), Brazil (27%), Argentina (19%), China (6%) and India (4%). The beans contain important amounts of phytic acid, alpha-linolenic acid, and isoflavones.

Vegetable Oil

A vegetable oil is a triglyceride extracted from a plant. Such oils have been part of human culture for millennia. The term "vegetable oil" can be narrowly defined as referring only to substances that are liquid at room temperature, or broadly defined without regard to a substance's state of matter at a given temperature. For this cause, vegetable oils that are solid at room temperature are sometimes described vegetable fats. Vegetable oils are composed of triglycerides, as contrasted with waxes which lack glycerin in their structure. Although several plant parts may yield oil, in commercial practice, oil is extracted primarily from seeds. On food packaging, the term "vegetable oil" is often used in ingredients lists instead of specifying the exact plant being used.

Fiber Crop

Fiber crops are field crops grown for their fibers, which are traditionally used to create paper, cloth, or rope. The fibers may be chemically customized, like in viscose (used to create rayon and cellophane). In recent years materials scientists have begun exploring further use of these fibers in composite materials. Fiber crops are usually harvestable after a single rising season, as separate from trees, which are typically grown for several years before being harvested for wood pulp fiber. In specific circumstances, fiber crops can be superior to wood pulp fiber in conditions of technological performance, environmental impact or cost. There are a number of issues concerning the use of fiber crops to create pulp. One of these is seasonal availability. While trees can be harvested continuously, several field crops are harvested once throughout the year and necessity is stored such that the crop doesn't rot in excess of an era of several months. Considering that several pulp mills require many thousand tonnes of fiber source per day, storage of the fiber source can be a major issue. Botanically, the fibers harvested from several of these plants are bast fibers; the fibers come from the phloem tissue of the plant. The other fiber crop fibers are seed padding, leaf fiber, or other parts of the plant.

Agroforestry

Agroforestry is an integrated approach of using the interactive benefits from combining trees and shrubs with crops and/or livestock. It combines agricultural and forestry technologies to make more diverse, productive, profitable, healthy, and sustainable land-use systems. A narrow definition of agroforestry is "trees on farms." The theoretical base for agroforestry comes from ecology, via agroecology. From this perspective, agroforestry is one of the three principal land-use sciences. The other two are agriculture and forestry. The efficiency of photosynthesis drops off with rising light intensity, and the rate of photosynthesis hardly increases once the light intensity is in excess of in relation to the one tenth that of direct overhead sun. This means that plants under trees can still grow well even though they get less light. By having more than one stage of vegetation, it is possible to get more photosynthesis than with a single layer. Agroforestry has a lot in general with intercropping. Both have two or more plant species (such as nitrogen-fixing plants) in secure interaction, both give multiple outputs, as a consequence, higher overall yields and, because a single application or input is shared, costs are reduced. Beyond these, there are gains specific to agroforestry. Agroforestry is also defined as the deliberate land management unit whereby, woody perennials are deliberately grown on similar piece of land beside with agricultural crop and or livestock in some form of spatial arrangement or temporal sequence.

Agro-techniques

Cropping System

- ***Classifications of Cropping System:*** Depending on the resources and technology accessible, dissimilar kinds of cropping systems are adopted on farms, which are as below.
- ***Mono-cropping or Single Cropping:*** Mono-cropping refers to rising only one crop on a scrupulous land year after year. Or Practice of rising only one crop in a piece of land year after year e.g. rising only rabbi crops in arid lands or only said crops in diary lands (Lands situated in river basins which often remain flooded throughout rainy season). This is due to climatologically and socio economic circumstances or due to specialization of a farmer in rising a scrupulous crop. Groundnut or cotton or sorghum is grown year due to limitation of rainfall. Flue-cured tobacco is grown in Günter (A.P.) due

to specialization of a farmer in rising a scrupulous crop. Rice crop is grown, as it is not possible to grow any other crops, in canal irrigated regions, and under water logged circumstances.

- ***Monoculture:*** Practice of repetitive rising only crop irrespective of its intensity as rice-rice-rice in Kerala, West Bengal and Orissa.
- ***Sole Cropping:*** One crop diversity grown alone in pure stand at normal density.
- ***Multiple Cropping or Polycropping:*** It is a cropping system where two or three crops are gown annually on the similar piece of land using high input without affecting vital fertility of the soil. Rising two or more crops on the similar piece of land in one calendar year recognized as multiple cropping. It is the intensification of cropping in time and legroom dimensions i.e. more number of crops within a year and more number of crops on the similar piece of land at any given era. It comprises inter-cropping, mixed cropping and sequence cropping. Molested (1954) has mentioned that multiples cropping is a philosophy of maximum crop manufacture per acre of land with minimum of soil deterioration.
- Rice-potato-green gram.
- Rice-mustard-maize.
- Rice-potato-sesame.
- Jut-rice-potato.
- Cropping intensity is more that 200 per cent when the farm as a whole is measured; the Multiple Cropping Index (MCI) is determined by the number of crops and total region planted divided by the total arable region. When the value is three or more, it is said to be mainly promising farm. This is also described as rigorous cropping.
- ***Polyculture:*** Farming of more than two kinds of crops grown jointly on a piece of land in a crop season. e.g.
- Subabul + Papaya + Pigeon pea + Dinanath grass.

- Mango + Pine apple + Turmeric
- Banana + Marigold + berseem.
- Relay Cropping: Rising the succeeding crop when previous crop attend its maturity stage-or-sowing of the after that crop immediately after the harvest of the standing crops. Or it is a system of cropping where one crop hands in excess of land to the crop in quick succession. E.g.
    - Paddy-lathers
    - Paddy-Lucerne.
    - Cotton-Berseem.
    - Rice-Cauliflower-Onion-summer gourds.
- ***Overlapping Cropping:*** In this system, the succeeding crop is sown in the standing crop before harvesting. Thus, in this system, one crop is sown before the harvesting of preceding crops. Here the lucre and berseem are broadcasted in standing paddy crop just before they are ready for harvesting.
- Advantages:
    - Minimum tillage is needed for relay cropping and primary cost of farming is less.
    - Weed infestation is less, as land is occupied with crops year round.
    - Crop residues are added in the soil and thus more organic matter.
    - Residual fertilizer of previous crops benefits succeeding crops.

Livestock

Livestock are domesticated animals raised in an agricultural setting to produce commodities such as food, fiber and labor. This article does not talk about poultry or farmed fish, although these, especially poultry, are commonly incorporated within the meaning of "livestock".

Livestock are usually raised for profit. Raising animals (animal husbandry) is a component of contemporary agriculture. It has been practiced in several cultures since the transition to farming from hunter-gather lifestyles.

History

Animal-rearing has its origins in the transition of cultures to settled farming societies rather than hunter-gatherer lifestyles. Animals are ‘domesticated’ when their breeding and livelihood circumstances are controlled by humans. In excess of time, the communal behaviour, life cycle, and physiology of livestock have changed radically. Several contemporary farm animals are unsuited to life in the wild. Dogs were domesticated in East Asia in relation to the 15,000 years ago, Goats and sheep were domesticated approximately 8000 BCE in Asia. Swine or pigs were domesticated by 7000 BCE in the Middle East and China. The earliest proof of horse domestication dates to approximately 4000 BCE

Older English sources, such as the King James Version of the Bible, refer to livestock in common as "cattle", as opposed to the word "deer", which then was used for wild animals which were not owned. The word *cattle* is derived from Old North French *catel*, which meant all types of movable personal property, including of course livestock, which was differentiated from non-movable real-estate ("real property"). In later English, sometimes smaller livestock was described "small cattle" in that sense of movable property on land, which was not automatically bought or sold with the land. Today, the contemporary meaning of "cattle", without a qualifier, usually refers to domesticated bovines. Other species of the genus *Bos* sometimes are described wild cattle.

Kinds

The term "livestock" is nebulous and may be defined narrowly or broadly. On a broader view, livestock refers to any breed or population of animal kept by humans for a useful, commercial purpose. This can mean domestic animals, semi-domestic animals, or captive wild animals. Semi-domesticated refers to animals which are only lightly domesticated or of disputed status. These populations may also be in the procedure of domestication. Some people may use the term livestock to refer to only domestic animals or even to only red meat animals.

Animal Rearing

Livestock' are defined, in part, by their end purpose as the manufacture of food, fiber and/or labor.

The economic value of livestock comprises:

- ***Meat:*** The manufacture of a useful form of dietary protein and power
- ***Dairy products:*** Mammalian livestock can be used as a source of milk, which can in turn easily be processed into other dairy products, such as yogurt, cheese, butter, ice cream, kefir, and kumis. Using livestock for this purpose can often yield many times the food power of slaughtering the animal outright.
- ***Fiber:*** Livestock produce a range of fiber/textiles. For instance, sheep and goats produce wool and mohair; cows, deer, and sheep skins can be made into leather; and bones, hooves and horns of livestock can be used.
- ***Fertilizer:*** Manure can be spread on meadows to augment crop yields. This is a significant cause why historically, plant and animal domestication have been intimately connected. Manure is also used to create plaster for walls and floors, and can be used as a fuel for fires. The blood and bone of animals are also used as fertilizer.
- ***Labor:*** Animals such as horses, donkey, and yaks can be used for mechanical power. Prior to steam power, livestock were the only accessible source of non-human labor. They are still used for this purpose in several spaces of the world, including ploughing meadows, transporting goods, and military functions.

- ***Land management:*** The grazing of livestock is sometimes used as a method to manage weeds and undergrowth. For instance, in regions prone to wild fires, goats and sheep are set to graze on arid scrub which removes combustible material and reduces the risk of fires.

Throughout the history of animal husbandry, several secondary products have arisen in an effort to augment carcass utilization and reduce waste. For instance, animal offal and non-edible parts may be transformed into products such as pet food and fertilizer. In the past, such waste products were sometimes also fed to livestock as well. Though, intra-species recycling poses a disease risk, threatening animal and even human health. Due primarily to BSE (mad cow disease), feeding animal scraps to animals has been banned in several countries, at least in regards to ruminants and pigs.

Farming Practices

Farming practices vary dramatically worldwide and flanked by kinds of animals. Livestock are usually kept in an enclosure, are fed by human-provided food and are intentionally bred, but some livestock are not enclosed, or are fed by access to natural foods, or are allowed to breed freely, or any combination thereof. Livestock rising historically was part of an itinerant or rustic form of material culture. The herding of camels and reindeer in some parts of the world remnants unassociated with sedentary agriculture. The transhumance form of herding in the Sierra Nevada Mountains of California still continues, as cattle, sheep or goats are moved from winter pasture in lower elevation valleys to spring and summer pasture in the foothills and alpine regions, as the seasons progress. Cattle were raised on the open range in the Western United States and Canada, on the Pampas of Argentina, and other prairie and steppe regions of the world.

The enclosure of livestock in pastures and barns is a relatively new development in the history of agriculture. When cattle are enclosed, the kind of ‘enclosure’ may vary from a small crate, a big fenced pasture or a paddock. The kind of feed may vary from natural rising grass, to highly sophisticated processed feed. Animals are usually intentionally bred through artificial insemination or through supervised mating. Indoor manufacture systems are typically used for pigs, dairy cattle and poultry, as well as for veal cattle, dairy goats and other animals, depending on the region and season. Animals kept indoors are usually farmed intensively, as big legroom necessities would create indoor farming unprofitable and impossible. Though, indoor farming systems are controversial due to the waste they produce, odor troubles, the potential for groundwater contamination and animal welfare concerns.

Other livestock are farmed outside, although the size of enclosure and stage of supervision may vary. In big open ranges animals may be only occasionally inspected or yarded in "round-ups" or a muster (livestock). Herding dogs may be used for mustering livestock as are cowboys, stockmen and jackaroos on horses, or with vehicles and also by helicopters. Since the advent of barbed wire (in the 1870s) and electric fence technology, fencing pastures has become much more feasible and pasture management simplified. Rotation of pasturage is a contemporary technique for improving nutrition and health while avoiding environmental damage to the land. In some cases very big numbers of animals may be kept in indoor or outdoor feeding operations (on feedlots), where the animals' feed is processed, offsite or onsite, and stored on location then fed to the animals.

Livestock - especially cattle - may be branded to indicate ownership and age, but in contemporary farming identification is more likely to be indicated by means of ear tags than branding. Sheep are also regularly marked by means of ear marks and/or ear tags. As fears of mad cow disease and other epidemic illnesses mount, the use of implants to monitor and trace animals in the food manufacture system is increasingly general, and sometimes required by government regulations.

Contemporary farming techniques seek to minimize human involvement, augment yield, and improve animal health. Economics, excellence and consumer safety all play a role in how animals are raised. Drug use and feed supplements (or even feed kind) may be regulated, or prohibited, to ensure yield is not increased at the expense of consumer health, safety or animal welfare. Practices vary approximately the world, for instance growth hormone use is permitted in the United States, but not in stock to be sold to the European Union. The improvement of health, using contemporary farming techniques, on the part of animals has come into question. Feeding corn to cattle, which have historically eaten grasses, is an instance; where the cattle are less adapted, the rumen pH changes to more acidic, leading to liver damage and other difficulties. The US F.D.A. still allows feedlots to feed non-ruminant animal proteins to cattle. For instance, feeding chicken manure and poultry meal is acceptable for cattle, and beef or pork meat and bone meal is being fed to chickens.

Predation

Livestock farmers have suffered from wild animal predation and theft by rustlers. In North America, animals such as the gray wolf, grizzly bear, cougar, and coyote are sometimes measured a threat to livestock. In Eurasia and Africa, predators contain the wolf, leopard, tiger, lion, dhole, Asiatic black bear, crocodile, spotted hyena and others. In South America, feral dogs, jaguar, anaconda and spectacled bear are a threat to livestock. In Australia, the dingo, foxes, wedge-tailed eagles are general predators, with an additional threat from domestic dogs because they may kill seemingly for fun, leaving the carcass uneaten.

Disease

Livestock diseases compromise animal welfare, reduce productivity, and can infect humans. Animal diseases may be tolerated, reduced through animal husbandry, or reduced through antibiotics and vaccines. In developing countries, animal diseases are tolerated in animal husbandry, resulting in considerably reduced productivity, especially given the low health-status of several developing country herds. Disease management for gains in productivity is often the first step taken in implementing an agriculture policy.

Disease management can be achieved through changes in animal husbandry. These events may aim to manage spread using biosecurity events, such as controlling animal mixing, controlling entry to farm lots and the use of protective clothing, and quarantining sick animals. Diseases also may be controlled by the use of vaccines and antibiotics. Antibiotics in sub-therapeutic doses may also be used as a growth-promoter, rising growth by 10-15%. The issue of antibiotic resistance has limited the practices of preventative dosing such as antibiotic-laced feed. Countries will often require the use of veterinary certificates before transporting, selling or showing animals. Disease-free regions often rigorously enforce rules for entry of potentially diseased animals, including quarantine.

Transportation and Marketing

Since several livestock are herd animals, they were historically driven to market "on the hoof" to a city or other central site. Throughout the era after the American Civil War, the abundance of Longhorn cattle in Texas, and the demand for beef in Northern markets, led to the implementation of the Old West cattle drive. The way is still used in some parts of the world. Truck transport is now general in urbanized countries. Local and local livestock auctions and commodity markets facilitate deal in livestock. In other regions, livestock may be bought and sold in a bazaar, such as may be establish in several parts of Central Asia, or a flea market kind setting.

Stock shows and fairs are events where people bring their best livestock to compete with one another. Organizations like 4-H, Block & Bridle, and FFA encourage young people to raise livestock for illustrate purposes. Special feeds are purchased and hours may be spent prior to the illustrate grooming the animal to seem its best. In cattle, sheep, and swine shows, the winning animals are regularly auctioned off to the highest bidder, and the funds are placed into scholarship finance for its owner. The movie *Grand Champion*, released in 2004, is the story of a young Texas boy's experience raising a prize steer.

Animal Welfare

The issue of raising livestock for human benefit raises the issue of the connection flanked by humans and animals, in conditions of the status of animals and obligations of people. Animal welfare is the viewpoint that animals under human care should be treated in such a method that they do not suffer unnecessarily. What is ‘unnecessary’ suffering may vary. Usually, though, the animal welfare perspective is based on an interpretation of scientific research on farming practices. By contrast, animal rights is the viewpoint that using animals for human benefit is, by its nature, usually use, regardless of the farming practices used. Animal rights activists would usually be vegan or vegetarian, whereas it is constant with the animal welfare perspective to eat meat, depending on manufacture procedures.

Animal welfare groups usually seek to generate public discussion on livestock raising practices and secure greater regulation and scrutiny of livestock industry practices. Animal rights groups usually seek the abolition of livestock farming, although some groups may recognize the necessity of achieving more stringent regulation first. Animal welfare groups, such as the RSPCA, are often, in first world countries, given a voice at governmental stage in the development of policy. Animal rights groups discover it harder to discover ways of input, and may go further and advocate civil disobedience or violence.

A number of animal husbandry practices have been the subject of campaigns in the 1990s and 2000s and have led to legislation in some countries. Confinement of livestock in small and unnatural spaces is often done for economic or health reasons. Animals may be kept in the minimum size of cage or pen with little or no legroom to exercise. Where livestock are used as a source of power, they may be pushed beyond their limits to the point of exhaustion. The public visibility of this abuse meant it was one of the first regions to receive legislation in the nineteenth century in European countries, but it still goes on in parts of Asia. Broiler hens may be de-beaked, pigs may have deciduous teeth pulled, cattle may be de-horned and branded, dairy cows and sheep may have tails cropped, merino sheep may be mulesed, and several kinds of male animals are castrated. Animals may be transported extensive distances to market and slaughter. Overcrowded circumstances, heat from tropical-region shipping and lack of food, water and rest breaks have been subject to legislation and protest. Slaughter of livestock was an early target for legislation. Campaigns continue to target Halal and Kosher religious ritual slaughter.

Environmental Impact

At first reports like the United Nations statement "Livestock's Extensive Shadow" cast a pall in excess of the livestock sector (primarily cattle, chickens, and pigs) for 'emerging as one of the top two or three mainly important contributors to our mainly serious environmental troubles.' In April 2008, the United States Environmental Protection Agency released a major stock take of emissions in the United States entitled *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2006*. On 6.1 it establish "In 2006, the agricultural sector was responsible for emissions of 454.1 teragrams of CO_2 equivalent (Tg CO_2 Eq.), or 6 percent of total U.S. greenhouse gas emissions." By method of comparison, transportation in the US produces more than 25% of all emissions. In 2009, World watch Institute released a statement which revealed 51% of Greenhouse Gas emissions were from the animal agriculture sector.

The issue of livestock as a major policy focus remnants, especially when dealing with troubles of deforestation in neotropical regions, land degradation, climate change and air pollution, water shortage and water pollution, and loss of biodiversity. A research team at Obihiro University of Agriculture and Veterinary Medicine in Hokkaidō establish that supplementing the animals' diet with cysteine, a kind of amino acid, and nitrate can reduce the methane gas produced, without jeopardizing the cattle's productivity or the excellence of their meat and milk.

Deforestation impacts the carbon cycle (and global and local climate) and causes habitat loss of several species. Forests that are sinks for the carbon cycle are lost through deforestation. Forests are either logged or burned to create room for grasslands, often the region needed is extensive. Deforestation can also make fragmentation, allowing only patches of habitat for species to live.

Land Degradation Research from the University of Botswana in 2008 has establish that farmers' general practice of overstocking cattle to cope with drought losses made ecosystems more vulnerable and risked extensive term damage to cattle herds, in turn, by actually depleting scarce biomass. The study of the Kgatleng district of Botswana predicted that by 2050, the cycle of mild drought is likely to become shorter for the region (18 months instead of two years) due to climate change.

Climate Change & Air Pollution Methane is one of the gasses emitted from livestock manure; it persists for extensive eras of time and is a green home gas. It is the second mainly abundant green home gas after carbon dioxide. Even though there is less methane then carbon dioxide its skill to warm the atmosphere is 25 times greater.

Water Shortage Livestock require water for consumption but also for watering drops necessary for feed. Granules are often used to feed live stock in relation to the 50% of US granules produced does and 40% of world granules produced does as well. Grain and in common crop manufacture requires several amounts of water, it takes 100,000 liters of water for a kilogram of grain fed beef, compared to wheat, which takes 900 liters.

Water Pollution Fertilizers that often contain manure are used to grow such crops (as cereal and fodder) that have phosphorus and nitrogen in them, 95% of which is estimated to be lost to the environment. The pollutants then cause dead zones for plants and aquatic animals due to the lack of oxygen in the water. The lack of oxygen is recognized as eutrophication, where organisms present in the water grow excessively and then later decompose using up the oxygen in the water. The mainly prominent instance of such is the Gulf of Mexico, where much of the nutrients in fertilizer used in the mid west are funneled down the Mississippi River into the Gulf causing huge dead zones. Another pollutant not mainly commonly though of is antibiotics and hormones. In southern Asia vultures that consumed carcasses of livestock declined 95% due to antibiotic recognized as Diclofenac.

Alternatives Researchers in Australia are looking into the possibility of reducing methane from cattle and sheep by introducing digestive bacteria from kangaroo intestines into livestock.

In semi arid rangelands such as the Great Plains in the U.S., there has been research that gives proof that livestock can be beneficial to maintaining grassland habitats. Livestock make and uphold habitat for big game species

Poultry

Poultry is a category of domesticated birds kept by humans for the purpose of collecting their eggs, or killing for their meat or feathers. These mainly typically are members of the super order Galloanserae (fowl), especially the order Galliformes (which comprises chickens, quails and turkeys) and the family Anatidae (in order Anseriformes), commonly recognized as "waterfowl" (e.g. domestic ducks and domestic geese). Poultry also comprises other birds which are killed for their meat, such as pigeons or doves or birds measured to be game, such as pheasants. Poultry comes from the French/Norman word *poule*, itself derived from the Latin word *pullus*, which means small animal.

Poultry is the second mainly widely eaten meat in the world, accounting for in relation to the 30% of meat manufacture worldwide, after pork at 38%.

Cuts of Poultry

The meatiest parts of a bird are the flight muscles on its chest, described breast meat, and the walking muscles on the first and second segments of its legs, described the thigh and drumstick, respectively. The wings are also eaten, usually (in the United States) without separating them, as in Buffalo wings; the first and second segment of the wings are referred to as drumette (meatier) and wingette (or flat) when these need to be distinguished, though these are technological conditions.

Dark meat, which avian myologists refer to as "red muscle," is used for sustained action—chiefly walking, in the case of a chicken. The dark color comes from the protein myoglobin, which plays a key role in oxygen uptake within cells. White muscle, in contrast, is appropriate only for short, ineffectual bursts of action such as, for chickens, flying. Thus the chicken's leg and thigh meat are dark while its breast meat (which creates up the primary flight muscles) is white. Other birds with breast muscle more appropriate for sustained flight, such as ducks and geese, have red muscle (and therefore dark meat) throughout.

Health

Chicken meat contains in relation to the two to three times as much polyunsaturated fat as mainly kinds of red meat when measured by weight. Though, for boneless, skinless chicken breast, the amount is much lower. A 100g serving of baked chicken breast contains 4 grams of fat and 31 grams of protein, compared to 10 grams of fat and 27 grams of protein for the similar portion of broiled, lean skirt steak.

A recent study by the Translational Genomics Research Institute showed that 47% of the meat and poultry in U.S. grocery stores were contaminated with *S. aureus*, and 52% of those bacteria were resistant to antibiotics.

Fishery

Usually, a fishery is an entity occupied in raising or harvesting fish which is determined by some power to be a fishery. According to the FAO, a fishery is typically defined in conditions of the "people involved, species or kind of fish, region of water or seabed, way of fishing, class of boats, purpose of the behaviors or a combination of the foregoing characteristics". The definition often comprises a combination of fish and fishers in a region, the latter fishing for similar species with similar gear kinds.

A fishery may involve the capture of wild fish or raising fish through fish farming or aquaculture. Directly or indirectly, the livelihood of in excess of 500 million people in developing countries depends on fisheries and aquaculture. Over fishing, including the taking of fish beyond sustainable stages is reducing fish stocks and employment in several world regions.

Kinds

Fisheries are harvested for their value (commercial, recreational or survival). They can be saltwater or freshwater, wild or farmed. Examples are the salmon fishery of Alaska, the cod fishery off the Lofoten islands, the tuna fishery of the Eastern Pacific, or the shrimp farm fisheries in China. Capture fisheries can be broadly classified as industrial level, small-level or artisanal, and recreational.

Secure to 90% of the world’s fishery catches come from oceans and seas, as opposed to inland waters. These marine catches have remained relatively stable since the mid-nineties (flanked by 80 and 86 million tonnes). Mainly marine fisheries are based close to the coast. This is not only because harvesting from relatively shallow waters is easier than in the open ocean, but also because fish are much more abundant close to the coastal shelf, due to the abundance of nutrients accessible there from coastal upwelling and land runoff. Though, productive wild fisheries also exist in open oceans, particularly by seamounts, and inland in lakes and rivers.

Mainly fisheries are wild fisheries, but farmed fisheries are rising. Farming can happen in coastal regions, such as with oyster farms, but more typically happen inland, in lakes, ponds, tanks and other enclosures.

There are species fisheries worldwide for finfish, mollusks, crustaceans and echinoderms, and by extension, aquatic plants such as kelp. Though, a very small number of species support the majority of the world’s fisheries. Some of these species are herring, cod, anchovy, tuna, flounder, mullet, squid, shrimp, salmon, crab, lobster, oyster and scallops. All except these last four provided a worldwide catch of well in excess of a million tonnes in 1999, with herring and sardines jointly providing a harvest of in excess of 22 million metric tons in 1999. Several other species are harvested in smaller numbers.

REVIEW QUESTIONS

- Explain how essential needs for the existence of life, such as energy, nutrition and water are continuously made available by certain processes going on in nature.
- Explain some of the salient ecological processes associated with oceans, atmosphere and forests.
- Define pollution, and list the sources and effects of primary air pollutants.
- Describe how photochemical smog and acid rain are formed, and how they affect the living beings
- Describe the non-conventional sources of energy and explain how they can be tapped for the production of energy for domestic and industrial use.

- Explain how, with wise and careful planning, various natural resources can be utilized for the betterment of mankind and how best our limited resources can be maximized.
- Describe how the forest resources can be used without depleting our forest stock.
- Describe the basic resources for agriculture.

CHAPTER 6

Human Life

STRUCTURE

- Learning objectives
- Scientific possibilities and social realities
- Food and nutrition
- Health and disease
- Mind and body
- Psychological aspects of behaviour
- Review questions

LEARNING OBJECTIVES

After studying this chapter, you should be able to:

- Outline the problems associated with modem agriculture.
- Realize the importance of biotechnology.
- Judge your daily intake of food and see whether it fulfils your nutritional needs.
- Understand good health.
- Distinguish between infectious and non-infectious diseases.
- Identify the parts of the brain and describe how human senses, reactions, and bodily functions are associated with different parts of the brain.
- Recognize and define a flex reaction.
- Identify some physical and behavioral changes that take place during adolescence.
- Distinguish between intelligence and creativity.

SCIENTIFIC POSSIBILITIES AND SOCIAL REALITIES

Agriculture in Special Regions

Arid-zone Agriculture

As an region of research and development, arid-zone agriculture, or desert agriculture, comprises studies of how to augment the agricultural productivity of lands dominated by lack of freshwater, an abundance of heat and sunlight, and usually one or more of extreme winter cold, short rainy season, saline soil or water, strong arid winds, poor soil structure, in excess of-grazing, limited technological development, poverty, political instability.

The two vital approaches are view the given environmental and socioeconomic features as negative obstacles to be overcome view as several as possible of them as positive possessions to be used

Dryland

Dryland farming is an agricultural technique for non-irrigated farming of drylands.

Locations

Dryland farming is used in the Great Plains, the Palo use plateau of Eastern Washington, and other arid regions of North America such as in the Southwestern United States and Mexico, the Middle East and in other grain rising regions such as the steppes of Eurasia and Argentina. Dryland farming was introduced to southern Russia and Ukraine by Russian Mennonites under the power of Johann Cornies, creation the region the breadbasket of Russia. In Australia, it is widely practiced in all states but the Northern Territory.

Crops

Winter wheat is the typical crop although skilled dryland farmers sometimes grow corn, beans or even watermelons. Successful dryland farming is possible with as little as 9 inches (230 mm) of precipitation a year; higher rainfall increases the diversity of crops. Native American tribes in the arid

Southwest subsisted for hundreds of years on dryland farming in regions with less than 10 inches (250 mm) of rain. The choice of crop is influenced by the timing of the predominant rainfall in relation to the seasons. For instance, winter wheat is more suited to regions with higher winter rainfall while regions with summer wet seasons may be more suited to summer rising crops such as sorghum, sunflowers or cotton.

Procedure

Dryland farming has evolved as a set of techniques and management practices used by farmers to continually adapt to the attendance or lack of moisture in a given crop cycle. In marginal regions, a farmer should be financially able to survive occasional crop failures, perhaps for many years in succession. Survival as a dryland farmer requires careful husbandry of the moisture accessible for the crop and aggressive management of expenses to minimize losses in poor years.

System

Dryland farming is uniquely dependent on natural rainfall, which can leave the ground vulnerable to dust storms, particularly if poor farming techniques are used or if the storms strike at a particularly vulnerable time. The information that a fallow era necessity be incorporated in the crop rotation means that meadows cannot always be protected by a cover crop, which might otherwise offer protection against erosion.

Key Elements

Capturing and Conservation of Moisture

In regions such as Eastern Washington State, the average annual precipitation accessible to a dryland farm may be as little as 8.5 inches (220 mm). Consequently moisture necessity is captured until the crop can utilize it. Techniques contain summer fallow rotation (in which one crop is grown on two seasons' precipitation, leaving standing stubble and crop residue to trap snow, and preventing runoff by terracing meadows.

"Terracing" is also practiced by farmers on a smaller level by laying out the direction of furrows to slow water runoff downhill, usually by plowing beside either contour rows or key lines. Moisture can be conserved by eliminating weeds and leaving crop residue to shade the soil.

Effective Use of Accessible Moisture

Once moisture is accessible for the crop to use, it necessity be used as effectively as possible. Seed planting depth and timing are cautiously measured to lay the seed at a depth at which enough moisture exists, or where it will exist when seasonal precipitation falls. Farmers tend to use crop diversities which are drought and heat-stress tolerant, (even lower-yielding diversities). Thus the likelihood of a successful crop is hedged if seasonal precipitation fails.

Soil Conservation

The nature of dryland farming creates it particularly susceptible to erosion, especially wind erosion. Some techniques for conserving soil moisture (such as frequent tillage to kill weeds) are at odds with techniques for conserving topsoil. Since healthy topsoil is critical to sustainable dryland agriculture, its preservation is usually measured the mainly significant extensive-term goal of a dryland farming operation. Erosion manage techniques such as windbreaks, reduced tillage or no-till, spreading straw (or other mulch on particularly susceptible ground), and strip farming are used to minimize topsoil loss.

Manage of Input Costs

Dryland farming is practiced in regions inherently marginal for non-irrigated agriculture. Because of this, there is an increased risk of crop failure and poor yields which may happen in an arid year (regardless of money or effort expended). Dryland farmers necessity evaluate the potential yield of a crop constantly throughout the rising season and be prepared to decrease inputs to the crop such as fertilizer and weed manage if it appears that it is likely to have a poor yield due to insufficient moisture. Conversely, in years when moisture is abundant, farmers may augment their input efforts and budget to maximize yields and to offset poor harvests.

Hills

In the hilly regions of our country, tribal practice an age-old way of farming recognized as jhum or slash-and-bum or podu farming. Under this system, a patch of land on the hills is cleared of vegetation, and the plants are burnt. This ash eventually mixes with soil, which can support a crop of millet. This provides a modest yield to meet the immediate needs of the tribal farmer. When the crop is harvested, the land is abandoned and the tribal's shift to adjoining regions, where the procedure is repeated. In relation to the five years, the first piece of land put under slash-and-bum farming, by and big, recovers its natural fertility and supports shrub vegetation. The tribal's come back to this land and start their primitive way once again. All this sounds very good, but actually it is not so. This system worked well, in the days when the population was small and shrub jungles were plentiful. Today, the tribal's do not have much land to shift to, with the result that they cultivate the similar piece of land again and again. Since practically no manure is applied, and the soils are given no time to recoup their nutrient losses in the natural method, their yields decline year after year. Soil erosion further aggravates the problem.

You might be wondering whether there is a solution to the agricultural problem of our hilly regions. Yes, there is. Based on a study of the slope and depth of the soil, and availability of water, scientists have devised a motivating agricultural system which requires low inputs, and puts the land to a mainly productive use, without disturbing the ecosystem.

Alkaline Soils

Alkali, or alkaline, soils are clay soils with high pH (> 8.5), a poor soil structure and a low infiltration capability. Often they have a hard calcareous layer at 0.5 to 1 meter depth. Alkali soils owe their unfavorable physico-chemical properties mainly to the dominating attendance of sodium carbonate which causes the soil to swell and hard to clarify/settle.

Causes

The causes of soil alkalinity are natural or they can be man-made.

- The natural cause is the attendance of soil minerals producing sodium carbonate (Na_2CO_3) and sodium bicarbonate ($NaHCO_3$) upon weathering.
- Coal fired boilers / power plants when using coal or lignite rich in limestone produces ash containing calcium oxide (CaO). CaO readily dissolves in water to form slaked lime / $Ca(OH)_2$ and accepted by rain water to rivers / irrigation water. Lime softening procedure precipitates Ca and Mg ions / removes hardness in the water and also converts sodium bicarbonates in river water into sodium carbonate. Sodium carbonates (washing soda) further reacts with the remaining Ca and Mg in the water to remove / precipitate the total hardness. Also water soluble sodium salts present in the ash enhance the sodium content in water. The global coal consumption is 7700 million tons in the year 2011. Thus river water is made devoid of Ca and Mg ions and enhanced Na by coal fired boilers.
- Several sodium salts are used in industrial and domestic applications such as Sodium carbonate, Sodium bicarbonate (baking soda), Sodium sulphate, Sodium hydroxide (caustic soda), Sodium hypochlorite (bleaching powder), etc in vast quantities. These salts are mainly produced from Sodium chloride (general salt). All the sodium in these salts enters into the river / ground water throughout their manufacture

procedure or consumption enhancing water sodality. The total global consumption of sodium chloride is 270 million tons in the year 2010. This is almost equal to the salt load in the mighty Amazon River. Manmade sodium salts contribution is almost 7% of total salt load of all the rivers. Sodium salt load problem aggravates in the downstream of intensively cultivated river basins situated in China, India, Egypt, Pakistan, west Asia, Australia, western USA, etc due to accumulation of salts in the remaining water after meeting several transpiration and evaporation losses.

- Another source of man made sodium salts addition to the agriculture meadows / land mass is in the vicinity of the wet cooling towers using sea water to dissipate waste heat generated in several industries situated close to the sea coast. Vast capability cooling towers are installed in oil refineries, petrochemical complexes, fertilizer plants, chemical plants, nuclear & thermal power stations, centralized HVAC systems, etc. The drift / fine droplets emitted from the cooling towers contain almost 6% sodium chloride which would deposit on the vicinity regions. This problem aggravates where the national pollution manage norms are not imposed or not implemented to minimize the drift emissions to the best industrial norm for the sea water based wet cooling towers.
- The man-made cause is the application of soft water in irrigation (surface or ground water) containing relatively high proportion of sodium bicarbonates and less calcium and magnesium.

Agricultural Troubles

Alkaline soils are hard to take into agricultural manufacture. Due to the low infiltration capability, rain water stagnates on the soil easily and, in arid eras, farming is hardly possible without copies irrigated water and good drainage. Agriculture is limited to crops tolerant to surface water logging (e.g. rice, grasses) and the productivity is low.

Chemistry

Soil alkalinity is associated with the attendance of sodium carbonate or washing soda (Na_2CO_3) in the soil, either as a result of natural weathering of the soil particles or brought in by irrigation and/or flood water.

The sodium carbonate, when dissolved in water, dissociates into $2Na^+$ (two sodium cations, i.e. ions with a positive electric charge) and CO_3^{2-} (a carbonate anion, i.e. an ion with a double negative electric charge).

The sodium carbonate can react with water to produce carbon dioxide (CO_2), escaping as a gas or absorbed by Algae, and sodium hydroxide (Na^+OH^-), which is alkaline (or rather vital) and provides high pH values (pH>8.5).

Notes:

- Water (H_2O) is partly dissociated into H_3O^+ (hydronium) and OH^- (hydroxyl) ions. The ion H_3O^+ has a positive electric charge (+) and the hydroxyl group OH^- has a negative charge (–). In pure, neutral water, the concentration of H_3O^+ and OH^- ions equals 10^{-7} eq/l each (respectively $19x10^{-7}$ g/l and $17x10^{-7}$ g/l), very small concentrations.
- 1 eq = 1 equivalent weight corresponds to as several grams of the substance as its formula weight divided by its valence. It is also recognized as *gram-molecule* or mole per unit of valence. For the hydronium ion (H_3O^+) the formula weight equals 19, and for the hydroxyl group (OH^-) it equals 17.
- In neutral water, the pH, being the negative log value of the H_3O^+ concentration in eq/l, is 7. Likewise, the pOH is also 7. Each unit decrease in pH designates a tenfold augment of the H_3O^+ concentration. Likewise, each unit augment in pH designates a tenfold augment of the OH^- concentration.

- In water with dissolved salts, the concentrations of the H_3O^+ y OH^- ions may change, but their sum remnants constant, namely 7 + 7 = 14. A pH of 7 therefore corresponds to a pOH of 7, and a pH of 9 with a pOH of 5.
- Formally it deserves preference to express the ion concentrations in conditions of chemical action, but this does hardly affect the value of pH.
- Water with excess H_3O^+ ions is described acid (pH < 7), and water with excess OH^- ions is described alkaline or rather vital (pH > 7). Soil moisture with pH < 4 is described very acid and with pH > 10 very alkaline (vital).

The reaction flanked by Na_2CO_3 and H_2O can be represented as follows:

- $2Na^+ + CO_3^{2-} + 2H^+ + 2OH^- \Rightarrow 2Na^+ + 2OH^- + H_2CO_3$

The acid H_2CO_3 is unstable and produces H_2O (water) and CO_2 (carbon dioxide gas, escaping into the atmosphere). This explains the remaining alkalinity (or rather basicity) in the form of soluble sodium hydroxide and the high pH or low pOH.

Not all sodium carbonate follows the above chemical reaction. The remaining sodium carbonate, and hence the attendance of CO_3^{2-} ions, causes $CaCO_3$ (which is only slightly soluble) to precipitate as solid calcium carbonate (limestone). Hence, the calcium ions Ca^{++} are immobilized.

The attendance of abundant Na^+ ions in the soil solution and the precipitation of Ca^{++} ions as a solid mineral causes the clay particles, which have negative electric charges beside their surfaces, to adsorb more Na^+ in the *diffuse adsorption zone* and, in exchange, release Ca^{++}, by which their *exchangeable sodium percentage* (ESP) is increased.

Na^+ is more mobile and has a smaller electric charge than Ca^{++} so that the thickness of the DAZ increases as more sodium is present. The thickness is also influenced by the total concentration of ions in the soil moisture in the sense that higher concentrations cause the DAZ zone to shrink.

Clay particles with considerable ESP (> 16), in get in touch with non-saline soil moisture have an expanded DAZ zone and the soil swells (dispersion). The phenomenon results in deterioration of the soil structure, and especially crust formation and compaction of the top layer. Hence the infiltration capability of the soil and the water availability in the soil is reduced, whereas the surface-water-logging or runoff is increased. Seedling emergence and crop manufacture are badly affected.

Note:

- Under saline circumstances, the several ions in the soil solution counteract the swelling of the soil, so that saline soils usually do not have unfavorable physical properties. *Alkaline soils, in principle, are not saline since the alkalinity problem is worse as the salinity is less.*

Alkalinity troubles are more pronounced in clay soils than in loamy, silty or sandy soils. The clay soils containing montmorillonite or smectite (swelling clays) are more subject to alkalinity troubles than illite or kaolinite clay soils. The cause is that the former kinds of clay have superior specific surface regions (i.e. the surface region of the soil particles divided by their volume) and higher cation exchange capability (CEC). Note:

- Sure clay minerals with approximately 100% ESP (i.e. approximately fully sodium saturated) are described bentonite, which is used in civil engineering to lay impermeable curtains in the soil, e.g. below dams, to prevent seepage of water.

Solutions

Alkaline soils with solid $CaCO_3$ can be reclaimed with grass cultures, organic compost, waste hair, organic garbage, etc ensuring the incorporation of much acidifying material (inorganic or organic material) into the soil, and enhancing dissolved Ca in the field water by releasing CO_2 gas. Deep plowing and incorporating the calcareous subsoil into the top soil also helps.

Many times salts migration to the top soil takes lay from the underground water sources rather than surface sources. Where the underground water table is high and the land is subjected to high solar radiation, ground water oozes to the land surface due to capillary action and gets evaporated leaving the dissolved salts in the top layer of the soil. Where the underground water contains high salts, it leads to acute salinity problem. This problem can be reduced by applying mulch to the land. Using poly-homes throughout summer for cultivating vegetables/crops is also advised to mitigate soil salinity and conserve water / soil moisture. Poly-homes filter the intense summer solar radiation in tropical countries to save the plants from water stress and leaf burns.

Where the ground water excellence is not alkaline / saline and ground water table is high, salts build up in the soil can be averted by using the land throughout the year for rising plantation trees / permanent crops with the help of lift irrigation. When the ground water is used at required leaching factor, the salts in the soil would not build up.

Plowing the field soon after cutting the crop is also advised to prevent salt migration to the top soil and conserve the soil moisture throughout the intense summer months. This is done to break the capillary pores in the soil to prevent water reaching the surface of the soil.

Clay soils in high annual rain fall (more than 100 cm) regions do not usually suffer from high alkalinity as the rain water runoff is able to reduce/leach the soil salts to comfortable stages if proper rain water harvesting ways are followed. In some agricultural regions, the use of subsurface "tile rows" are used to facilitate drainage and leach salts.

It is also possible to reclaim alkaline soils by adding acidifying minerals like pyrite or cheaper alum or Aluminum sulfate.

Alternatively, gypsum (calcium sulfate, $CaSO_4$. $2H_2O$) can also be applied as a source of Ca^{++} ions to replace the sodium at the exchange intricate. Gypsum also reacts with sodium carbonate to convert into sodium sulphate which is a neutral salt and does not contribute to high pH. There necessity is enough natural drainage to the underground, or else an artificial subsurface drainage system necessity is present, to permit leaching of the excess sodium by percolation of rain and/or irrigation water through the soil profile.

Calcium Chloride is also used to reclaim alkali soils. $CaCl_2$ converts Na_2CO_3 into NaCl precipitating $CaCO_3$. NaCl is drained off by leaching water. Spent acids (HCl, H_2SO_4, etc) can also be used to reduce the excess Na_2CO_3 in the soil.

Where urea is made accessible cheaply to farmers, it is also used to reduce the soil alkalinity / salinity primarily. The NH_4 (Ammonium) present in urea which is a weak cation releases the strong cation Na from the soil structure into water. Thus alkali soils absorb / consume more urea compared to other soils.

To reclaim the soils totally one needs prohibitively high doses of amendments. Mainly efforts are therefore directed to improving the top layer only (say the first 10 cm of the soils), as the top layer is mainly sensitive to deterioration of the soil structure. The treatments, though, need to be repeated in a few (say 5) years time. Trees / plants follow gravitropism. It is hard to survive in alkali soils for the trees with deeper rooting system which can be more than 60 meters deep in good non-alkali soils.

It will be significant to refrain from irrigation (ground water or surface water) with poor excellence water.

One method of reducing sodium carbonate is to cultivate glasswort or saltwort or barilla plants. These plants sequester the sodium carbonate they absorb from alkali soil into their tissues. The ash of these plants contains good quantity of sodium carbonate which can be commercially extracted and used in lay of sodium carbonate derived from general salt which is highly power rigorous procedure. Thus alkali lands deterioration can be checked by cultivating barilla plants which can serve as food source, biomass fuel and raw material for soda ash and potash, etc.

Leaching Saline Sodic Soils

Saline soils are mostly also sodic (the predominant salt is sodium chloride), but they do not have a very high pH nor a poor infiltration rate. Upon leaching they are usually not converted into a (sodic) alkali soil as the Na^+ ions are easily removed. Therefore, saline (sodic) soils mostly do not need gypsum applications for their reclamation.

Troubles Associated with Modem Agriculture

Several current troubles in agriculture are not new. Erosion and pollution, for instance, have been approximately as extensive as agriculture. Though, agriculture has changed drastically within its ten-thousand-year history, especially since the dawn of the Industrial Revolution in the seventeenth century.

Erosion and pollution are now better troubles than before and have been joined by a host of other issues that are equally critical—not all related to physical deterioration.

Monoculture

Contemporary agriculture emphasizes crop specialization, also recognized as monoculture. Farmers, especially in industrialized regions, often grow a single crop on much of their land. Troubles associated with this practice are exacerbated when a single diversity or cultivar of a species is grown. Such a strategy allows the farmer to reduce costs, but it also creates the crop, and thus the farmland society, susceptible to widespread crop failure.

The corn blight of 1970 devastated more than 15 percent of the North American corn crop. Chemical antidotes can fight pests, but they augment pollution.

Maintaining species diversity or varietals diversity—raising many dissimilar crops instead of one or two—allows for crop failures without jeopardizing the whole economy of a farm or region that specializes in a scrupulous monoculture, such as tobacco, coffee, or bananas.

Genetic Engineering

Rising genetically customized (GM) crops is one effort to replace post-infestation chemical treatments. Recombinant technologies used to splice genes into diversities of rice or potatoes from other organisms are becoming increasingly general. The benefits of such GM crops contain more pest-resistant plants and higher crop yields.

Though, environmentalists fear new genes could trigger strange face effects with more serious, extensive-term environmental and economic consequences than the troubles they were used to solve. GM plants intended to resist herbicide applications could potentially pass the resistant gene to closely related wild weed species that would then become "super weeds".

Also, pests, just as they can develop resistance to pesticides, may also become resistant to defenses engineered into GM plants. The high cost of recombinant technologies calls into question the feasibility of continuing development of GM plants.

Erosion

An age-old problem, soil loss from erosion occurs all in excess of the world. As soil becomes unproductive or erodes absent, more land is plowed. The newly plowed lands usually are measured marginal, meaning they are too steep, nonporous or too sandy, or deficient in some other method.

When natural vegetative cover blankets these soils, it protects them from erosive mediators: water, wind, ice, or gravity. Plant cover "catches" rainwater that seeps downward into the soil rather than running off into rivers. As marginal land is plowed or cleared to grow crops, erosion increases.

Expansion of land under farming is not the only factor contributing to erosion. Fragile grasslands in arid regions also are being used more intensively. Grazing more livestock than these pastures can handle decreases the amount of grass in the pasture and exposes more of the soil to wind, the primary erosive agent in arid regions.

Overgrazing can affect pastureland in tropical regions too. Thousands of acres of tropical forest have been cleared to set up cattle-grazing ranges in Latin America. Tropical soils, although thick, are not very fertile. After one or two rising seasons, crops grown in these soils will yield considerably less than before.

Tropical meadows require fallow eras of in relation to the ten years to restore the soil after it is depleted. That is why tropical farmers using slash-and-burn agriculture move to new meadows every few years in a cycle that returns them to the similar lay years later, after their scrupulous lands have regenerated.

Where there is heavy forest cover, soils are protected from exposure to the huge amounts of rainfall. Organic material for crops is present as extensive as the forest remnants in lay.

When the forest is cleared, though, the resulting grassland cannot give the adequate protection, and erosion accelerates. Lands that are heavily grazed give even less protection from heavy rains, and erosion accelerates even more.

The use of machines also promotes erosion, and contemporary agriculture relies on machinery such as tractors, harvesters, trucks, balers, and ditchers. In industrialized nations, machinery is used intensely. Machinery use is on the rise in developing countries such as India, China, Mexico, and Indonesia, where traditional, non-mechanized farming ways are the norm.

Farming machines, in gaining traction, loosen topsoil and inhibit vegetative cover growth, especially when farm implements intended to rid the soil of weeds are attached. The soil is then more prone to erode.

Eco-fallow farming has become more popular in the United States and Europe as a method to reduce erosion. This way of agriculture, which leaves the crop residue in lay in excess of the fallow (non-rising) season, does not root the soil in lay as well as livelihood plants do.

As a result, some erosion continues. Additionally, eco-fallow ways require heavy use of chemicals, such as herbicides, to "burn down" weed growth at the start of the rising season. This contributes to increased erosion and pollution.

Pollution and Silt

Besides causing resistance in the middle of harmful bacteria, insects, and weeds, pesticides inevitably wash into, and contaminate, surface and groundwater supplies. Chemicals, although problematic, are not as hard to contend with as the increasingly heavy silt load choking the life out of streams and rivers.

Accelerated erosion from water runoff carries silt particles into streams, where they remain suspended and inhibit the growth of several shapes of plant and animal life.

The silt load in American streams has become so heavy that the Mississippi River Delta is rising faster than it once did. Heavy silt loads, combined with chemical residues, are creating an expanded dead zone. By taxing the capabilities of ecosystems approximately the Delta, sediments are filtered out slowly, plant absorption of nutrients is decreased, and salinity stages for aquatic life cannot be stabilized.

Mainly of the world's population lives in coastal zones, and 80 percent of the world's fish catch comes from coastal waters in excess of continental shelves that are mainly susceptible to this form of pollution.

Pesticide Resistance

With the onset of the Green Revolution, the use of herbicides, insecticides, and other pesticides increased dramatically all in excess of the world. A rising awareness of troubles caused by overuse of pesticides extends even to household antibacterial cleaning mediators and other products. Mutations in the middle of the genes of bacteria and plants have allowed these organisms to resist the effects of chemicals that were toxic to their ancestors.

Use of pesticides leads to a cycle wherein more, or dissimilar combinations of, chemicals are used, and more pests develop resistance to these toxins. Additionally, the development of herbicide-resistant crop plants enables greater use of herbicides to kill undesirable weeds on croplands.

Rising interest in biopesticides may slow the cycle of pesticide resistance. Kinds of biopesticides contain beneficial microbes, fungi, and insects such as ladybugs that can be released in infested regions to prey upon specific pests. Biopesticides used today contain naturally occurring and genetically customized organisms. Their use also avoids excessive reliance on chemical pesticides.

Fertilizers and Eutrophication

Increased use of fertilizers was another result of the Green Revolution. Particulate amounts of mainly fertilizers enter the hydrologic cycle through run-off. As a result, bodies of water become enriched in dissolved nutrients, such as nitrates and phosphates.

The growth of aquatic plants in rivers and lakes is over stimulated, and these results in the depletion of dissolved oxygen. This procedure of eutrophication can harm all aquatic life in these ecosystems.

Water Depletion

With a rising reliance on irrigation, groundwater possessions are mismanaged and over tapped. The rate of groundwater recharge is slow, usually flanked by 0.1 and 0.3 percent per year. When the amount of water pumped out of the ground exceeds the recharge rate, it is referred to as aquifer overdraft. An aquifer is a water-bearing stratum of permeable rock, sand, or gravel.

In Tamil Nadu, India, groundwater stages dropped 25 to 30 meters throughout the 1970’s due to excessive pumping for irrigation. In Tianjin, China, the groundwater stage declines 4.4 meters per year. In the United States, aquifer overdraft averages 25 percent in excess of the replacement rate.

The Ogallala aquifer under Kansas, Nebraska, and Texas symbolizes an extreme instance of overdraft: Depletion is 130 to 160 percent above the replacement rate annually. At this rate, this aquifer, which supplies water to countless societies and farms, has been projected to become nonproductive by 2030.

Soil Salinization

In addition, sustained irrigation of arid regions can lead to soil troubles. Soil salinization is widespread in the small-grained soils of these regions, which have a high water absorption capability and a low infiltration rate.

Some irrigation practices add big amounts of salts into the soil, raising its natural rate of salinization. This can also happen at the base of a hill slope. Soil salinization has been recognized as a major procedure of land degradation.

In agriculture, for instance, drip irrigation can reduce water use by almost 50 percent. In developing countries, though, equipment and installation costs often limit the availability of these more efficient technologies.

Urban Sprawl

As more farms become mechanized, the need for farmers and farm workers is being drastically reduced. From a peak in 1935 of in relation to the 6.8 million farmers farming 1.1 billion acres, the United States at the end of the twentieth century counted fewer than 2 million farmers farming 950 million acres.

Urban sprawl converts a tremendous amount of cropland into parking lots, malls, industrial parks, and suburban neighborhoods. If municipalities were situated in marginal regions, then concern in relation to the loss of farmland to commercial development would be nominal.

Though, the municipalities attracting the greatest numbers of people have too often replaced the best cropland. Taking the best cropland out of primary manufacture imposes a severe economic penalty.

Biotechnology in Agriculture

Biotechnology is the use of livelihood systems and organisms to develop or create useful products, or "any technological application that uses biological systems, livelihood organisms or derivatives thereof, to create or vary products or procedures for specific use" (UN Convention on Biological Diversity). Depending on the apparatus and applications, it often overlaps with the (related) meadows of bioengineering and biomedical engineering.

For thousands of years, humankind has used biotechnology in agriculture, food manufacture and medicine. The term itself is mainly whispered to have been coined in 1919 by Hungarian engineer Karl Ereky. In the late 20th and early 21st century, biotechnology has expanded to contain new and diverse sciences such as genomics, recombinant gene technologies, applied immunology, and development of pharmaceutical therapies and diagnostic tests.

Crop Yield

Using the techniques of contemporary biotechnology, one or two genes (Smartstax from Monsanto in collaboration with Dow Agro Sciences will use eight, starting in 2010) may be transferred to a highly urbanized crop diversity to impart a new character that would augment its yield. Though, while increases in crop yield are the mainly obvious applications of contemporary biotechnology in agriculture, they are also the mainly hard ones. Current genetic engineering techniques work best for effects that are controlled by a single gene. Several of the genetic features associated with yield (e.g., enhanced growth) are controlled by a big number of genes, each of which has a minimal effect on the overall yield. There is, therefore, much scientific work to be done in this region.

Reduced Vulnerability of Crops to Environmental Stresses

Crops containing genes that will enable them to withstand biotic and abiotic stresses may be urbanized. For instance, drought and excessively salty soil are two significant limiting factors in crop productivity. Biotechnologists work to discover genes that enable some plants to cope with these extreme circumstances and eventually to transfer these genes to the more productive crops. One of the latest growths is the identification of a plant gene, At-DBF2, from *Arabidopsis thaliana*. *Arabidopsis thaliana* is a tiny weed often used for plant research because it is very easy to grow. The At-DBF2 gene shows tolerance to salt, drought and the heat and cold in plants. When this gene was inserted into tomato and tobacco cells, the cells withstood these circumstances distant better than ordinary cells. If these preliminary results prove successful in superior trials, then At-DBF2 genes can help in engineering crops that can better withstand harsh environments. Researchers have also created transgenic rice plants that resist rice yellow mottle virus (RYMV). In Africa, this virus destroys a majority of the rice crops and creates the surviving plants more susceptible to fungal infections. While all of these technological advances have the probability for commercial use, they need to be researched more publicly so they can be proven as a stable source of manufacture.

Increased Nutritional Qualities

Proteins in foods may be customized to augment their nutritional qualities. Proteins in legumes and cereals may be transformed to give the amino acids needed by human beings for a balanced diet. An instance is the work of Professors Ingo Potrykus and Peter Beyer in creating Golden rice. The rice was a result of utilizing genetic modification with genetic material from corn and a soil microorganism. The genetically customized rice produced beta carotene which is converted to vitamin A. The extra beta carotene content turned the rice a golden color.

Improved Taste, Texture, or Appearance of Food

Contemporary biotechnology can be used to slow down the procedure of spoilage. Customized fruit can ripen longer on the plant and then be transported to the consumer with less risk of spoilage, and a still-reasonable shelf life. This alters the taste, texture and appearance of the fruit. Reduction in spoilage could expand the market for farmers in developing countries. Though, there is sometimes a lack of understanding by researchers in urbanized countries in relation to the actual needs of prospective beneficiaries in developing countries. For instance, engineering soybeans to resist spoilage creates them less appropriate for producing tempeh, an important source of protein that depends on fermentation. Customized soybeans produce tempeh which chefs discover lumpy, less palatable, and less convenient. This is much the similar as sure varietals of apples which have been bred for appearance and often lack the taste qualities of less visually attractive varietals.

The first genetically customized food product was a tomato which was transformed to delay its ripening. Researchers in Indonesia, Malaysia, Thailand, Philippines and Vietnam are currently working on delayed-ripening papaya in collaboration with the University of Nottingham and Zeneca.

Biotechnology in cheese manufacture: enzymes produced by micro-organisms give an alternative to animal rennet – a cheese coagulant – and an alternative supply for cheese makers.

In relation to the 85 million tons of wheat flour is used every year to bake bread. By adding an enzyme described maltogenic amylase to the flour, bread stays fresher longer. Assuming that 10–15% of bread is thrown absent as stale, if it could be kept fresh another 5–7 days then perhaps 2 million tons of flour per year would be saved. Other enzymes can cause bread to expand to create a lighter loaf, or can alter the loaf in a range of methods.

Reduced Dependence on Fertilizers, Pesticides and other Agrochemicals

Mainly of the current commercial applications of contemporary biotechnology in agriculture are on reducing the dependence of farmers on agrochemicals. For instance, *Bacillus thuringiensis* (BT) is a soil bacterium that produces a protein with insecticidal qualities. Traditionally, a fermentation procedure has been used to produce an insecticidal spray from these bacteria. In this form, the BT toxin occurs as an inactive protoxin, which requires digestion by an insect to be effective. There are many BT toxins and each one is specific to sure target insects. Crop plants have now been engineered to contain and express the genes for BT toxin, which they produce in its active form. When a susceptible insect ingests the transgenic crop cultivar expressing the BT protein, it stops feeding and soon thereafter dies as a result of the BT toxin binding to its gut wall. BT corn is now commercially accessible in a number of countries to manage corn borer (a lepidopteron insect), which is otherwise controlled by spraying (a more hard procedure).

Crops have also been genetically engineered to acquire tolerance to broad-spectrum herbicide. The lack of herbicides with broad-spectrum action and no crop injury was a constant limitation in crop weed management. Multiple applications of numerous herbicides were routinely used to manage a wide range of weed species detrimental to agronomic crops. Weed management tended to rely on pre-emergence—that is, herbicide applications were sprayed in response to expected weed infestations rather than in response to actual weeds present. Mechanical farming and hand weeding were often necessary to manage weeds not controlled by herbicide applications. The introduction of herbicide-tolerant crops has the potential of reducing the number of herbicide active ingredients used for weed management, reducing the number of herbicide applications made throughout a season, and rising yield due to improved weed management and less crop injury. Transgenic crops that express tolerance to glyphosate, glufosinate and bromoxynil have been urbanized. These herbicides can now be sprayed on transgenic crops without inflicting damage on the crops while killing nearby weeds.

From 1996 to 2001, herbicide tolerance was the mainly dominant trait introduced to commercially accessible transgenic crops, followed by insect resistance. In 2001, herbicide tolerance deployed in soybean, corn and cotton accounted for 77% of the 626,000 square kilometers planted to transgenic crops; BT crops accounted for 15%; and "stacked genes" for herbicide tolerance and insect resistance used in both cotton and corn accounted for 8%.

Manufacture of Novel Substances in Crop Plants

Biotechnology is finding novel uses beyond food. For instance, oilseed can be customized to produce fatty acids for detergents, substitute fuels and petrochemicals. Potatoes, tomatoes, rice, tobacco, lettuce, safflowers, and other plants have been genetically engineered to produce insulin and sure vaccines. If future clinical trials prove successful, the advantages of edible vaccines would be enormous, especially for developing countries. The transgenic plants may be grown in the vicinity and cheaply. Homegrown vaccines would also avoid logistical and economic troubles posed by having to transport traditional preparations in excess of extensive distances and by having to stay them cold in transit. And since they would be edible, they would not need syringes, which are not only an additional expense in the traditional vaccine preparations but also a source of infections if contaminated. In the case of insulin grown in transgenic plants, it is well-recognized that the gastrointestinal system breaks the protein down therefore this could not currently be administered as an edible protein. Though, it might be produced at significantly lower cost than insulin produced in costly bioreactors. For instance, Calgary, Canada-based Symbiosis Genetics, Inc. reports that its safflower-produced insulin will reduce unit costs by in excess of 25% or more and approximates a reduction in the capital costs associated with structure a commercial-level insulin manufacturing facility of in excess of $100 million, compared to traditional biomanufacturing facilities.

Animal Biotechnology

In animals, biotechnology techniques are being used to improve genetics and for pharmaceutical or industrial applications. Molecular biology techniques can help drive breeding programs by directing selection of superior animals. Animal cloning, through somatic cell nuclear transfer (SCNT), allows for genetic replication of selected animals. Genetic engineering, using recombinant DNA, alters the genetic makeup of the animal for selected purposes, including for producing therapeutic proteins in cows and goats. The FDA is considering for approval a genetically altered salmon with an increased growth rate.

Criticism

There is another face to the agricultural biotechnology issue. It comprises increased herbicide usage and resultant herbicide resistance, "super weeds," residues on and in food crops, genetic contamination of non-GM crops which hurt organic and conventional farmers, etc. Besides this, there is the obvious discomfort and concern of the public concerned with preserving that which has urbanized on its own in nature for millions of years and appears to have a source of being several consider vital and original and which belongs, and which has superior taste with no equal in excellence, character or suitability no matter how big or how small and which no man we know of could have ever invented or devised. In other words, the thought of leaving well enough alone has merit.

FOOD AND NUTRITION

Importance of Nutrition

Do you eat to live or live to eat?

"You are what you eat" is more that just a catchy phrase your mother used to get you to eat right. It's a profound truth. From the Stone Age to the Industrial Age, people have recognized the healthful properties of sure foods. And now, in the Information Age, the importance of nutrition is so well recognized and supported by scientific proof that virtually every major public health organization in the world creates dietary recommendations. The link flanked by good nutrition and disease prevention is likewise strong. In the United States, for instance, the American Cancer Society estimates that 35% of cancers that are not genetically predetermined can be prevented basically by eating right!

"We necessity shift our national focus from avoiding nutritional deficiencies to understanding the preventive miracles proper nutrition offers," wrote Dr. Bernadine Healy, former director of the U.S. National Institutes of Health, in her book *A New Prescription for Women's Health.* "The validity of nutrition as a legitimate scientific discipline can no longer be questioned." The foods and supplements we consume create up our diet.

In recent years, the belief that a balanced diet is a cornerstone of health has sparked a revolution in the method people think in relation to the food. Whereas meat, potatoes, and salad constituted "eating well" in much of the 20th century, the diet of the 21st century will likely incorporate Mediterranean, Asian, and vegetarian eating patterns and low-fat, low-salt, high-fiber foods. Fueled by our rising knowledge of health and nutrition, our new view of food focuses on eating to achieve optimal health. But people have intuitively recognized the health benefits of foods for centuries, as evidenced by a well-quoted row from 17thcentury French playwright Molière: "One should eat to live, not live to eat."

Cellular Nutrition is the Base of Health

If you built your dream home, you'd first build a strong base and then assemble the finest materials accessible to complete your project. Constructing a base of health that will last a lifetime requires the similar commitment to excellence structure materials. Cells are the "structure blocks" that create up a body, and each of the human body's in relation to the 73 trillion highly dedicated cells require clean air and water and essential nutrients — carbohydrates, lipids and sterols, proteins, vitamins and related food factors (such as phytonutrients), minerals, and enzymes. Good whole foods and good whole food supplements give the nutritional diversity and density that lay the base for good health.

Nutrition Affects your Health both Today and Tomorrow

The diet is your body's only source for raw materials it needs to perform its day-to-day functions. Cellular workings are complicated and continual. Fortunately, your cells perform their jobs automatically, without any forethought on your part. *Your only responsibility to this intricate, dynamic system is to give the high-excellence nutrients the body needs to do a good job.*

This task is demanding, since every day billions of cells are created, destroyed, and replaced. In excess of the course of seven years, mainly of our cells, with the exception of brain cells and a few very specific glandular cells, are replaced. For instance, red blood cells, which carry oxygen throughout your body, have a life span of only four months before they're removed from the bloodstream and destroyed. The human body contains in relation to the 25 trillion red blood cells, so the demand for nutrients to constantly replace these cells is enormous! Some cells, such as those of the mouth or intestines, turn in excess of even faster — every day, in information!

Furthermore, dissimilar cells and tissues have special nutritional necessities. For instance, lung cells have a higher requirement for vitamin C than several cells, whereas eye tissue has a higher need for lute in and other carotenoid phytonutrients. The body's nutrient supply, provided by foods and supplements, necessity exceed demand, or deficiency symptoms result.

In excess of the short term, a nutrient-deficient diet compromises day-to-day health. For instance, carotenoids — colorful plant pigments responsible for the red in tomatoes, the orange in carrots, and the yellow in squash — are critical to the function of sure blood cells that defend the body against microbial invaders. Studies illustrate that a carotenoid-deficient diet weakens immunity. Conversely, a carotenoid-rich diet boosts immunity. So may vitamin C and zinc (both may shorten the duration of a cold). Short-term effects of nutrient deficiencies are also apparent — evidenced as lower power stages — in people whose diets are deficient in B-vitamins or iron. In excess of the extensive term, suboptimal nutrition may predispose us to early aging and degenerative disease.

Disease is not an Inevitable Consequence of Aging

Several gerontologists (scientists who study aging) consider that disease and debility are not inevitable consequences of rising older. They consider that longer and healthier lives are achievable through a healthful balance of diet, exercise, rest, and relaxation.

The seeds of suboptimal health are often sown in childhood, when several children and teens consume highly processed, fatty, salty, and sugary foods. By their 20s, mainly people are not as healthy as they should be because they fail to get enough exercise or to eat diets rich in antioxidants or other nutrients. By the time they're in their 30s, prime time for devotion to family and career, they are often too busy for regular exercise and enough sleep. By their 40s, due to stress, poor diets, and inactivity, they're tense, undernourished, and overweight. At in relation to the age 50, mainly diseases begin to manifest themselves. Several women, for instance, begin to illustrate signs of osteoporosis, and several people of both sexes begin taking one medication or another. Big portions of the population begin to receive regular care for hypertension and high cholesterol.

Health continues to decline, with millions of people each year suffering from chronic circumstances that limit their action: broken hips, arthritis, heart disease, high blood pressure, diabetes, slipped disks, asthma, visual impairment, hearing loss, paralysis, stroke, mental impairment, lung disease, etc. Mainly people die in their mid-70s of heart disease, cancer, or osteoporosis (complications from hip injuries). Poor nutritional habits are a key cause.

A Global Glance at Mortality: Poor Nutrition takes its Toll Everywhere

The life expectancy in the world's least-urbanized countries is 43 years, compared to 78 years in one of the world's mainly urbanized countries, according to the World Health Organization. The global average for life expectancy is approximately 65 years. Other World Health Organization statistics illustrate the widespread occurrence of diseases which may be exacerbated by poor diets. Worldwide, circulatory system diseases, the main single cause of death, kill in relation to the 10 million people each year. Hypertension (high blood pressure) — a major contributor to heart disease, stroke, and kidney failure — affects 8 to 18% of adults worldwide. Cancer claims in relation to the 6 million lives, with breast cancer the main cause of cancer deaths in the middle of women in urbanized countries and lung cancer the major killer of men. By the end of this century, more than 100 million people will suffer from diabetes — 90% of them with the form strongly connected to lifestyle habits such as inappropriate diet and lack of action. And

1 in 3 women in excess of age 50 have osteoporosis (thinning of the bones) and are therefore at heightened risk for bone fractures.

It doesn't have to be this method! Today some of the world's leading scientists are influenced that poor nutrition contributes to every one of these diseases! Poor nutrition and other unhealthy, unbalanced aspects of our lifestyles are robbing us of the skill to achieve our theoretical biological potential of 120+ years. Barring infectious disease and accidents, there's no cause why big portions of the population can't live to be in excess of 100. But the issue is not just adding years to your life — it's adding life to your years! Regardless of age, a balance of good nutrition, exercise, and rest goes an extensive method toward achieving health, vitality, and longevity. But good nutrition is more than eating healthy foods which supply necessary carbohydrates, lipids, sterols, protein, vitamins and related food factors (such as phytonutrients), minerals, and enzymes. It means giving our bodies substances it can *use.* Note that diet is what we eat, but nutrition is what our cells and tissues actually *receive.*

Eating Well by Itself is no Guarantee of Good Nutrition

Foods necessity pass through six stages: diet (eating healthy foods), digestion (mechanically breaking down foods through mouth chewing and stomach churning), absorption (passage of nutrients from the intestines into the bloodstream), circulation (sharing of nutrients accepted in blood to cells), assimilation (incorporation of nutrients into cells), and elimination (removal of metabolic waste products from cells). Only when *all* of these challenges are successfully met do our foods give our bodies with the nutrition they need so you can see that eating well *by itself* is no guarantee of good nutrition. Nonetheless, a good diet is the base upon which our health and vitality are built.

Nutrient Groups and their Functions

There are six classes of essential nutrients necessary for human survival: carbohydrates, proteins, lipids, vitamins, minerals and water. The best method to get these nutrients is by following a varied, healthy diet featuring plenty of fresh vegetables and fruits, whole granules, lean proteins, nonfat dairy products and healthy fats. Dietary necessities vary with age and sex. Consult your physician or a registered dietitian in relation to the diet that is best for you.

Carbohydrates

Carbohydrates are a major power source. Beside with providing fuel for physical action, they also power the body's involuntary functions, including heartbeat, breathing and digestive procedures. Food sources of carbohydrates contain granules and grain products, vegetables, fruits, legumes, dairy products and sugars. Carbohydrates should supply 40 to 60 percent of the average person's caloric intake.

Proteins

Skin, muscle and bones depend on dietary protein for normal growth, development and maintenance. Getting enough protein is rarely a problem in industrialized countries such as the U.S. Complete proteins from animal sources contain all the amino acids your body needs for normal functioning. Plant sources only contain partial proteins, meaning some amino acids are missing. If you do not eat much meat, poultry, fish or other animal products, eat a diversity of protein-rich plant foods such as beans, nuts and whole granules to ensure an optimal combination of amino acids.

Lipids

You may think of lipids, or fats, as dietary enemies, but they are as necessary to the body's normal functioning as the other essential nutrients.

Dietary fat helps the absorption of vitamins, supports cell membrane health and helps uphold the immune system. Not all fats are equal. Choose healthy unsaturated fats such as olive oil and nut oil instead of saturated fats from fatty meats.

Vitamins and Minerals

Vitamins are micronutrients, meaning the body needs them in small quantities. Vitamins are organic compounds produced by livelihood beings, while minerals are inorganic elements that originate in the earth. Vitamins and minerals support the body's biochemical procedures. Each of the vitamins and minerals has a separate function, including regulating metabolism, guarding the cells from oxidative stress and synthesizing hormones.

Water

Comprising 60 percent of your body weight, water is vital for the normal functioning of all your body's systems. It helps cleanse your body of wastes and toxins, carries essential nutrients to your cells, lubricates your joints and helps uphold your body temperature.

Essential Nutrient

An essential nutrient is a nutrient required for normal body functioning that either cannot be synthesized by the body at all, or cannot be synthesized in amounts adequate for good health (e.g. niacin, choline), and thus necessity be obtained from a dietary source. Essential nutrients are also defined by the communal physiological proof for their importance in the diet, as represented in e.g. US government approved tables for Dietary Reference Intake.

Some categories of essential nutrients contain vitamins, dietary minerals, essential fatty acids, and essential amino acids. Dissimilar species have very dissimilar essential nutrients. For instance, mainly mammals synthesize their own ascorbic acid, and it is therefore not measured an essential nutrient for such species. It is, though, an essential nutrient for human beings, who require external sources of ascorbic acid (recognized as Vitamin C in the context of nutrition).

Several essential nutrients are toxic in big doses. Some can be taken in amounts superior than required in a typical diet, with no apparent ill effects. Linus Pauling said of vitamin B_3, (either niacin or niacin amide), "What astonished me was the very low toxicity of a substance that has such very great physiological power. A little pinch, 5 mg, every day, is enough to stay a person from dying of pellagra, but it is so lacking in toxicity that ten thousand times as much can be taken without harm."

For Humans

Fatty Acids

Essential fatty acids cannot be synthesized by humans, as humans lack the desaturase enzymes required for their manufacture.

- α-Linolenic acid (ALA, 18:3), an omega-3 fatty acid
- Linoleic acid (LA, 18:2), an omega-6 fatty acid
- α-Linolenic acid is not used by the body in its original form.

It is broken down by the body into the required extensive-chain polyunsaturated fatty acids eicosapentaenoic acid and docosahexaenoic acid. EPA and DHA can also be consumed from a direct source by consuming fish or fish oil.

Linoleic acid is not used by the body in its original form either. It is broken down by the body into the required extensive-chain polyunsaturated fatty acids gamma-linolenic acid, dihomo-gamma-linolenic acid and arachidonic acid.

Omega-9 fatty acids are not essential in humans, because humans usually possess all the enzymes required for their synthesis.

Amino Acids

- Isoleucine
- Lysine
- Leucine
- Methionine
- Phenylalanine
- Threonine
- Tryptophan
- Valine
- Histidine

Essential amino acids necessary for preterm children but not healthy individuals:

- Arginine

Carbohydrates

No carbohydrate is an essential nutrient in humans. Carbohydrates can be synthesized from amino acids and fatty acids, by *de novo* synthesis.

Vitamins

- Vitamin A (retinol)
- Vitamin Bp (choline)
- Vitamin B_1 (thiamin)
- Vitamin B_2 (riboflavin, vitamin G)
- Vitamin B_3 (niacin, vitamin P, vitamin PP)
- Vitamin B_5 (pantothenic acid)
- Vitamin B_6 (pyridoxine, pyridoxamine, or pyridoxal)
- Vitamin B_7 (biotin, vitamin H)
- Vitamin B_9 (folic acid, folate, vitamin M)
- Vitamin B_{12} (cobalamin)

- Vitamin C (ascorbic acid)
- Vitamin D (ergocalciferol, or cholecalciferol)
- Vitamin E (tocopherol)
- Vitamin K (naphthoquinoids)

Dietary Minerals

- Calcium (Ca)
- Chloride (Cl)
- Chromium (Cr)
- Cobalt (Co) (as part of Vitamin B_{12})
- Copper (Cu)
- Iodine (I)
- Iron (Fe)
- Magnesium (Mg)
- Manganese (Mn)
- Molybdenum (Mo)
- Phosphorus (P)
- Potassium (K)
- Selenium (Se)
- Sodium (Na)
- Zinc (Zn)

The required quantity varies widely flanked by nutrients. At one extreme, a 70 kg human contains 1.0 kg of calcium, but only 3 mg of cobalt.

Elements with Speculated Role in Human Health

Several elements have been implicated at several times to have a role in human health. For none of these elements, though, has a specific protein, intricate or dietary reference intake been recognized.

Food as Fuel for the Body Machine

The body requires food for internal as well as external behaviors and for growth. Another method of looking at this is that the body requires power for both its internal and external behaviors . In this sense, the body can be compared with a machine and food is the fuel which is required to run the body. Power is produced in the body from food by a procedure described metabolism which is comparable to combustion or burning of a fuel. Oxygen is used up in this 'combustion' and carbon dioxide is produced. If the body does not get at least a minimum of power, it will not be able to carry on its normal internal functions or undertake external work.

Though, a major variation flanked by a machine and the human body is that the latter is composed of the similar fuel which it uses to give power. A machine cannot use itself as fuel to run. But our body can. Thus, throughout fast the body can bum its own fats to get power, resulting in loss of weight. If a body is supplied with more power than is required to run it, it is stored in the body in the form of fat for future use.

Power necessities of the body are measured in terns of "calories" or kilo-calories (1000 calories), usually written as Calories, with a capital C. For instance, a tea spoon of sugar (5 gm), when burnt, produces 20 Calories of heat. Scientists have studied power necessities of infants, girls, boys and adults of dissimilar ages and weights to discover out how several Calories they use in doing dissimilar things. You would be curious to know how much food is required to stay our body healthy and active. In order to calculate this, we need to know :

- Power value of dissimilar nutrients and
- Factors influencing the power requirement of an individual.

Balanced Diet

Eating a balanced diet means choosing a wide diversity of foods and drinks from all the food groups. It also means eating sure things in moderation, namely saturated fat, trans fat, cholesterol, refined sugar, salt and alcohol. The goal is to take in nutrients you need for health at the recommended stages.

Where to Begin

Two examples of a balanced eating pattern are the USDA Food Guide at MyPyramid.gov and the Dietary Approaches to Stop Hypertension (DASH Diet).

Both eating patterns emphasize fruits, vegetables and whole granules, as well as low or no-fat dairy products, and lean animal proteins. Fish is recommended at least two times per week, beans, nuts and seeds are encouraged, and unsaturated fats are always the fats of choice - like olive oil.

What in Relation to the Calories?

Your balanced diet necessity be planned at your own calorie stage, and portion size is key. You want to get the mainly nutrients for the calories by choosing food with a high-nutrient density. Nutrient-thick foods give substantial amounts of vitamins and minerals and relatively few calories, such as fresh fruit and vegetables, lean meat and fish, and whole granules and beans. Low-nutrient thick foods have few vitamins but lots of calories, such as candy bars, soda, donuts and onion rings.

Example Meals

A high nutrient-thick lunch would seem something like this:

- 2 slices whole wheat bread
- Deli turkey
- 1 slice roasted red pepper

- romaine lettuce
- 1 tsp mayonnaise
- baby carrots
- hummus
- 8 oz non-fat milk

A low nutrient-thick lunch would seem something like this:

- One ground beef hamburger patty
- Two hamburger buns
- Iceberg lettuce
- 1 tbsp mayonnaise
- 1 slice American cheese
- Order of French fries, fried in peanut oil
- Big regular soda
- Candy bar

Know Thyself

What really matters, though, knows you. You need to create responsible eating choices within the context of your preferences and lifestyle. What are your goals? Which food groups do you like to eat? Which food groups are missing? Do you eat too much sugar, salt and fried food? Which foods are the contributors and what foods can you eat instead? The locus of manage rests within you to design the best eating plan for you.

A Differing Opinion

Nutrition guidelines recommend eating a wide diversity of foods. But, there's a school of thought that eating diversity of foods leads to overeating. There's "the tendency to stay hungry longer and eat more food when flavors are diverse and stay changing", according to Dr. David Katz, who maintains that we "fill up on fewer calories when flavor diversity is controlled".

Food Faddism

The phrases food faddism and fad diet originally referred to idiosyncratic diets and eating patterns that promote short-term weight loss, usually with no concern for extensive-term weight maintenance, and enjoy temporary popularity.

The term food fad may also be used with a positive connotation, namely, to describe the short term popularity in the middle of restaurants and consumers of an ingredient, dish, or preparation technique.

Scientific View

"Fad diet" is a term of popular media, not science. Some so-described fad diets may create pseudo-scientific claims, but others labeled "fad" are based on science. According to one definition, fad diets claim to be scientific but do not follow the scientific way in establishing their validity. In the middle of the scientific shortcomings of the claims made in support of fad diets:

- Not being open to revisions, whereas real science is
- Observations that prompt explanations are used as proof of the validity of the explanation.

The term "fad diet" has been pulled into the debate in the scientific society in excess of the physiology of weight gain and loss. It has been used by proponents of recognized views to refute claims of non-traditional ways of weight loss such as low-carbohydrate diets. Some researchers hold to the recognized belief that weight loss is strictly a function of a reduction in caloric intake, and that no other strategy can help dieters achieve extensive term weight loss.

Fad Diets

Food fad is a term originally used to describe easy, catchy diets that often focused on a single element such as cabbage, grapefruit or cottage cheese. In 1974, the term was defined as three categories of food fads.

A scrupulous food or food group is exaggerated and purported to cure specific diseases.

Foods are eliminated from an individual's diet because they are viewed as harmful. An emphasis is placed on eating sure foods to express a scrupulous lifestyle.

Food fad is also used by media and the scientific society to refer to diets that do not follow general nutritional guidelines, regardless of their actual status as a fad; for instance, the Atkins and Paleo diets are commonly referred to as food fads, even though they have enjoyed cycles of popularity for many decades. Thus, while described food fads, they are not actual fads (which are defined by sharp but brief spikes in popularity).

In information, some of these diets can actually be dangerous to your health. They then offer an extensive list that comprises low-carbohydrate diets in common and Atkins, the Zone diet and three others by name. One scientific study contradicts the website's assertions. A 2007 study published in the Journal of American Medicine concluded that overweight pre-menopausal women age 25 - 50 without any heart, renal, kidney, or diabetic disease on the Atkins diet lost more weight than those on specific low-fat diets after 12 months. The researchers concluded that low-carbohydrate diets are a "feasible alternative recommendation for weight loss." Though, this study did not compare the Atkins diet to calorie restriction diets.

Food Allergy

A food allergy is an adverse immune response to a food protein. They are separate from other adverse responses to food, such as food intolerance, pharmacological reactions, and toxin-mediated reactions.

The protein in the food is the mainly general allergic component. These types of allergies happen when the body's immune system mistakenly identifies a protein as harmful. Some proteins or fragments of proteins are resistant to digestion and those that are not broken down in the digestive procedure are tagged by the Immunoglobulin E (IgE). These tags fool the immune system into thinking that the protein is an invader. The immune system, thinking the organism (the individual) is under attack, sends white blood cells to attack, and that triggers an allergic reaction. These reactions can range from mild to severe. Allergic responses contain dermatitis, gastrointestinal and respiratory distress, including such life-threatening anaphylactic responses as biphasic anaphylaxis and vasodilatation; these require immediate emergency intervention. Individuals with protein allergies commonly avoid get in touch with the problematic protein. Some medications may prevent, minimize or treat protein allergy reactions. There is no cure.

Treatment consists of either immunotherapy (desensitization) or avoidance, in which the allergic person avoids all shapes of get in touch with the food to which they are allergic. Regions of research contain anti-IgE antibody (omalizumab, or Xolair) and specific oral tolerance induction (SOTI), which have shown some promise for treatment of sure food allergies. People diagnosed with a food allergy may carry an injectable form of epinephrine such as an EpiPen, or wear some form of medical alert jewelry, or develop an emergency action plan, in accordance with their doctor.

The scope of the problem, particularly for young people, is an important public health issue.

Classification

Food allergy is thought to develop more easily in patients with the atopic syndrome, a very general combination of diseases: allergic rhinitis and conjunctivitis, eczema and asthma. The syndrome has a strong inherited component; a family history of allergic diseases can be indicative of the atopic syndrome.

Circumstances caused by food allergies are classified into 3 groups according to the mechanism of the allergic response:

- IgE-mediated (classic):
    - Kind-I immediate hypersensitivity reaction
    - Oral allergy syndrome
- IgE and/or non-IgE-mediated:
    - Allergic eosinophilic esophagitis
    - Allergic eosinophilic gastritis
    - Allergic eosinophilic gastroenteritis
- Non-IgE mediated:
    - Food protein-induced Enterocolitis syndrome (FPIES)
    - Food protein proctocolitis/proctitis
    - Food protein-induced enteropathy. A significant instance is Celiac disease, which is an adverse immune response to the protein gluten.
    - Milk-soy protein intolerance (MSPI) is a non-IgE mediated allergic response to milk and/or soy protein throughout infancy and early childhood. Symptoms of MSPI are usually attributable to food protein proctocolitis or FPIES.
    - Heiner syndrome — lung disease due to formation of milk protein/IgG antibody immune complexes (milk precipitins) in the blood stream after it is absorbed from the GI tract. The lung disease commonly causes bleeding into the lungs and results in pulmonary hemosiderosis.

Signs and Symptoms

Classic immunoglobulin-E (IgE)-mediated food allergies are classified as kind-I immediate Hypersensitivity reaction. These allergic reactions have an acute onset (from seconds to one hour) and may contain:

- Hives
- Itching of mouth, lips, tongue, throat, eyes, skin, or other regions
- Swelling (angioedema) of lips, tongue, eyelids, or the whole face
- Difficulty swallowing
- Runny or congested nose
- Hoarse voice
- Wheezing and/or shortness of breath
- Nausea
- Vomiting
- Abdominal pain and/or stomach cramps
- Lightheadedness
- Fainting

Symptoms of allergies vary from person to person. The amount of food needed to trigger a reaction also varies from person to person.

Cardiopulmonary

Serious danger concerning allergies can begin when the respiratory tract or blood circulation is affected. The latter can be indicated through wheezing and cyanosis. Poor blood circulation leads to a weak pulse, pale skin, and fainting.

A severe case of an allergic reaction, caused by symptoms affecting the respiratory tract and blood circulation, is described anaphylaxis. When symptoms are shown where breathing is impaired and circulation is affected, the person is said to be in anaphylactic shock. Anaphylaxis occurs when IgE Antibodies are involved, and regions of the body that are not in direct get in touch with the food become affected and illustrate symptoms. This occurs because no nutrients are circulated throughout the body, causing the widening of blood vessels. This vasodilatation causes blood pressure to decrease, which leads to the loss of consciousness. Those with asthma or an allergy to peanuts, tree nuts, or seafood are at greater risk for anaphylaxis.

General Allergies

One of the mainly general food allergies is sensitivity to peanuts, a member of the bean family. Peanut allergies may be severe, but children with peanut allergies sometimes outgrow them. Tree nuts, including pecans, pistachios, pine nuts, coconuts, and walnuts, are also general allergens. Sufferers may be sensitive to one scrupulous tree nut or to several dissimilar tree nuts. Also seeds, including sesame seeds and poppy seeds, contain oils where protein is present, which may elicit an allergic reaction.

Egg allergies affect in relation to the one in fifty children but are regularly outgrown by children when they reach age five. Typically the sensitivity is to proteins in the white, rather than the yolk.

Milk, from cows, goats or sheep, is another general food allergen, and several sufferers are also unable to tolerate dairy products such as cheese. A very small portion of children with a milk allergy, roughly ten percent, will have a reaction to beef. Beef contains a small amount of protein that is present in cow's milk.

Other foods containing allergenic proteins contain soy, wheat, fish, shellfish, fruits, vegetables, maize, spices, synthetic and natural colors, and chemical additives.

Although sensitivity stages vary by country, the mainly general food allergies are allergies to milk, eggs, peanuts, tree nuts, seafood, shellfish, soy and wheat. These are often referred to as "the big eight." Allergies to seeds — especially sesame — appear to be rising in several countries. An instance of allergies more general to a scrupulous region is the surfeit of rice allergies in East Asia where rice shapes a big part of the diet.

Cross Reactivity

Some children who are allergic to cow's milk protein also illustrate a cross sensitivity to soy-based products. There are infant formulas in which the milk and soy proteins are degraded so when taken by an infant, their immune system does not recognize the allergen and they can safely consume the product. Hypoallergenic infant formulas can be based on hydrolyzed proteins, which are proteins partially predigested in a less antigenic form. Other formulas, based on free amino acids, are the least antigenic and give complete nutrition support in severe shapes of milk allergy.

People with latex allergy often also develop allergies to bananas, kiwi, avocados, and some other foods.

Pathophysiology

Allergic reactions are hyperactive responses of the immune system to usually innocuous substances. When immune cells encounter the allergenic protein, IgE antibodies are produced; this is similar to the immune system's reaction to foreign pathogens. The IgE antibodies identify the allergenic proteins as harmful and initiate the allergic reaction. The harmful proteins are those that do not break down due to the strong bonds of the protein. IgE antibodies bind to a receptor on the on the surface of the protein, creating a tag, just as a virus or parasite becomes tagged. It is not entirely clear why some proteins do not denature and subsequently trigger allergic reactions and hypersensitivity while others do not.

Hypersensitivities are categorized according to the parts of the immune system that are attacked and the amount of time it takes for the response to happen. There are four kinds of Hypersensitivity reaction: Kind 1, Immediate IgE-mediated, Kind 2, Cytotoxic, Kind 3, Immune intricate-mediated, and Kind 4, Delayed cell-mediated. The path physiology of allergic responses can be divided into two phases. The first is an acute response that occurs immediately after exposure to an allergen. This stage can either subside or progress into a "late stage reaction" which can considerably prolong the symptoms of a response, and result in tissue damage.

Several food allergies are caused by hypersensitivities to scrupulous proteins in dissimilar foods. Proteins have unique properties that allow them to become allergens, such as stabilizing forces in the tertiary and quaternary structure which prevent degradation throughout digestion. Several theoretically allergenic proteins cannot survive the destructive environment of the digestive tract and thus don't trigger hypersensitive reactions.

Acute Response

In the early stages of allergy, a kind I hypersensitivity reaction against an allergen, encountered for the first time, causes a response in a kind of immune cell described a T_H2 lymphocyte, which belongs to a subset of T cells that produce a cytokine described interleukin-4 (IL-4). These T_H2 cells interact with other lymphocytes described B cells, whose role is the manufacture of antibodies. Secreted IgE circulates in the blood and binds to an IgE-specific receptor on the surface of other types of immune cells described mast cells and basophiles, which are both involved in the acute inflammatory response. The IgE-coated cells, at this stage are sensitized to the allergen.

If later exposure to the similar allergen occurs, the allergen can bind to the IgE molecules held on the surface of the mast cells or basophiles. Cross-linking of the IgE and Fc receptors occurs when more than one IgE-receptor intricate interacts with the similar allergenic molecule, and activates the sensitized cell. Activated mast cells and basophiles undergo a procedure described deregulation, throughout which they release histamine and other inflammatory chemical mediators (cytokines, interleukins, leukotrienes, and prostaglandins) from their granules into the nearby tissue causing many systemic effects, such as vasodilatation, mucous secretion, nerve stimulation and smooth muscle contraction. This results in rhinorrhea, itchiness, dyspnea, and anaphylaxis. Depending on the individual, the allergen, and the mode of introduction, the symptoms can be system-wide (classical anaphylaxis), or localized to scrupulous body systems; asthma is localized to the respiratory system and eczema is localized to the dermis.

Late-stage Response

After the chemical mediators of the acute response subside, late stage responses can often happen. This is due to the migration of other leukocytes such as neutrophils, lymphocytes, eosinophils, and macrophages to the initial location. The reaction is usually seen 2–24 hours after the original reaction. Cytokines from mast cells may also play a role in the persistence of extensive-term effects. Late stage responses seen in asthma are slightly dissimilar from those seen in other allergic responses, although they are still caused by release of mediators from eosinophils, and are still dependent on action of T_H2 cells.

Protein Structure and Organization

Proteins are composed of amino acid monomers connected by peptide bonds. The higher order structure of a protein depends on the sequence of amino acids which form its primary sequence, as several non-covalent interactions flanked by these amino acids ensure proper protein folding. Proteins have specific amino acid sequences, which all identical proteins share.

A protein's secondary structure is created by hydrogen-bond interactions flanked by the amide and carboxyl groups of the amino acid backbone. Secondary structure comprises the formation of alpha helices and beta sheets. The tertiary structure is the overall form of the protein, and is usually driven by the protein's tendency to orient hydrophobic amino acid face chains internally, although hydrogen bonding, ionic interactions and disulfide bonds also help to stabilize proteins in the tertiary state Quaternary structure is the overall combination of polypeptide subunits to form the functional unit.

Protein Function

Protein folding is essential to the overall function of the individual protein; some protein structures allow them to resist degradation in the acidic environment of the digestive tract. Polypeptide chains are often very extensive and flexible, which leads to a wide diversity of methods for a protein to fold. Non-covalent interactions manage the form and structure of the nascent protein. A protein's proper amino acid sequence is absolutely required to induce proper folding into the quaternary structure. Two general folding patterns seen in proteins are the alpha helix and beta sheets.

Diagnosis

There are three general kinds of allergy testing: skin prick test, blood test, and food challenges. An allergist can perform these tests, and they can also go into further depth depending on the results.

- For skin prick tests, a tiny board with protruding needles is used. The allergens are placed either on the board or directly on the skin. The board is then placed on the skin, in order to puncture the skin and for the allergens to enter the body. If a hive appears, the person will be measured positive for the allergy. This test only works for IgE antibodies. Allergic reactions caused by other antibodies cannot be detected through skin prick tests.
- Blood testing is another method to test for allergies; though, it poses the similar disadvantage and only detects IgE allergens and does not work for every possible allergen. RAST, Radio Allergo Sorbent Test, is used to detect IgE antibodies present to a sure allergen. The score taken from the RAST test is compared to predictive values, taken from a specific kind of RAST test. If the score is higher than the predictive values, there is a great chance the allergy is present in the person. One advantage of this test is that it can test several allergens at one time.

- Food challenges test for allergens other than those caused by IgE allergens. The allergen is given to the person in the form of a pill, so the person can ingest the allergen directly. The person is watched for signs and symptoms. The problem with food challenges is that they necessity be performed in the hospital under careful watch, due to the possibility of anaphylaxis.

The best way for diagnosing food allergy is to be assessed by an allergist. The allergist will review the patient's history and the symptoms or reactions that have been noted after food ingestion. If the allergist feels the symptoms or reactions are constant with food allergy, he/she will perform allergy tests.

Examples of allergy testing contain:

- Skin prick testing is easy to do and results are accessible in minutes. Dissimilar allergists may use dissimilar devices for skin prick testing. Some use a "bifurcated needle", which looks like a fork with 2 prongs. Others use a "multi-test", which may seem like a small board with many pins sticking out of it. In these tests, a tiny amount of the suspected allergen is put onto the skin or into a testing device, and the device is placed on the skin to prick, or break through, the top layer of skin. This puts a small amount of the allergen under the skin. A hive will form at any spot where the person is allergic. This test usually yields a positive or negative result. It is good for quickly learning if a person is allergic to a scrupulous food or not, because it detects allergic antibodies recognized as IgE. Skin tests cannot predict if a reaction would happen or what type of reaction might happen if a person ingests that scrupulous allergen. They can though confirm an allergy in light of a patient's history of reactions to a scrupulous food. Non-IgE mediated allergies cannot be detected by this way.

- Blood tests are another useful diagnostic tool for evaluating IgE-mediated food allergies. For instance, the RAST (RadioAllergoSorbent Test) detects the attendance of IgE antibodies to a scrupulous allergen. A CAP-RAST test is a specific kind of RAST test with greater specificity: it can illustrate the amount of IgE present to each allergen. Researchers have been able to determine "predictive values" for sure foods. These predictive values can be compared to the RAST blood test results. If a persons RAST score is higher than the predictive value for that food, then there is in excess of a 95% chance the person will have an allergic reaction (limited to rash and anaphylaxis reactions) if they ingest that food. Currently, predictive values are accessible for the following foods: milk, egg, peanut, fish, soy, and wheat. Blood tests allow for hundreds of allergens to be screened from a single example, and cover food allergies as well as inhalants. Though, non-IgE mediated allergies cannot be detected by this way. Other widely promoted tests such as the *antigen leukocyte cellular antibody test* (ALCAT) and the *Food Allergy Profile* are measured unproven ways, the use of which is not advised.
- Food challenges, especially double-blind placebo-controlled food challenges (DBPCFC), are the gold average for diagnosis of food allergies, including mainly non-IgE mediated reactions. Blind food challenges involve packaging the suspected allergen into a capsule, giving it to the patient, and observing the patient for signs or symptoms of an allergic reaction. Due to the risk of anaphylaxis, food challenges are usually mannered in a hospital environment in the attendance of a doctor.
- Additional diagnostic apparatus for evaluation of eosinophilic or non-IgE mediated reactions contain endoscopy, colonoscopy, and biopsy.

Differential Diagnosis

Significant differential diagnoses are:

- Lactose intolerance; this usually develops later in life but can present in young patients in severe cases. This is due to an enzyme deficiency (lactase) and not allergy. It occurs in several non-Western people.
- Celiac disease; this is an autoimmune disorder triggered by gluten proteins such as gliadin (present in wheat, rye and barley). It is a non-IgE mediated food allergy by definition.
- Irritable bowel syndrome (IBS)
- C1 esterase inhibitor deficiency (hereditary angioedema); this unusual disease usually causes attacks of angioedema, but can present solely with abdominal pain and occasional diarrhea.

Prevention

According to a statement issued by the American Academy of Pediatrics, "There is proof that breastfeeding for at least 4 months, compared with feeding infants formula made with intact cow milk protein, prevents or delays the occurrence of atopic dermatitis, cow milk allergy, and wheezing in early childhood."

In order to avoid an allergic reaction, a strict diet can be followed. It is hard to determine the amount of allergenic food required to elicit a reaction, so complete avoidance should be attempted unless otherwise suggested by a qualified medical professional. In some cases, hypersensitive reactions can be triggered by exposures to allergens though skin get in touch with, inhalation, kissing, participation in sports, blood transfusions, cosmetics, and alcohol.

When avoiding sure foods in order to lessen the risk of reaction, it can be hard to uphold the proper amounts of nutrients. Some allergens are also general sources of vitamins and minerals, as well as macronutrients such as fat and protein; healthcare providers will often suggest alternate food sources of essential vitamins and minerals which are less allergenic.

Treatment

The mainstay of treatment for food allergy is avoidance of the foods that have been recognized as allergens. For people who are very sensitive, this may involve the total avoidance of any exposure with the allergen, including touching or inhaling the problematic food as well as touching any surfaces that may have come into get in touch with it.

If the food is accidentally ingested and a systemic reaction (anaphylaxis) occurs, then epinephrine should be used. It is possible that a second dose of epinephrine may be required for severe reactions.

There are treatments for an allergic reaction. In the middle of the first time the reaction occurs, it is mainly beneficial to take the person to the emergency room, where proper action may be taken. Other treatments contain: epinephrine, antihistamines, and steroids.

Epinephrine

Epinephrine, also recognized as adrenaline, is a general medication used to treat allergic reactions. Epinephrine reverses the allergic reaction by improving blood circulation. This is done by tightening blood vessels in order to augment the heart beat and circulation to bodily organs. Epinephrine is produced naturally in the body. It is produced throughout "flight-or-fight" response. When a person is presented with a dangerous situation, the adrenal gland is triggered to release adrenaline; this provides the person an increased heart rate and more power to attempt to fight off the danger being imposed on the individual. Epinephrine is also prescribed by a physician in a form that is self-injectable. This is what is described an epi-pen.

Antihistamines

Antihistamines are also used to treat allergic reactions. Antihistamines block the action of histamine, which causes blood vessels to dilate and become leaky to plasma proteins. Histamine also causes itchiness by acting on sensory nerve terminals. The mainly general antihistamine given for food allergies is diphenhydramine, also recognized as Benedryl. Antihistamines relieve symptoms. When it comes to dealing with anaphylaxis, though, they do not totally improve the dangerous symptoms that affect breathing.

Steroids

Steroids are used to calm down the immune system cells that are attacked by the chemicals released throughout an allergic reaction. This form of treatment in the form of a nasal spray should not be used to treat anaphylaxis, for it only relieves symptoms in the region in which the steroid is in get in touch with. Another cause steroids should not be used to treat anaphylaxis is due to the extensive amount of time it takes to reduce inflammation and start to work. Steroids can also be taken orally or through injection. By taking a steroid in these manners, every part of the body can be reached and treated, but an extensive time is usually needed for these to take effect.

Desensitization, also Recognized as, Oral Immunotherapy

For food allergy, desensitization can be achieved through oral immunotherapy. While not a cure, this program enables food allergic children and adults to consume foods that they were allergic to previously, without any allergic reaction. A study mannered in 2011 by Dr. Kari Nadeau et al. shows that anti-IgE therapy prior to and throughout oral immunotherapy can augment patients' rate of reaching desensitization to their allergen.

Traditional Chinese Medicine

As of early 2012, stage II clinical trials for human efficacy have gotten underway for a formula described FAHF-2 (food allergy herbal formula 2). This formula is based on an extensive-used Traditional Chinese Medicine formula for parasite infection. In early clinical trials, it has been establish to totally block anaphylaxis in mouse models.

Vaccines

Prof. Dr. Ronald van Ree of The University of Amsterdam and The Academic Medical Center theorizes that vaccines can be created using genetic engineering to cure allergies.

Epidemiology

The mainly general food allergens contain peanuts, milk, eggs, tree nuts, fish, shellfish, soy, and wheat — these foods explanation for in relation to the 90% of all allergic reactions. The mainly general food allergies in adults are shellfish, peanuts, tree nuts, fish, and egg. The mainly general food allergies in children are milk, eggs, peanuts, and tree nuts.

Six to eight percent of children under the age of three have food allergies and almost four percent of adults have food allergies.

For reasons that are not entirely understood, the diagnosis of food allergies has apparently become more general in Western nations in recent times. In the United States, food allergy affects as several as 5% of infants less than three years of age and 3% to 4% of adults. There is a similar prevalence in Canada.

Seventy-five percent of children who have allergies to milk protein are able to tolerate baked-in milk products, i.e., muffins, cookies, cake.

In relation to the 50% of children with allergies to milk, egg, soy, and wheat will outgrow their allergy by the age of 6.

Peanut and tree nut allergies are less likely to be outgrown, although proof now shows that in relation to the 20% of those with peanut allergies and 9% of those with tree nut allergies will outgrow them.

In Central Europe, celery allergy is more general. In Japan, allergy to buckwheat flour, used for soba noodles, is more general.

Meat allergy is very unusual in the common population, but a geographic cluster of people allergic to meat has been observed in Sydney, Australia. There appears to be a possible association flanked by localized reaction to tick bite and the development of meat allergy.

Fruit allergies exist, such as to apples, peaches, pears, jackfruit, strawberries, etc...This is suspected to be associated with Ragweed Pollen allergy but could be due to other reasons

Corn allergy may also be prevalent in several populations, although it may be hard to recognize in regions such as the United States and Canada where corn derivatives are general in the food supply. Protein allergies or intolerance of seeds, nuts, meat, and milk are especially general in the middle of children.

Adulterated Food

Adulterated food is usually defined as impure, unsafe, or unwholesome food. In the United States, the Food and Drug Management (FDA), regulates and enforces laws on food safety and has technological definitions of adulterated food in several United States laws.

Definition

"Adulteration" is a legal term meaning that a food product fails to meet federal or state standards. Adulteration usually refers to noncompliance with health or safety standards as determined, in the United States, by the FDA and the U.S. Department of Agriculture (USDA).

1938 - Federal Food, Drug, and Cosmetic Act

The Federal Food, Drug, and Cosmetic (FD&C) Act (1938) gives that food is "adulterated" if it meets any one of the following criteria:

- It bears or contains any "poisonous or deleterious substance" which may render it injurious to health;
- It bears or contains any added poisonous or added deleterious substance (other than a pesticide residue, food additive, color additive,

or new animal drug, which are sheltered by separate provisions) that is unsafe;

- Its container is composed, in whole or in part, of any poisonous or deleterious substance which may render the contents injurious to health; or
- It bears or contains a pesticide chemical residue that is unsafe.

Food also meets the definition of adulteration if:

- It is, or it bears or contains, an unsafe food additive;
- It is, or it bears or contains, an unsafe new animal drug;
- It is, or it bears or contains, an unsafe color additive;
- It consists, in whole or in part, of "any filthy, putrid, or decomposed substance" or is otherwise unfit for food; or
- It has been prepared, packed, or held under unsanitary circumstances (insect, rodent, or bird infestation) whereby it may have become contaminated with filth or rendered injurious to health.

Further, food is measured adulterated if:

- It has been irradiated and the irradiation processing was not done in conventionality with a regulation permitting irradiation of the food in question (the FDA has approved irradiation of a number of foods, including refrigerated or frozen uncooked meat, fresh or frozen uncooked poultry, and seeds for sprouting);
- It contains a dietary ingredient that presents a important or unreasonable risk of illness or injury under the circumstances of use recommended in labeling (for instance, foods or dietary supplements containing aristolochic acids, which have been connected to kidney failure, have been banned.);
- A valuable constituent has been omitted in whole or in part or replaced with another substance; damage or inferiority has been concealed in

any manner; or a substance has been added to augment the product's bulk or weight, reduce its excellence or strength, or create it appear of greater value than it is (this is "economic adulteration"); or

- It is offered for import into the United States and is a food that has previously been refused admission, unless the person reoffering the food establishes that it is in compliance with U.S. law.

Federal Meat Inspection Act and the Poultry Products Inspection Act

The Federal Meat Inspection Act and the Poultry Products Inspection Act of 1957 contain similar provisions for meat and poultry products.

Poisonous or Deleterious Substances

It can cause several harms. It is adulterated. For instance, apple cider contaminated with E. coli O157:H7 and Brie cheese contaminated with Listeria monocytogenes are adulterated. There are two exceptions to this common rule. First, if the poisonous substance is inherent or naturally occurring and its quantity in the food does not ordinarily render it injurious to health, the food will not be measured adulterated. Thus, a food that contains a natural toxin at very low stages that would not ordinarily be harmful (for instance, small amounts of amygdaline in apricot kernels) is not adulterated.

Second, if the poisonous or deleterious substance is unavoidable and is within a recognized tolerance, regulatory limit, or action stage, the food will not be deemed to be adulterated. Tolerances and regulatory limits are thresholds above which a food will be measured adulterated. They are binding on FDA, the food industry, and the courts. Action stages are limits at or above which FDA may regard food as adulterated. They are not binding on FDA. FDA has recognized numerous action stages (for instance, one part per million methyl mercury in fish), which are set forth in its booklet Action Stages for Poisonous or Deleterious Substances in Human Food and Animal Feed.

If a food contains a poisonous substance in excess of a tolerance, regulatory limit, or action stage, mixing it with "clean" food to reduce the stage of contamination is not allowed. The deliberate mixing of adulterated food with good food renders the finished product adulterated.

Filth and Foreign Matter

Filth and extraneous material contain any objectionable substances in foods, such as foreign matter (for instance, glass, metal, plastic, wood, stones, sand, cigarette butts), undesirable parts of the raw plant material (such as stems, pits in pitted olives, pieces of shell in canned oysters), and filth (namely, mold, rot, insect and rodent parts, excreta, decomposition). Under a strict reading of the FD&C Act, any amount of filth in a food would render it a, though, authorize the agency to issue Defect Action Stages (DALs) for natural, unavoidable defects that at low stages do not pose a human health hazard. These DALs are advisory only; they do not have the force of law and do not bind FDA.

In mainly cases, DALs are food-specific and defect-specific. For instance, the DAL for insect fragments in peanut butter is an average of thirty or more insect fragments per 100 grams (g). In the case of hard or sharp foreign objects, the DAL, which is based on the size of the substance and the likelihood it will pose a risk of choking or injury, applies to all foods.

Economic Adulteration

A food is adulterated if it omits a valuable constituent or substitutes another substance, in whole or in part, for a valuable constituent (for instance, olive oil diluted with tea tree oil); conceals damage or inferiority in any manner (such as fresh fruit with food coloring on its surface to conceal defects); or any substance has been added to it or packed with it to augment its bulk or weight, reduce its excellence or strength, or create it appear better or of greater value than it is (for instance, scallops to which water has been added to create them heavier).

Microbiological Contamination and Adulteration

The information that a food is contaminated with pathogens (harmful microorganisms such as bacteria, viruses, or protozoa) may, or may not, render it adulterated. Usually, for ready-to-eat foods, the attendance of pathogens will render the food adulterated. For instance, the attendance of Salmonella on fresh fruits or vegetables or in ready-to-eat meat or poultry products (such as luncheon meats) will render those products adulterated.

For meat and poultry products, which are regulated by USDA, the rules are more complicated. Ready-to-eat meat and poultry products contaminated with pathogens, such as Salmonella or Listeria monocytogenes, are adulterated. (Note that hotdogs are measured ready-to-eat products.) For raw meat or poultry products, the attendance of pathogens will not always render a product adulterated (because raw meat and poultry products are planned to be cooked, and proper cooking should kill pathogens). Raw poultry contaminated with Salmonella is not adulterated. Though, USDA's Food Safety and Inspection Service (FSIS) have ruled that raw meat or poultry products contaminated with E. coli O157:H7 are adulterated. This is because normal cooking ways may not reduce E. coli O157:H7 below infectious stages. E. coli O157:H7 is the only pathogen that is measured an adulterant when present in raw meat or poultry products.

Enforcement Actions against Adulterated Food

If a food is adulterated, FDA and FSIS have a broad array of enforcement apparatus. They are of several kinds. These contain seizing and condemning the product, detaining imported product, enjoining persons from manufacturing or distributing the product, or requesting a recall of the product. Enforcement action is usually preceded by a Warning Letter from FDA to the manufacturer or distributor of the adulterated product. In the case of an adulterated meat or poultry product, FSIS has sure additional powers. FSIS may suspend or withdraw federal inspection of an official establishment.

Without federal inspection, an establishment may not produce or procedure meat or poultry products, and therefore necessity cease operations. With the exception of infant formula, neither FDA nor FSIS has the power to require a company to recall an adulterated food product. Though, the skill to generate negative publicity provides them considerable powers of persuasion.

State regulators usually have similar enforcement apparatus at their disposal to prevent the manufacture and sharing of adulterated food. In addition, several states have the power to immediately embargo adulterated food and to impose civil fines. Federal agencies often will coordinate with state or local authorities to remove unsafe food from the market as quickly as possible.

Food Adulteration Discovery

Food Tea Leaves Adulterant Iron Flakes Discovery Spread a small quantity (2 tea-spoons) of the example on a piece of paper. Draw a magnet in excess of it. Iron flakes, if present, cling to the magnet. The similar test may be accepted out to trace iron flakes from tea half-dust and iron filings from tea dust. Food Tea Leaves Adulterant Leather Flakes Discovery Prepare a paper-ball. Fire the ball and drop a little amount of the example on it. The attendance of leather flakes emits an odor of burnt leather. Food Tea Leaves Adulterant Coal Tar Dye Discovery Scatter a little amount (1 tea-spoon) of the example on a moistened white blotting paper. After 5 minutes, remove the example and look at the paper. A revelation of colored spots designates the use of the dye. Sprinkle it on water in a bowl. Spice powder gets sediment at the bottom and saw-dust floats on the surface. Food Green vegetables like Bitter Gourd, Green Chilli and others Adulterant Malachite Green Discovery Take a small part of the example and lay it on a piece of moistened white blotting paper. The impression of color on the paper designates the use of malachite green, or any other low priced artificial color. Food Arhar Pulse Adulterant Kesarri Pulse Discovery Kesari Pulse has a feature wedge form. Superior Kesari resembles Arhar (Tur). It can be separated by visual examination. Food Black Pepper Adulterant Papaya Seeds Discovery Papaya seeds do not have any smell and are relatively smaller in size. Adulteration of papaya seed with Black Pepper may be detected by method of visual examination as also by method of smelling. Food Rice Adulterant Earth, sand, grit, unhusked paddy, rice bran, talc, etc. Discovery These adulterants may be detected visually and removed by method of sorting, picking, and washing. Food Wheat Adulterant Earth, sand, grit, chopped straw, bran, unhusked grain, and seeds of weeds. Discovery These adulterants may be detected visually and removed by method of sorting, picking, and washing. CHEMICAL TEST

Food Coffee powder Adulterant Cereal starch Discovery Take a small quantity (one-fourth of a tea-spoon) of the example in a test tube and add 3 ml of distilled water in it. Light a spirit lamp and heat the contents to colorize. Add 33 ml of a solution of potassium permanganate and muratic acid (1:1) to decolorize the mixture. The formation of blue color in mixture by addition of a drop of 1% aqueous solution of iodine indicated adulteration with starch. Food Coffee powder Adulterant Powder of scorched persimmon stones Discovery Take a small quantity (1 tea-spoon) of the example and spread it on a moistened blotting paper. Pour on it, with much care, 3 ml of 2% aqueous solution of sodium carbonate. A red coloration designates the attendance of powder of scorched persimmon stones in coffee powder. Food Jaggery Adulterant Sodium bicarbonate Discovery Take a little amount (one-fourth of a tea-spoon) of the example in a test tube. Add 3 ml of muratic acid. The attendance of sodium carbonate or sodium bicarbonate effects effervescence. Food Jaggery Adulterant Metanil yellow color Discovery Take a little amount (one-fourth of a tea-spoon) of the example in a test tube. Add 3 ml of alcohol and shake the tube vigorously to mix up the contents. Pour 10 drops of hydrochloric acid in it. A pink coloration designates the attendance of metanil yellow color in jaggery.

Food Asafoetida Adulterant Resin and color Discovery Take a little amount of small parts of the example in test tube. Add 3 ml of distilled water and shake the tube gently. Pure asafetida dissolves in water very quickly and produces a milky white color, but in case of adulteration with a chemical color the mixture turns to be colored. The purity of asafetida may also be examined by taking a little amount of it on the tip of a force and placing the similar on the flame of a spirit lamp. Asafoetida burns quickly, producing bright flame and leaving the impurities behind.

Food Gram powder Adulterant Kesari powder Discovery Take a little amount (a half of a tea-spoon) of the example in a test tube with 3 ml of distilled water. Add 3 ml of muratic acid. Immerse the tube in warm water. Check the tube after 15 minutes. A violet coloration designates the attendance of Kesari powder in Gram powder.

Food Gram powder Adulterant Metanil yellow color Discovery Take a small quantity (a half of a tea-spoon) of the example in a test tube. Add 3 ml of alcohol. Shake the tube to mix up the contents thoroughly. Add 10 drops of hydrochloric acid in it. A pink coloration designates adulteration of gram powder with metanil yellow.

Food Processed food, sweetmeat or syrup Adulterant Rhodamine B color Discovery The attendance of this chemical color in food is very easy to detect as it shines very brightly under sun. A more precise ways of discovery is also there. Take a little amount (a half of a tea-spoon) of the example in a test tube. Add 3 ml of carbon tetrachloride and shake the tube to mix up the contents thoroughly. The mixture becomes colorless and an addition of a drop of hydrochloric acid brings the color back when food contains Rhodamine B color.

Food Processed food, sweetmeat or syrup Adulterant Metanil Yellow Discovery Take little amount (a half of a tea-spoon) of the example in a test tube. Add 10 drops of muratic acid or hydrochloric acid in it. The appearance of rosy color designates adulteration of food with metanil yellow.

Food Parched rice Adulterant Urea Discovery Take 30 pieces of parched rice in a test tube. Add 5 ml of distilled water. Shake the tube to mix up the contents thoroughly. After 5 minutes, filter water contents and add to it a little amount (a half of a tea-spoon) of powder of arhar or soyabean. Wait for another 5 minutes and then dip a red litmus paper in the mixture. Lift the paper after 30 seconds and look at it. A blue coloration designates the use of urea in parched rice. Food Turmeric powder Adulterant Metanil Yellow color Discovery Take a little amount (one-fourth of a tea-spoon) of the example in a test tube. Add 3 ml of alcohol. Shake the tube to mix up the contents thoroughly. Add 10 drops of muratic acid or hydrochloric acid in it. A pink coloration designates the use of metanil yellow color in turmeric powder.

Adulterant Malachite Green Discovery Rub the outer green surface of a small part of the example with a liquid paraffin soaked cotton. The example is adulterated when the white cotton turns green.

Food Arid red chili Adulterant Rhodamine B color Discovery Take a red chili from the example and rub the outer surface with a piece of cotton soaked in liquid paraffin. The example is adulterated if the cotton becomes red.

Food Arid turmeric root Adulterant Metanil yellow color Discovery Take a piece of arid turmeric root and rub the outer surface with a piece of cotton soaked in liquid paraffin. A yellow coloration of cotton designates adulteration of turmeric root with metanil yellow color.

Food Sweet potato Adulterant Rhodamine B color Discovery Take a small part of the example and rub the red outer surface with a piece of cotton soaked in liquid paraffin. The cotton adhering color designates the use of Rhodamine B color on outer surface of the sweet potato.

HEALTH AND DISEASE

Health

Health is the stage of functional or, metabolic efficiency of a livelihood being. In humans, it is the common condition of a person's mind and body, usually meaning to be free from illness, injury or pain (as in "*good health*" or "*healthy*"). The World Health Organization (WHO) defined health in its broader sense in 1946 as "a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity." Although this definition has been subject to controversy, in scrupulous as lacking operational value and because of the problem created by use of the word "complete," it remnants the mainly enduring . Other definitions have been proposed, in the middle of which a recent definition that correlates health and personal satisfaction. Classification systems such as the WHO Family of International Classifications, including the International Classification of Functioning, Disability and Health (ICF) and the International Classification of Diseases (ICD), are commonly used to describe and measure the components of health.

Systematic behaviors to prevent or cure health troubles and promote good health in humans are undertaken by health care providers. Applications with regard to animal health are sheltered by the veterinary sciences. The term "healthy" is also widely used in the context of several kinds of non-livelihood organizations and their impacts for the benefit of humans, such as in the sense of healthy societies, healthy municipalities or healthy environments. In addition to health care interventions and a person's surroundings, a number of other factors are recognized to power the health status of individuals, including their background, lifestyle, and economic and social circumstances; these are referred to as "determinants of health."

Determinants of Health

Usually, the context in which an individual lives is of great importance for his health status and excellence of life. It is increasingly recognized that health is maintained and improved not only through the advancement and application of health science, but also through the efforts and intelligent lifestyle choices of the individual and society. According to the World Health Organization, the main determinants of health contain the social and economic environment, the physical environment, and the person's individual features and behaviors.

More specifically, key factors that have been establish to power whether people are healthy or unhealthy contain:

- Income and social status
- Social support networks
- Education and literacy
- Employment/working circumstances
- Social environments
- Physical environments
- Personal health practices and coping skills
- Healthy child development
- Biology and genetics
- Health care services
- Gender
- Culture

An rising number of studies and reports from dissimilar organizations and contexts look at the linkages flanked by health and dissimilar factors, including lifestyles, environments, health care organization, and health policy —such as the 1974 Lalonde statement from Canada; the Alameda County Study in California; and the series of World Health Reports of the World Health Organization, which focuses on global health issues including access to health care and improving public health outcomes, especially in developing countries.

The concept of the "*health field,*" as separate from medical care, appeared from the Lalonde statement from Canada. The statement recognized three interdependent meadows as key determinants of an individual's health. These are:

- ***Lifestyle:*** The aggregation of personal decisions (i.e., in excess of which the individual has manage) that can be said to contribute to, or cause, illness or death;
- ***Environmental:*** All matters related to health external to the human body and in excess of which the individual has little or no manage;
- ***Biomedical:*** All aspects of health, physical and mental, urbanized within the human body as influenced by genetic create-up.

The maintenance and promotion of health is achieved through dissimilar combination of physical, mental, and social well-being, jointly sometimes referred to as the *"health triangle."* The WHO's 1986 *Ottawa Charter for Health Promotion* further stated that health is not just a state, but also "a resource for everyday life, not the objective of livelihood. Health is a positive concept emphasizing social and personal possessions, as well as physical capacities."

Focusing more on lifestyle issues and their relationships with functional health, data from the Alameda County Study suggested that people can improve their health via exercise, enough sleep, maintaining a healthy body weight, limiting alcohol use, and avoiding smoking. The skill to *adapt* and to *self manage* has been suggested as core components of human health.

The environment is often cited as a significant factor influencing the health status of individuals. This comprises features of the natural environment, the built environment, and the social environment. Factors such as clean water and air, adequate housing, and safe societies and roads all have been establish to contribute to good health, especially to the health of infants and children. Some studies have shown that a lack of neighborhood recreational spaces including natural environment leads to lower stages of personal satisfaction and higher stages of obesity, connected to lower overall health and well being. This suggests that the positive health benefits of natural legroom in urban neighborhoods should be taken into explanation in public policy and land use.

Genetics, or inherited traits from parents, also play a role in determining the health status of individuals and populations. This can encompass both the predisposition to sure diseases and health circumstances, as well as the habits and behaviors individuals develop through the lifestyle of their families. For instance, genetics may play a role in the manner in which people cope with stress, either mental, emotional or physical (One difficulty is the issue raised by the debate in excess of the relative strengths of genetics and other factors; interactions flanked by genetics and environment may be of scrupulous importance.).

Mental Health

The World Health Organization describes mental health as "a state of well-being in which the individual realizes his or her own abilities, can cope with the normal stresses of life, can work productively and fruitfully, and is able to create a contribution to his or her society". Mental Health is not just the absence of mental illness.

Having a mental Illness can seriously impair; temporarily or permanently, the mental functioning of a person. Other conditions contain: 'mental health problem', 'illness', 'disorder', 'dysfunction'..

Roughly a quarter of all adults 18 and in excess of in the US suffers from a diagnosable mental illness. Mental illnesses are the leading cause of disability in the US and Canada. Examples contain, schizophrenia, ADHD, major depressive disorder, bipolar disorder, anxiety disorder, post-traumatic stress disorder and autism.

Maintaining Health

Achieving and maintaining health is an ongoing procedure, shaped by both the development of health care knowledge and practices as well as personal strategies and organized interventions for waiting healthy.

Role of Science in Health

Health science is the branch of science focused on health. There are two main approaches to health science: the study and research of the body and health-related issues to understand how humans (and animals) function, and the application of that knowledge to improve health and to prevent and cure diseases and other physical and mental impairments. The science builds on several sub-meadows, including biology, biochemistry, physics, epidemiology, pharmacology, medical sociology. Applied health sciences endeavor to better understand and improve human health through applications in regions such as health education, biomedical engineering, biotechnology and public health.

Organized interventions to improve health based on the principles and procedures urbanized through the health sciences are provided by practitioners trained in medicine, nursing, nutrition, pharmacy, social work, psychology, occupational therapy, physical therapy and other health care professions. Clinical practitioners focus mainly on the health of individuals, while public health practitioners consider the overall health of societies and populations. Workplace wellness programs are increasingly adopted by companies for their value in improving the health and well-being of their employees, as are school health services to improve the health and well-being of children.

Role of Public Health

Public health has been described as "the science and art of preventing disease, prolonging life and promoting health through the organized efforts and informed choices of society, organizations, public and private, societies and individuals." It is concerned with threats to the overall health of a society based on population health analysis. The population in question can be as small as a handful of people or as big as all the inhabitants of many continents (for instance, in the case of a pandemic). Public health has several sub-meadows, but typically comprises the interdisciplinary categories of epidemiology, biostatistics and health services. Environmental health, society health, behavioral health, and occupational health are also significant regions of public health.

The focus of public health interventions is to prevent and manage diseases, injuries and other health circumstances through surveillance of cases and the promotion of healthy behavior, societies, and (in aspects relevant to human health) environments. Its aim is to prevent health troubles from happening or re-occurring by implementing educational programs, developing policies, administering services, and conducting research. In several cases, treating a disease or controlling a pathogen can be vital to preventing it in others, such as throughout an outbreak. Vaccination programs and sharing of condoms to prevent the spread of communicable diseases are examples of general preventive public health events, as are educational campaigns to promote vaccination and the use of condoms (including overcoming resistance to such).

Public health also takes several actions to limit the health disparities flanked by dissimilar regions of the country and, in some cases, the continent or world. One issue is the access of individuals and societies to health care in conditions of financial, geographical or socio-cultural constraints to accessing and using services. Applications of the public health system contain the regions of maternal and child health, health services management, emergency response, and prevention and manage of infectious and chronic diseases.

The great positive impact of public health programs is widely acknowledged. Due in part to the policies and actions urbanized through public health, the 20th century registered a decrease in the mortality rates for infants and children and a continual augment in life expectancy in mainly parts of the world. For instance, it is estimated that life expectancy has increased for Americans by thirty years since 1900, and worldwide by six years since 1990.

Self-care Strategies

Personal health depends partially on the active, passive, and assisted cues people observe and adopt in relation to the own health. These contain personal actions for preventing or minimizing the effects of a disease, usually a chronic condition, through integrative care. They also contain personal hygiene practices to prevent infection and illness, such as bathing and washing hands with soap; brushing and flossing teeth; storing, preparing and handling food safely; and several others. The information gleaned from personal observations of daily livelihood - such as in relation to the sleep patterns, exercise behavior, nutritional intake, and environmental aspects - may be used to inform personal decisions and actions (*e.g.*, "I feel tired in the morning so I am going to attempt sleeping on a dissimilar pillow"), as well as clinical decisions and treatment plans (*e.g.*, a patient who notices his or her shoes are tighter than usual may be having exacerbation of left-sided heart failure, and may require diuretic medication to reduce fluid overload).

Personal health also depends partially on the social structure of a person's life. The maintenance of strong social relationships, volunteering, and other social behaviors have been connected to positive mental health and even increased longevity. One American study in the middle of seniors in excess of age 70, establish that frequent volunteering was associated with reduced risk of dying compared with older persons who did not volunteer, regardless of physical health status. Another study from Singapore accounted that volunteering retirees had significantly better cognitive performance scores, fewer depressive symptoms, and better mental well-being and life satisfaction than non-volunteering retirees.

Prolonged psychological stress may negatively impact health, and has been cited as a factor in cognitive impairment with aging, depressive illness, and expression of disease. Stress management is the application of ways to either reduce stress or augment tolerance to stress. Relaxation techniques are physical ways used to relieve stress. Psychological ways contain cognitive therapy, meditation, and positive thinking, which work by reducing response to stress. Improving relevant skills, such as problem solving and time management skills, reduces uncertainty and builds confidence, which also reduces the reaction to stress-causing situations where those skills are applicable.

Occupational Health

In addition to safety risks, several jobs also present risks of disease, illness, and other extensive-term health troubles. In the middle of the mainly general occupational diseases are several shapes of pneumoconiosis, including silicosis and coal worker's pneumoconiosis (black lung disease). Asthma is another respiratory illness that several workers are vulnerable to. Workers may also be vulnerable to skin diseases, including eczema, dermatitis, urinary, sunburn, and skin cancer. Other occupational diseases of concern contain carpal tunnel syndrome and lead poisoning.

As the number of service sector jobs has risen in urbanized countries, more and more jobs have become sedentary, presenting a dissimilar array of health troubles than those associated with manufacturing and the primary sector. Modern troubles such as the rising rate of obesity and issues relating to stress and overwork in several countries have further complicated the interaction flanked by work and health.

Several governments view occupational health as a social challenge and have shaped public organizations to ensure the health and safety of workers. Examples of these contain the British Health and Safety Executive and in the United States, the National Institute for Occupational Safety and

Health, which conducts research on occupational health and safety, and the Occupational Safety and Health Management, which handles regulation and policy relating to worker safety and health.

Disease

A disease is an abnormal condition that affects the body of an organism. It is often construed as a medical condition associated with specific symptoms and signs. It may be caused by factors originally from an external source, such as infectious disease, or it may be caused by internal dysfunctions, such as autoimmune diseases. In humans, "disease" is often used more broadly to refer to any condition that causes pain, dysfunction, distress, social troubles, or death to the person afflicted, or similar troubles for those in get in touch with the person. In this broader sense, it sometimes comprises injuries, disabilities, disorders, syndromes, infections, in accessible symptoms, deviant behaviors, and atypical variations of structure and function, while in other contexts and for other purposes these may be measured distinguishable categories. Diseases usually affect people not only physically, but also emotionally, as contracting and livelihood with several diseases can alter one's perspective on life, and their personality.

Death due to disease is described death by natural causes. There are four main kinds of disease: pathogenic disease, deficiency disease, hereditary disease, and physiological disease. Diseases can also be classified as communicable and non-communicable disease.

Terminology

Concepts

In several cases, the conditions *disease*, *disorder*, *morbidity* and *illness* are used interchangeably. In some situations, specific conditions are measured preferable.

Disease

The term *disease* broadly refers to any condition that impairs normal function, and is therefore associated with dysfunction of normal homeostasis. Commonly, term *disease* is used to refer specifically to infectious diseases, which are clinically apparent diseases that result from the attendance of pathogenic microbial mediators, including viruses, bacteria, fungi, protozoa, multi-cellular organisms, and aberrant proteins recognized as prisons. An infection that does not and will not produce clinically apparent impairment of normal functioning, such as the attendance of the normal bacteria and yeasts in the gut, or of a passenger virus, is not measured a disease. By contrast, an infection that is asymptomatic throughout its incubation era, but expected to produce symptoms later, is usually measured a disease. Non-infectious diseases are all other diseases, including mainly shapes of cancer, heart disease, and genetic disease.

Illness

Illness and *sickness* are usually used as synonyms for *disease*. Though, this term is occasionally used to refer specifically to the patient's personal experience of their disease.

In this model, it is possible for a person have a disease without being ill (to have an objectively definable, but asymptomatic, medical condition), and to be *ill* without being *diseased* (such as when a person perceives a normal experience as a medical condition, or medicalizes a non-disease situation their life). Illness is often not due to infection, but to a collection of evolved responses—sickness behavior by the body—that helps clears infection. Such aspects of illness can contain lethargy, depression, anorexia, sleepiness, hyperalgesia, and inability to concentrate.

Disorder

In medicine, a disorder is a functional abnormality or disturbance. Medical disorders can be categorized into mental disorders, physical disorders, genetic disorders, emotional and behavioral disorders, and functional disorders. The term *disorder* is often measured more value-neutral and less stigmatizing than the conditions *disease* or *illness*, and therefore is preferred terminology in some circumstances. In mental health, the term mental disorder is used as a method of acknowledging the intricate interaction of biological, social, and psychological factors in psychiatric circumstances. Though, the term *disorder* is also used in several other regions of medicine, primarily to identify physical disorders that are not caused by infectious organisms, such as metabolic disorders.

Medical Condition

A medical condition is a broad term that comprises all diseases and disorders. While the term *medical condition* usually comprises mental illnesses, in some contexts the term is used specifically to denote any illness, injury, or disease except for mental illnesses. The Diagnostic and Statistical Manual of Mental Disorders (DSM), the widely used psychiatric manual that defines all mental disorders, uses the term *common medical condition* to refer to all diseases, illnesses, and injuries except for mental disorders. This usage is also commonly seen in the psychiatric literature. Some health insurance policies also describe a *medical condition* as any illness, injury, or disease except for psychiatric illnesses.

As it is more value-neutral than conditions like *disease*, the term *medical condition* is sometimes preferred by people with health issues that they do not consider deleterious. On the other hand, by emphasizing the medical nature of the condition, this term is sometimes rejected, such as by proponents of the autism rights movement.

The term *medical condition* is also a synonym for *medical state*, in which case it describes an individual patient's current state from a medical standpoint. This usage appears in statements that describe a patient as being *in critical condition*, for instance.

Morbidity

Morbidity (from Latin *morbidus*, meaning "sick, unhealthy") is a diseased state, disability, or poor health due to any cause. The term may be used to refer to the subsistence of any form of disease, or to the degree that the health condition affects the patient. In the middle of severely ill patients, the stage of morbidity is often measured by ICU scoring systems. Comorbidity is the simultaneous attendance of two or more medical circumstances, such as schizophrenia and substance abuse.

In epidemiology and actuarial science, the term morbidity rate can refer to either the incidence rate, or the prevalence of a disease or medical condition. This measure of sickness is contrasted with the mortality rate of a condition, which is the proportion of people dying throughout a given time interval.

Syndrome

A syndrome is the association of many medical signs, symptoms, and or other features that often happen jointly. Some syndromes, such as Down syndrome, have only one cause; others, such as Parkinsonian syndrome, have multiple possible causes. In other cases, the cause of the syndrome is strange. A well-known syndrome name often remnants in use even after an underlying cause has been establish, or when there are a number of dissimilar possible primary causes.

Predisease

Predisease is a kind of disease creep or medicalization in which currently healthy people with risk factors for disease, but no proof of actual disease, are told that they are sick. Prediabetes and pre-hypertension are general examples. Labeling a healthy person with pre-disease can result in over treatment, such as taking drugs that only help people with severe disease, or in useful preventive events, such as motivating the person to get a healthful amount of physical exercise.

Kinds

- Infectious diseases
- Contagious diseases
- ***Food borne illness:*** Food borne illness or food poisoning is any illness resulting from the consumption of food contaminated with pathogenic bacteria, toxins, viruses, prisons or parasites.
- Communicable diseases
- Non-communicable diseases
- Airborne diseases
- ***Lifestyle diseases:*** A lifestyle disease is any disease that appears to augment in frequency as countries become more industrialized and people live longer, especially if the risk factors contain behavioral choices like a sedentary lifestyle or a diet high in unhealthful foods such as refined carbohydrates, trans fats, or alcoholic beverages.
- ***Mental disorders:*** Mental illness is a broad, generic label for a category of illnesses that may contain affective or emotional instability, behavioral dysregulation, and/or cognitive dysfunction or impairment. Specific illnesses recognized as mental illnesses contain major depression, generalized anxiety disorder, schizophrenia, and attention deficit hyperactivity disorder, to name a few. Mental illness can be of biological (e.g., anatomical, chemical, or genetic) or psychological (e.g., trauma or disagreement) origin. It can impair the affected person's skill to work or school and harm interpersonal relationships. The term insanity is used technically as a legal term.

- ***Organic disease:*** An organic disease is one caused by a physical or physiological change to some tissue or organ of the body. The term sometimes excludes infections. It is commonly used in contrast with mental disorders. It comprises emotional and behavioral disorders if they are due to changes to the physical structures or functioning of the body, such as after a stroke or a traumatic brain injury, but not if they are due to psychosocial issues.

Stages

In an infectious disease, the incubation era is the time flanked by infection and the appearance of symptoms. The latency era is the time flanked by infection and the skill of the disease to spread to another person, which may precede, follow, or be simultaneous with the appearance of symptoms. Some viruses also exhibit a dormant stage, described viral latency, in which the virus hides in the body in an inactive state. For instance, vermicelli zoster virus causes chickenpox in the acute stage; after recovery from chickenpox, the virus may remain dormant in nerve cells for several years, and later cause herpes zoster (shingles).

- ***Acute disease:*** An acute disease is a short-existed disease, like the general cold.
- ***Chronic disease:*** A chronic disease is one that lasts for an extensive time, usually at least six months. Throughout that time, it may be constantly present, or it may go into remission and periodically relapse. A chronic disease may be stable (does not get any worse) or it may be progressive (gets worse in excess of time). Some chronic diseases can be permanently cured. Mainly chronic diseases can be beneficially treated, even if they cannot be permanently cured.
- ***Flare-up:*** A flare-up can refer to either the recurrence of symptoms or an onset of more severe symptoms.

- ***Refractory disease:*** A refractory disease is a disease that resists treatment, especially an individual case that resists treatment more than is normal for the specific disease in question.
- ***Progressive disease:*** Progressive disease is a disease whose typical natural course is the worsening of the disease until death, serious debility, or organ failure occurs. Slowly progressive diseases are also chronic diseases; several are also degenerative diseases. The opposite of progressive disease is *stable disease* or *static disease*: a medical condition that exists, but does not get better or worse.
- ***Cure:*** A cure is the end of a medical condition or a treatment that is very likely to end it, while remission refers to the disappearance, perhaps temporarily, of symptoms. Complete remission is the best possible outcome for incurable diseases.

Scope

- ***Localized disease:*** A localized disease is one that affects only one part of the body, such as athlete's foot or an eye infection.
- ***Disseminated disease:*** A disseminated disease has spread to other parts; with cancer, this is usually described metastasis disease.
- ***Systemic disease:*** A systemic disease is a disease that affects the whole body, such as influenza or high blood pressure.

Causes and Transmissibility

Only some diseases such as influenza are contagious and commonly whispered infectious. The micro-organisms that cause these diseases are recognized as pathogens and contain diversities of bacteria, viruses, protozoa and fungi. Infectious diseases can be transmitted, e.g. by hand-to-mouth get in touch with infectious material on surfaces, by bites of insects or other carriers of the disease, and from contaminated water or food (often via faucal contamination), etc. In addition, there are sexually transmitted diseases. In some cases, micro-organisms that are not readily spread from person to person play a role, while other diseases can be prevented or ameliorated with appropriate nutrition or other lifestyle changes.

Some diseases, such as mainly (but not all) shapes of cancer, heart disease and mental disorders, are non-infectious diseases. Several non-infectious diseases have a partly or totally genetic foundation and may thus be transmitted from one generation to another.

Social determinants of health are the social circumstances in which people live that determine their health. Illnesses are usually related to social, economic, political, and environmental circumstances. Social determinants of health have been recognized by many health organizations such as the Public Health Agency of Canada and the World Health Organization to greatly power communal and personal well-being. The World Health Organization's Social Determinants Council also recognizes Social determinants of health in poverty.

When the cause of a disease is poorly understood, societies tend to mythologize the disease or use it as a metaphor or symbol of whatever that culture considers evil. For instance, until the bacterial cause of tuberculosis was exposed in 1882, experts variously ascribed the disease to heredity, a sedentary lifestyle, depressed mood, and overindulgence in sex, rich food, or alcohol—all the social ills of the time.

Burdens of Disease

Disease burden is the impact of a health problem in a region measured by financial cost, mortality, morbidity, or other indicators.

There are many events used to quantify the burden imposed by diseases on people. The years of potential life lost (YPLL) is an easy estimate of the number of years that a person's life was shortened due to a disease. For instance, if a person dies at the age of 65 from a disease, and would almost certainly have existed until age 80 without that disease, then that disease has caused a loss of 15 years of potential life. YPLL measurements do not explanation for how disabled a person is before dying, so the measurement treats a person who dies suddenly and a person who died at the similar age after decades of illness as equivalent. In 2004, the World Health Organization calculated that 932 million years of potential life were lost to premature death.

The excellence-adjusted life year (QALY) and disability-adjusted life year (DALY) metrics are similar, but take into explanation whether the person was healthy after diagnosis. In addition to the number of years lost due to premature death, these measurements add part of the years lost to being sick. Unlike YPLL, these measurements illustrate the burden imposed on people who are very sick, but who live a normal lifespan. A disease that has high morbidity, but low mortality, has a high DALY and a low YPLL. In 2004, the World Health Organization calculated that 1.5 billion disability-adjusted life years were lost to disease and injury. In the urbanized world, heart disease and stroke cause the mainly loss of life, but neuropsychiatry circumstances like major depressive disorder cause the mainly years lost to being sick.

Prevention

Several diseases and disorders can be prevented through a diversity of means. These contain sanitation, proper nutrition, adequate exercise, vaccinations, and other self-care and public health events.

Treatments

Medical therapies or treatments are efforts to cure or improve a disease or other health problem. In the medical field, therapy is synonymous with the word *treatment*. In the middle of psychologists, the term may refer specifically to psychotherapy or "talk therapy". General treatments contain medications, surgery, medical devices, and self-care. Treatments may be provided by an organized health care system, or informally, by the patient or family members.

A prevention or preventive therapy is a method to avoid an injury, sickness, or disease in the first lay. A treatment or cure is applied after a medical problem has already started. A treatment attempts to improve or remove a problem, but treatments may not produce permanent cures, especially in chronic diseases. Cures are a subset of treatments that reverse diseases totally or end medical troubles permanently. Several diseases that cannot be totally cured are still treatable. Pain management (also described pain medicine) is that branch of medicine employing an interdisciplinary approach to the relief of pain and improvement in the excellence of life of that livelihood with pain

Treatment for medical emergencies necessity is provided promptly, often through an emergency department or, in less critical situations, through an urgent care facility.

Epidemiology

Epidemiology is the study of the factors that cause or encourage diseases. Some diseases are more general in sure geographic regions, in the middle of people with sure genetic or socioeconomic features, or at dissimilar times of the year.

Epidemiology is measured a cornerstone methodology of public health research, and is highly regarded in proof -based medicine for identifying risk factors for disease. In the study of communicable and non-communicable diseases, the work of epidemiologists ranges from outbreak investigation to study design, data collection and analysis including the development of statistical models to test hypotheses and the documentation of results for submission to peer-reviewed journals. Epidemiologists also study the interaction of diseases in a population, a condition recognized as a syndemic. Epidemiologists rely on a number of other scientific disciplines such as biology (to better understand disease procedures), biostatistics (the current raw information accessible), Geographic Information Science (to store data and map disease patterns) and social science disciplines (to better understand proximate and distal risk factors). Epidemiology can help identify causes as well as guide prevention efforts.

In learning diseases, epidemiology faces the challenge of defining them. Especially for poorly understood diseases, dissimilar groups might use significantly dissimilar definitions. Without an agreed-on definition, dissimilar researchers may statement dissimilar numbers of cases and features of the disease.

Social and Cultural Responses

How a society responds to diseases is the subject of medical sociology.

A condition may be measured a disease in some cultures or eras but not in others. For instance, obesity can symbolize wealth and abundance, and is a status symbol in famine-prone regions and some spaces hard-hit by HIV/AIDS. Epilepsy is measured a sign of spiritual gifts in the middle of the Hmong people.

Sickness confers the social legitimization of sure benefits, such as illness benefits, work avoidance, and being looked after by others. The person who is sick takes on a social role described the sick role. A person who responds to a dreaded disease, such as cancer, in a culturally acceptable fashion may be publicly and privately honored with higher social status. In return for these benefits, the sick person is obligated to seek treatment and work to become well once more. As a comparison, consider pregnancy, which is not interpreted as a disease or sickness, even if the mother and baby may both benefit from medical care.

Mainly religions grant exceptions from religious duties to people who are sick. For instance, one whose life would be endangered by fasting on Yom Kippur or throughout Ramadan is exempted from the requirement, or even forbidden from participating. People who are sick are also exempted from social duties. For instance, ill health is the only socially acceptable cause for an American to refuse an invitation to the White Home.

The identification of a condition as a disease, rather than as basically a difference of human structure or function, can have important social or economic implications. The controversial recognitions as diseases of repetitive stress injury (RSI) and post-traumatic stress disorder (also recognized as "Soldier's heart", "shell shock", and "combat fatigue") has had a number of positive and negative effects on the financial and other responsibilities of governments, corporations and institutions towards individuals, as well as on the individuals themselves. The social implication of viewing aging as a disease could be profound, though this classification is not yet widespread.

Lepers were people who were historically shunned because they had an infectious disease, and the term "leper" still evokes social stigma. Fear of disease can still be a widespread social phenomenon, though not all diseases evoke extreme social stigma.

Social standing and economic status affect health. Diseases of poverty are diseases that are associated with poverty and low social status; diseases of affluence are diseases that are associated with high social and economic status. Which diseases are associated with which states vary according to time, lay, and technology. Some diseases, such as diabetes mellitus, may be associated with both poverty (poor food choices) and affluence (extensive lifespan and sedentary lifestyles), through dissimilar mechanisms. The term diseases of culture describe diseases that are more general in the middle of older people. For instance, cancer is distant more general in societies in which mainly members live until they reach the age of 80 than in societies in which mainly members die before they reach the age of 50.

Language of Disease

An illness narrative is a method of organizing a medical experience into a coherent story that illustrates the sick individual's personal experience.

People use metaphors to create sense of their experiences with disease. The metaphors move disease from an objective thing that exists to an affective experience. The mainly popular metaphors draw on military concepts: Disease is an enemy that necessity be feared, fought, battled, and routed. The patient or the healthcare provider is a warrior, rather than a passive victim or bystander. The mediators of communicable diseases are invaders; non-communicable diseases constitute internal insurrection or civil war. Because the threat is urgent, perhaps a matter of life and death, unthinkably radical, even oppressive, events are society's and the patient's moral duty as they courageously rally to thrash about against destruction. The War on Cancer is an instance of this metaphorical use of language.

Another class of metaphors describes the experience of illness as a journey: The person travels to or from a lay of disease, and changes himself, discovers new information, or increases his experience beside the method. He may travel "on the road to recovery" or create changes to "get on the right track". Some are explicitly immigration-themed: the patient has been exiled from the house territory of health to the land of the ill, changing identity and relationships in the procedure.

Some metaphors are disease-specific. Slavery is a general metaphor for addictions: The alcoholic is enslaved by drink, and the smoker is captive to nicotine. Some cancer patients treat the loss of their hair from chemotherapy as a metonymy or metaphor for all the losses caused by the disease.

Some diseases are used as metaphors for social ills: "Cancer" is a general account for anything that is endemic and destructive in society, such as poverty, injustice, or racism. AIDS was seen as a divine judgment for moral decadence, and only by purging itself from the "pollution" of the "invader" could society become healthy again. Authors in the 19th century commonly used tuberculosis as a symbol and a metaphor for transcendence. Victims of the disease were portrayed in literature as having risen above daily life to become ephemeral objects of spiritual or artistic attainment. In the 20th century, after its cause was better understood, the similar disease became the emblem of poverty, squalor, and other social troubles.

Infectious Disease

Infectious diseases, also recognized as transmissible diseases or communicable diseases comprise clinically apparent illness (i.e., feature medical signs and/or symptoms of disease) resulting from the infection, attendance and growth of pathogenic biological mediators in an individual host organism. In sure cases, infectious diseases may be asymptomatic for much or even their entire course in a given host. In the latter case, the disease may only be defined as a "disease" (which by definition means an illness) in hosts who secondarily become ill after get in touch with an asymptomatic carrier. An infection is not synonymous with an infectious disease, as some infections do not cause illness in a host.

Infectious pathogens contain some viruses, bacteria, fungi, protozoa, multi-cellular parasites, and aberrant proteins recognized as prisons. These pathogens are the cause of disease epidemics, in the sense that without the pathogen, no infectious epidemic occurs.

The term *infectivity* describes the skill of an organism to enter, survive and multiply in the host, while the *infectiousness* of a disease designates the relative ease with which the disease is transmitted to other hosts. Transmission of pathogen can happen in several methods including physical get in touch with, contaminated food, body fluids, objects, airborne inhalation, or through vector organisms.

Infectious diseases are sometimes described "contagious" when they are easily transmitted by get in touch with an ill person or their secretions (e.g., influenza). Thus, a contagious disease is a subset of infectious disease that is especially infective or easily transmitted. Other kinds of infectious/transmissible/communicable diseases with more dedicated routes of infection, such as vector transmission or sexual transmission, are usually not regarded as "contagious," and often do not require medical separation (sometimes loosely described quarantine) of victims. Though, this dedicated connotation of the word "contagious" and "contagious disease" (easy transmissibility) is not always respected in popular use.

Classification

In the middle of the approximately infinite diversities of microorganisms, relatively few cause disease in otherwise healthy individuals. Infectious disease results from the interplay flanked by those few pathogens and the defenses of the hosts they infect. The appearance and severity of disease resulting from any pathogen depends upon the skill of that pathogen to damage the host as well as the skill of the host to resist the pathogen. Clinicians therefore classify infectious microorganisms or microbes according to the status of host defenses - either as *primary pathogens* or as *opportunistic pathogens*:

Primary pathogens cause disease as a result of their attendance or action within the normal, healthy host, and their intrinsic virulence (the severity of the disease they cause) is, in part, a necessary consequence of their need to reproduce and spread. Several of the mainly general primary pathogens of humans only infect humans, though several serious diseases are caused by organisms acquired from the environment or which infect non-human hosts.

Organisms which cause an infectious disease in a host with depressed resistance are classified as opportunistic pathogens. Opportunistic disease may be caused by microbes that are ordinarily in get in touch with the host, such as pathogenic bacteria or fungi in the gastrointestinal or the upper respiratory tract, and they may also result from (otherwise innocuous) microbes acquired from other hosts (as in *Clostridium difficult* colitis) or from the environment as a result of traumatic introduction (as in surgical wound infections or compound fractures). An opportunistic disease requires impairment of host defenses, which may happen as a result of genetic defects (such as Chronic glaucomatous disease), exposure to antimicrobial drugs or immunosuppressive chemicals (as might happen following poisoning or cancer chemotherapy), exposure to ionizing radiation, or as a result of an infectious disease with immunosuppressive action (such as with measles, malaria or HIV disease). Primary pathogens may also cause more severe disease in a host with depressed resistance than would normally happen in an immune sufficient host.

One method of proving that a given disease is "infectious", is to satisfy Koch's postulates (first proposed by Robert Koch), which demands that the infectious agent be recognized only in patients and not in healthy controls, and that patients who contract the agent also develop the disease. These postulates were first used in the detection that Mycobacteria species cause tuberculosis. Koch's postulates can not be met ethically for several human diseases because they require experimental infection of a healthy individual with a pathogen produced as a pure culture. Often, even diseases that are quite clearly infectious do not meet the infectious criteria. For instance, *Treponema pallidum*, the causative spirochete of syphilis, cannot be cultured *in vitro* - though the organism can be cultured in rabbit testes. It is less clear that a pure culture comes from an animal source serving as host than it is when derived from microbes derived from plate culture. Epidemiology is another significant tool used to study disease in a population. For infectious diseases it helps to determine if a disease outbreak is sporadic (occasional occurrence), endemic (regular cases often occurring in a region), epidemic (an unusually high number of cases in a region), or pandemic (a global epidemic).

Transmission

An infectious disease is transmitted from some source. Defining the means of transmission plays a significant part in understanding the biology of an infectious agent, and in addressing the disease it causes. Transmission may happen through many dissimilar mechanisms. Respiratory diseases and meningitis are commonly acquired by get in touch with aerosolized droplets, spread by sneezing, coughing, talking, kissing or even singing. Gastrointestinal diseases are often acquired by ingesting contaminated food and water. Sexually transmitted diseases are acquired through get in touch with bodily fluids, usually as a result of sexual action. Some infectious mediators may be spread as a result of get in touch with a contaminated, inanimate substance, such as a coin passed from one person to another, while other diseases penetrate the skin directly.

Transmission of infectious diseases may also involve a vector. Vectors may be mechanical or biological. A mechanical vector picks up an infectious agent on the outside of its body and transmits it in a passive manner. An instance of a mechanical vector is a housefly, which lands on cow dung, contaminating its appendages with bacteria from the feces, and then lands on food prior to consumption. The pathogen never enters the body of the fly.

In contrast, biological vectors harbor pathogens within their bodies and deliver pathogens to new hosts in an active manner, usually a bite. Biological vectors are often responsible for serious blood-borne diseases, such as malaria, viral encephalitis, Chagas disease, Lyme disease and African sleeping sickness. Biological vectors are usually, though not exclusively, arthropods, such as mosquitoes, ticks, fleas and lice. Vectors are often required in the life cycle of a pathogen. A general strategy used to manage vector borne infectious diseases is to interrupt the life cycle of a pathogen by killing the vector.

The connection flanked by virulence and transmission is intricate, and has significant consequences for the extensive term development of a pathogen. Since it takes several generations for a microbe and a new host species to co-evolve, an emerging pathogen may hit its earliest victims especially hard. It is usually in the first wave of a new disease that death rates are highest. If a disease is rapidly fatal, the host may die before the microbe can get passed beside to another host. Though, this cost may be overwhelmed by the short term benefit of higher infectiousness if transmission is connected to virulence, as it is for instance in the case of cholera (the explosive diarrhea aids the bacterium in finding new hosts) or several respiratory infections (sneezing and coughing make infectious aerosols).

Prevention

One of the methods to prevent or slow down the transmission of infectious diseases is to recognize the dissimilar features of several diseases. Some critical disease features that should be evaluated contain virulence, aloofness traveled by victims, and stage of contagiousness. The human strains of Ebola virus, for instance, incapacitate its victims very quickly and kills them soon after. As a result, the victims of this disease do not have the opportunity to travel very distant from the initial infection zone. Also, this virus necessity spread through skin lesions or permeable membranes such as the eye. Thus, the initial stage of Ebola is not very contagious since its victims experience only internal hemorrhaging. The spread of Ebola is very rapid and usually stays within a relatively confined geographical region. In contrast, the Human Immunodeficiency Virus (HIV) kills its victims very slowly by attacking their immune system. As a result, several of its victims transmit the virus to other individuals before even realizing that they are carrying the disease. Also, the relatively low virulence allows its victims to travel extensive distances, raising the likelihood of an epidemic.

Another effective method to decrease the transmission rate of infectious diseases is to recognize the effects of small-world networks. In epidemics, there are often extensive interactions within hubs or groups of infected individuals and other interactions within discrete hubs of susceptible individuals. Despite the low interaction flanked by discrete hubs, the disease can jump to and spread in a susceptible hub via a single or few interactions with an infected hub. Thus, infection rates in small-world networks can be reduced somewhat if interactions flanked by individuals within infected hubs are eliminated. Though, infection rates can be drastically reduced if the main focus is on the prevention of transmission jumps flanked by hubs. The use of needle exchange programs in regions with a high density of drug users with HIV is an instance of the successful implementation of this treatment way. Another instance is the use of ring culling or vaccination of potentially susceptible livestock in adjacent farms to prevent the spread of the foot-and-mouth virus in 2001.

Common ways to prevent transmission of pathogens may contain disinfection and pest manages.

Immunity

Infection with mainly pathogens does not result in death of the host and the offending organism is ultimately cleared after the symptoms of the disease have waned. This procedure requires immune mechanisms to kill or inactivate the inoculums of the pathogen. Specific acquired immunity against infectious diseases may be mediated by antibodies and/or T lymphocytes. Immunity mediated by these two factors may be manifested by:

- A direct effect upon a pathogen, such as antibody-initiated complement-dependent bacteriolysis, opsonoization, phagocytosis and killing, as occurs for some bacteria,
- Neutralization of viruses so that these organisms cannot enter cells,
- Or by T lymphocytes which will kill a cell parasitized by a microorganism.

The immune system response to a microorganism often causes symptoms such as a high fever and inflammation, and has the potential to be more devastating than direct damage caused by a microbe.

Resistance to infection (immunity) may be acquired following a disease, by asymptomatic carriage of the pathogen, by harboring an organism with a similar structure (cross reacting), or by vaccination. Knowledge of the protective antigens and specific acquired host immune factors is more complete for primary pathogens than for opportunistic pathogens.

Immune resistance to an infectious disease requires a critical stage of either antigen-specific antibodies and/or T cells when the host encounters the pathogen. Some individuals develop natural serum antibodies to the surface polysaccharides of some mediators although they have had little or no get in touch with the agent, these natural antibodies confer specific protection to adults and are passively transmitted to newborns.

Host Genetic Factors

The clearance of the pathogens, either treatment-induced or spontaneous, it can be influenced by the genetic variants accepted by the individual patients. For instance, for genotype 1 hepatitis C treated with Pegylated interferon-alpha-2a or Pegylated interferon-alpha-2b (brand names Pegasys or PEG-Intron) combined with repairing, it has been shown that genetic polymorphisms close to the human IL28B gene, encoding interferon lambda 3, are associated with important differences in the treatment-induced clearance of the virus. This finding, originally accounted in Nature, showed that genotype 1 hepatitis C patients carrying sure genetic variant alleles close to the IL28B gene are more perhaps to achieve sustained virological response after the treatment than others. Later statement from Nature demonstrated that the similar genetic variants are also associated with the natural clearance of the genotype 1 hepatitis C virus.

Diagnosis

Diagnosis of infectious disease sometimes involves identifying an infectious agent either directly or indirectly. In practice mainly minor infectious diseases such as warts, cutaneous abscesses, respiratory system infections and diarrheal diseases are diagnosed by their clinical presentation. Conclusions in relation to the cause of the disease are based upon the likelihood that a patient came in get in touch with a scrupulous agent, the attendance of a microbe in a society, and other epidemiological thoughts. Given enough effort, all recognized infectious mediators can be specifically recognized. The benefits of identification, though, are often greatly outweighed by the cost, as often there is no specific treatment, the cause is obvious, or the outcome of an infection is benign.

Diagnosis of infectious disease is almost always initiated by medical history and physical examination. Culture allows identification of infectious organisms by examining their microscopic aspects, by detecting the attendance of substances produced by pathogens, and by directly identifying an organism by its genotype. Other techniques (such as X-rays, CAT scans, PET scans or NMR) are used to produce images of internal abnormalities resulting from the growth of an infectious agent. The images are useful in discovery of, for instance, a bone abscess or a spongiform encephalopathy produced by a prison.

Microbial Culture

Microbiological culture is a principal tool used to diagnose infectious disease. In a microbial culture, a growth medium is provided for a specific agent. An example taken from potentially diseased tissue or fluid is then tested for the attendance of an infectious agent able to grow within that medium. Mainly pathogenic bacteria are easily grown on nutrient agar, a form of solid medium that supplies carbohydrates and proteins necessary for growth of a bacterium, beside with copious amounts of water. A single bacterium will grow into a visible mound on the surface of the plate described a colony, which may be separated from other colonies or melded jointly into a "lawn". The size, color, form and form of a colony is feature of the bacterial species, its specific genetic makeup (its strain), and the environment which supports its growth. Other ingredients are often added to the plate to aid in identification. Plates may contain substances that permit the growth of some bacteria and not others, or that change color in response to sure bacteria and not others. Bacteriological plates such as these are commonly used in the clinical identification of infectious bacterium. Microbial culture may also be used in the identification of viruses: the medium in this case being cells grown in culture that the virus can infect, and then alter or kill. In the case of viral identification, a region of dead cells results from viral growth, and is described a "plaque". Eukaryotic parasites may also be grown in culture as a means of identifying a scrupulous agent.

In the absence of appropriate plate culture techniques, some microbes require culture within live animals. Bacteria such as *Mycobacterium leprae* and *Treponema pallidum* can be grown in animals, although serological and microscopic techniques create the use of live animals unnecessary. Viruses are also usually recognized using alternatives to growth in culture or animals. Some viruses may be grown in embryonated eggs. Another useful identification way is Xenodiagnosis, or the use of a vector to support the growth of an infectious agent. Chagas disease is the mainly important instance, because it is hard to directly demonstrate the attendance of the causative agent, *Trypanosoma cruzi* in a patient, which therefore creates it hard to definitively create a diagnosis. In this case, xenodiagnosis involves the use of the vector of the Chagas agent *T. cruzi*, an uninfected triatomine bug, which takes a blood meal from a person suspected of having been infected. The bug is later inspected for growth of *T. cruzi* within its gut.

Microscopy

Another principal tool in the diagnosis of infectious disease is microscopy. Virtually all of the culture techniques rely, at some point, on microscopic examination for definitive identification of the infectious agent. Microscopy may be accepted out with easy instruments, such as the compound light microscope, or with instruments as intricate as an electron microscope. Samples obtained from patients may be viewed directly under the light microscope, and can often rapidly lead to identification. Microscopy is often also used in conjunction with biochemical staining techniques, and can be made exquisitely specific when used in combination with antibody based techniques. For instance, the use of antibodies made artificially fluorescent (fluorescently labeled antibodies) can be directed to bind to and identify a specific antigens present on a pathogen. A fluorescence microscope is then used to detect fluorescently labeled antibodies bound to internalized antigens within clinical samples or cultured cells. This technique is especially useful in the diagnosis of viral diseases, where the light microscope is incapable of identifying a virus directly.

Other microscopic procedures may also aid in identifying infectious mediators. Approximately all cells readily stain with a number of vital dyes due to the electrostatic attraction flanked by negatively charged cellular molecules and the positive charge on the dye. A cell is normally transparent under a microscope, and using a stain increases the contrast of a cell with its background. Staining a cell with a dye such as Giemsa stain or crystal violet allows a microscopist to describe its size, form, internal and external components and its associations with other cells. The response of bacteria to dissimilar staining procedures is used in the taxonomic classification of microbes as well. Two ways, the Gram stain and the acid-fast stain, are the average approaches used to classify bacteria and to diagnosis of disease. The Gram stain identifies the bacterial groups Firmicutes and Actinobacteria, both of which contain several important human pathogens. The acid-fast staining procedure identifies the Actinobacterial genera *Mycobacterium* and *Nocardia*.

Biochemical Tests

Biochemical tests used in the identification of infectious mediators contain the discovery of metabolic or enzymatic products feature of a scrupulous infectious agent. Since bacteria ferment carbohydrates in patterns feature of their genus and species, the discovery of fermentation products is commonly used in bacterial identification. Acids, alcohols and gases are usually detected in these tests when bacteria are grown in selective liquid or solid media.

The separation of enzymes from infected tissue can also give the foundation of a biochemical diagnosis of an infectious disease. For instance, humans can create neither RNA replicases nor reverse transcriptase, and the attendance of these enzymes is feature of specific kinds of viral infections. The skill of the viral protein hem agglutinin to bind red blood cells jointly into a detectable matrix may also be characterized as a biochemical test for viral infection, although strictly speaking hem agglutinin is not an *enzyme* and has no metabolic function.

Serological ways are highly sensitive, specific and often very rapid tests used to identify microorganisms. These tests are based upon the skill of an antibody to bind specifically to an antigen. The antigen, usually a protein or carbohydrate made by an infectious agent, is bound by the antibody. This binding then sets off a chain of events that can be visibly obvious in several methods, dependent upon the test. For instance, "Strep throat" is often diagnosed within minutes, and is based on the appearance of antigens made by the causative agent, *S. pyogenes*, that is retrieved from a patients throat with a cotton swab. Serological tests, if accessible, are usually the preferred route of identification, though the tests are costly to develop and the reagents used in the test often require refrigeration. Some serological ways are very costly, although when commonly used, such as with the "strep test", they can be inexpensive.

Intricate serological techniques have been urbanized into what are recognized as Immunoassays. Immunoassays can use the vital antibody – antigen binding as the foundation to produce an electro - magnetic or particle radiation signal, which can be detected by some form of instrumentation. Signal of unknowns can be compared to that of standards allowing quantitation of the target antigen. To aid in the diagnosis of infectious diseases, immunoassays can detect or measure antigens from either infectious mediators or proteins generated by an infected organism in response to a foreign agent. For instance, immunoassay A may detect the attendance of a surface protein from a virus particle. Immunoassay B on the other hand may detect or measure antibodies produced by an organism's immune system which are made to neutralize and allow the destruction of the virus.

Instrumentation can be used to read very small signals created by secondary reactions connected to the antibody – antigen binding. Instrumentation can manage sampling, reagent use, reaction times, signal discovery, calculation of results, and data management to yield a cost effective automated procedure for diagnosis of infectious disease.

Molecular Diagnostics

Technologies based upon the polymerase chain reaction (PCR) way will become almost ubiquitous gold standards of diagnostics of the close to future, for many reasons. First, the catalog of infectious mediators has grown to the point that virtually all of the important infectious mediators of the human population have been recognized. Second, an infectious agent necessity grow within the human body to cause disease; essentially it necessity amplify its own nucleic acids in order to cause a disease. This amplification of nucleic acid in infected tissue offers an opportunity to detect the infectious agent by using PCR. Third, the essential apparatus for directing PCR, primers, are derived from the genomes of infectious mediators, and with time those genomes will be recognized, if they are not already.

Thus, the technological skill to detect any infectious agent rapidly and specifically is currently accessible. The only remaining blockades to the use of PCR as an average tool of diagnosis are in its cost and application, neither of which is insurmountable. The diagnosis of a few diseases will not benefit from the development of PCR ways, such as some of the clostridia diseases (tetanus and botulism). These diseases are fundamentally biological poisonings by relatively small numbers of infectious bacteria that produce very potent neurotoxins. An important proliferation of the infectious agent does not happen, this limits the skill of PCR to detect the attendance of any bacteria.

Indication of Tests

There is usually an indication for a specific identification of an infectious agent only when such identification can aid in the treatment or prevention of the disease, or to advance knowledge of the course of an illness prior to the development of effective therapeutic or preventative events. For instance, in the early 1980s, prior to the appearance of AZT for the treatment of AIDS, the course of the disease was closely followed by monitoring the composition of patient blood samples, even though the outcome would not offer the patient any further treatment options. In part, these studies on the appearance of HIV in specific societies permitted the advancement of hypotheses as to the route of transmission of the virus. By understanding how the disease was transmitted, possessions could be targeted to the societies at greatest risk in campaigns aimed at reducing the number of new infections. The specific serological diagnostic identification, and later genotypic or molecular identification, of HIV also enabled the development of hypotheses as to the temporal and geographical origins of the virus, as well as a myriad of other hypothesis. The development of molecular diagnostic apparatus has enabled physicians and researchers to monitor the efficacy of treatment with anti-retroviral drugs. Molecular diagnostics are now commonly used to identify HIV in healthy people extensive before the onset of illness and have been used to demonstrate the subsistence of people who are genetically resistant to HIV infection. Thus, while there still is no cure for AIDS, there is great therapeutic and predictive benefit to identifying the virus and monitoring the virus stages within the blood of infected individuals, both for the patient and for the society at big.

Historic Pandemics

A pandemic (or global epidemic) is a disease that affects people in excess of an extensive geographical region. Plague of Justinian, from 541 to 750, killed flanked by 50% and 60% of Europe's population.

The Black Death of 1347 to 1352 killed 25 million in Europe in excess of 5 years. The plague reduced the world population from an estimated 450 million to flank by 350 and 375 million in the 14th century.

The introduction of smallpox, measles, and typhus to the regions of Central and South America by European explorers throughout the 15th and 16th centuries caused pandemics in the middle of the native inhabitants. Flanked by 1518 and 1568 disease pandemics are said to have caused the population of Mexico to fall from 20 million to 3 million.

The first European influenza epidemic occurred flanked by 1556 and 1560, with an estimated mortality rate of 20%.

Smallpox killed an estimated 60 million Europeans throughout the 18th century (almost 400,000 per year). Up to 30% of those infected, including 80% of the children under 5 years of age, died from the disease, and one-third of the survivors went blind.

In the 19th century, tuberculosis killed an estimated one-quarter of the adult population of Europe; by 1918 one in six deaths in France were still caused by TB.

The Influenza Pandemic of 1918 (or the Spanish Flu) killed 25-50 million people (in relation to the 2% of world population of 1.7 billion). Today Influenza kills in relation to the 250,000 to 500,000 worldwide each year.

Emerging Diseases

In mainly cases, microorganisms live in harmony with their hosts via mutual or commensally interactions. Diseases can emerge when existing parasites become pathogenic or when new pathogenic parasites enter a new host.

Co-evolution flanked by parasite and host can lead to hosts becoming resistant to the parasites or the parasites may evolve greater virulence, leading to immune pathological disease.

Human action is involved with several emerging infectious diseases, such as environmental change enabling a parasite to inhabit new niches. When that happens, a pathogen that had been confined to a remote habitat has a wider sharing and perhaps a new host organism. Parasites jumping from nonhuman to human hosts are recognized as zoonoses. Under disease invasion, when a parasite invades a new host species, it may become pathogenic in the new host. Many human behaviors have led to the emergence and spread of new diseases:

- ***Encroachment on wildlife habitats*:** The construction of new villages and housing growths in rural regions force animals to live in thick populations, creating opportunities for microbes to mutate and emerge.
- ***Changes in agriculture:*** The introduction of new crops attracts new crop pests and the microbes they carry to farming societies, exposing people to unfamiliar diseases.
- ***The destruction of rain forests:*** As countries create use of their rain forests, by structure roads through forests and clearing regions for resolution or commercial ventures, people encounter insects and other animals harboring previously strange microorganisms.
- ***Uncontrolled urbanization:*** The rapid growth of municipalities in several developing countries tends to concentrate big numbers of people into crowded regions with poor sanitation. These circumstances foster transmission of contagious diseases.
- ***Contemporary transport:*** Ships and other cargo carriers often harbor unintended "passengers" that can spread diseases to distant destinations. While with international jet-airplane travel, people infected with a disease can carry it to distant lands, or house to their families, before their first symptoms appear.

Health in India

India has a universal health care system run by the constituent states and territories of India. The Constitution charges every state with "raising the stage of nutrition and the average of livelihood of its people and the improvement of public health as in the middle of its primary duties". The National Health Policy was endorsed by the Parliament of India in 1983 and updated in 2002.

Parallel to the public health sector, and indeed more popular than it, is the private medical sector in India. Both urban and rural Indian households tend to use the private medical sector more regularly than the public sector, as reflected in surveys.

India has a life expectancy of 64/67 years (m/f), and an infant mortality rate of 61 per 1000 live births.

Health Issues

Malnutrition

42% of India's children below the age of three are malnourished, which is greater than the statistics of sub-Saharan African region of 28%. Although India's economy grew 50% from 2001–2006, its child-malnutrition rate only dropped 1%, lagging behind countries of similar growth rate. Malnutrition impedes the social and cognitive development of a child, reducing his educational attainment and income as an adult. These irreversible damages result in lower productivity.

High Infant Mortality Rate

Almost 1.72 million children die each year before turning one. The under five mortality and infant mortality rates have been declining, from 202 and 190 deaths per thousand live births respectively in 1970 to 64 and 50 deaths per thousand live births in 2009. Though, this rate of decline is slowing.

Reduced funding for immunization leaves only 43.5% of the young fully immunized. A study mannered by the Future Health Systems Consortium in Murshidabad, West Bengal designates that barriers to immunization coverage are adverse geographic site, absent or inadequately trained health workers and low perceived need for immunization. Infrastructure like hospitals, roads, water and sanitation are lacking in rural regions. Shortages of healthcare providers, poor intra-partum and newborn care, diarrheal diseases and acute respiratory infections also contribute to the high infant mortality rate.

Diseases

Diseases such as dengue fever, hepatitis, tuberculosis, malaria and pneumonia continue to plague India due to increased resistance to drugs. In 2011, India urbanized a *totally drug-resistant* form of tuberculosis. India is ranked 3rd highest in the middle of countries with a high rate of HIV-infected persons. Diarrheal diseases are the primary causes of early childhood mortality. These diseases can be attributed to poor sanitation and inadequate safe drinking water in India. India also has the world's highest incidence of Rabies.

This was achieved because of the Pulse Polio Programme started in 1995-96 by the government of India. Indians are also at particularly high risk for atherosclerosis and coronary artery disease. This may be attributed to a genetic predisposition to metabolic syndrome and adverse changes in coronary artery vasodilatation. NGOs such as the Indian Heart Base and the Medwin Base have been created to raise awareness of this public health issue.

Poor Sanitation

As more than 122 million households have no toilets, and 33% lack access to latrines, in excess of 50% of the population (638 million) defecate in the open. This is relatively higher than Bangladesh and Brazil (7%) and China (4%). Although 211 million people gained access to improved sanitation from 1990–2008, only 31% use the facilities provided. Only 11% of Indian rural families dispose of stools safely whereas 80% of the population leave their stools in the open or throw them in the garbage. Open air defecation leads to the spread of disease and malnutrition through parasitic and bacterial infections.

Inadequate Safe Drinking Water

Access to protected sources of drinking water has improved from 68% of the population in 1990 to 88% in 2008. Though, only 26% of the slum population has access to safe drinking water, and 25% of the total population has drinking water on their premises. This problem is exacerbated by falling stages of groundwater caused mainly by rising extraction for irrigation. Insufficient maintenance of the environment approximately water sources, groundwater pollution, excessive arsenic and fluoride in drinking water pose a major threat to India's health.

Female Health Issues

Women's health in India involves numerous issues. Some of them contain the following:

- ***Malnutrition :*** The main cause of female malnutrition in India is the custom requiring women to eat last, even throughout pregnancy and when they are lactating.
- ***Breast Cancer :*** One of the mainly severe and rising troubles in the middle of women in India, resulting in higher mortality rates.
- ***Polycystic ovarian disease (PCOD) :*** PCOD increases the infertility rate in females. This condition causes several small cysts to form in the ovaries, which can negatively affect a woman's skill to conceive.
- ***Maternal Mortality :*** Indian maternal mortality rates in rural regions are in the middle of the highest in the world.

Rural Health

Rural India contains in excess of 68% of India's total population with half livelihood below the poverty row, struggling for better and easy access to health care and services. Health issues confronted by rural people are several and diverse – from severe malaria to uncontrolled diabetes, from a badly infected wound to cancer. Postpartum maternal illness is a serious problem in resource-poor settings and contributes to maternal mortality, particularly in rural India. A study mannered in 2009 establish that 43.9% of mothers accounted they experienced postpartum illnesses six weeks after delivery. Rural medical practitioners are highly sought after by people livelihood in rural India as they are more financially affordable and geographically accessible than practitioners working in the formal public health care sector.

Health Care System

Public and Private Sector

According to National Family Health Survey-3, the private medical sector remnants the primary source of health care for 70% of households in urban regions and 63% of households in rural regions. Reliance on public and private health care sector varies significantly flanked by states. Many reasons are cited for relying on private rather than public sector; the main cause at the national stage is poor excellence of care in the public sector, with more than 57% of households pointing to this as the cause for a preference for private heath care. Other major reasons are aloofness of the public sector facility, extensive wait times, and inconvenient hours of operation.

National Rural Health Mission

The National Rural Health Mission (NRHM) was launched in April 2005 by the Government of India. The goal of the NRHM was to give effective healthcare to rural people with a focus on 18 states which have poor public health indicators and/or weak infrastructure.

MIND AND BODY

Mind-Body Question

In the Vedic times, in India, philosophers held the belief that man consisted of atma (soul), anas (mind), indriyan (sense organs) and sarira (body). The sarira was taken to be the indriyan which were situated in its several parts. Manas were one of the 11 gans thought to be present in the body and, it was measured to be the organ for memory knowledge and feeling etc. The atma was capable of knowing, feeling and action but without the manas, indriyan and sarira, it could not function. In later times, Yoga and Tantra came to view the brain and the nerves as the organs of the soul. The mind, though, had always been regarded as of great importance and all behaviors such as hearing, seeing, desiring and believing were assigned to it.

By the 19th century, scientific explanations for the functions of the body were accessible, based on concrete observations and experiments. Mental procedures were seen to be connected to the brain. It was recognized that the mind cannot exist without the body. Our reception in relation to the world, its sights, sounds and smells is entirely determined by our system, i.e., the eyes, ears, nose, skin etc., and the brain.

You can perhaps see that our account of ancient and philosophical views in relation to the mind d mental procedures is too brief to do justice to the philosophers. But our purpose is not to into details of what people have thought in relation to the mental procedures in the course of thousands of years of human history. Our purpose is to provide you, again briefly, what is identically recognized at present in relation to the human mind and behaviour. The whole functioning of the human body is coordinated by the nervous system which insists of the brain, the spinal cord and the peripheral nerves. The working of the brain gained a mystery for an extensive time. Even today, there is a good deal we do not know in relation to the brain works, although a lot of information has been pieced jointly from observing behaviour of patients that suffer from diseases related to tumors or other physical defects in brain. Though, the properties of individual nerve cells that create up the brain and the nervous system are well understood now. From these properties we can effort to main the operations of the whole nervous system.

Functional Unit of the Nervous System — Neuron

The human brain is composed of more than one hundred billion (100,000,000,000 or 10") cells described 'neurons'. This number which is comparable to the number of stars in the Milky Method, provides us and thought in relation to the size of the neurons also — because 10" of them fit in a legroom which slightly more than a liter of water can inhabit. Since these neurons are the functional units of the whole nervous system, let us become well-known with some of their vital aspects. Neurons can be categorized into the following types according to their functions:

- ***Motor neurons:*** Send signals from the nervous system to muscles and glands.
- ***Sensory neurons:*** Carry signals from the receptor cells in sense organs in the body to the nervous system. For instance, signals generated by touch or smell or hearing etc.
- ***Inter neurons or association neurons:*** Procedure the sensory information received from other neurons, and convey messages. For instance, when an insect bites, the fingers are given a command to scratch at that point. Mainly of the brain's neurons fall in this category.

Central Nervous System

The central nervous system (CNS) is the part of the nervous system that integrates the information that it receives from, and coordinates the action of, all parts of the bodies of bilaterian animals—that is, all multicellular animals except radically symmetric animals such as sponges and jellyfish. It contains the majority of the nervous system and consists of the brain and the spinal cord. Some classifications also contain the retina and the cranial nerves in the CNS. Jointly with the peripheral nervous system, it has a fundamental role in manage of behavior. The CNS is contained within the dorsal cavity, with the brain in the cranial cavity and the spinal cord in the spinal cavity. In vertebrates, the brain is protected by the skull, while the spinal cord is protected by the vertebrae, and both are enclosed in the meanings.

Development

Throughout early development of the vertebrate embryo, a longitudinal groove on the neural plate slowly deepens and the ridges on either face of the groove (the neural folds) become elevated, and ultimately meet, transforming the groove into a closed tube, the ectodermic wall of which shapes the rudiment of the nervous system. This tube initially differentiates into three vesicles (pockets): the pros encephalon at the front, the mesencephalon, and, flanked by the mesencephalon and the spinal cord, the rhombencephalon. (By six weeks in the human embryo) the prosencephalon then divides further into the telencephalon and diencephalon; and the rhombencephalon divides into the metencephalon and myelencephalon.

As the vertebrate grows, these vesicles differentiate further still. The telencephalon differentiates into, in the middle of other things, the striatum, the hippocampus and the neo-cortex, and its cavity becomes the first and second ventricles. Diencephalon elaborations contain the sub thalamus, hypothalamus, thalamus and epithalamus, and its cavity shapes the third ventricle. The tectum, pretectum, cerebral peduncle and other structures develop out of the mesencephalon, and its cavity grows into the mesencephalic duct (cerebral aqueduct). The metencephalon becomes, in the middle of other things, the pons and the cerebellum, the myelencephalon shapes the medulla oblongata, and their cavities develop into the fourth ventricle.

Planarians, members of the phylum Platyhelminthes (flatworms), have the simplest, clearly defined delineation of a nervous system into a central nervous system (CNS) and a peripheral nervous system (PNS). Their primitive brain, consisting of two fused anterior ganglia, and longitudinal nerve cords form the CNS; the laterally projecting nerves form the PNS. A molecular study establish that more than 95% of the 116 genes involved in the nervous system of planarians, which comprises genes related to the CNS, also exist in humans. Like planarians, vertebrates have a separate CNS and PNS, though more intricate than those of planarians.

The CNS of chordates differs from that of other animals in being placed dorsally in the body, above the gut and notochord/spine. The vital pattern of the CNS is highly conserved throughout the dissimilar species of vertebrates and throughout development. The major trend that can be observed is towards a progressive telencephalisation: the telencephalon of reptiles is only an appendix to the big olfactory bulb, while in mammals it creates up mainly of the volume of the CNS. In the human brain, the telencephalon covers mainly of the diencephalon and the mesencephalon. Indeed, the allometric study of brain size in the middle of dissimilar species shows a striking stability from rats to whales, and allows us to complete the knowledge in relation to the development of the CNS obtained through cranial end casts.

Mammals – which appear in the fossil record after the first fishes, amphibians, and reptiles – are the only vertebrates to possess the evolutionarily recent, outermost part of the cerebral cortex recognized as the neo-cortex. The neo-cortex of monotremes (the duck-billed platypus and many species of spiny anteaters) and of marsupials (such as kangaroos, koalas, opossums, wombats, and Tasmanian devils) lack the convolutions – gyri and sulci – establish in the neocortex of mainly placental mammals (eutherians).

Within placental mammals, the size and complexity of the neocortex increased in excess of time. The region of the neocortex of mice is only in relation to the 1/100 that of monkeys, and that of monkeys is only in relation to the 1/10 that of humans. In addition, rats lack convolutions in their neocortex (perhaps also because rats are small mammals), whereas cats have a moderate degree of convolutions, and humans have quite extensive convolutions. Extreme convolution of the neocortex is established in dolphins, perhaps related to their intricate echolocation.

Diseases of the Central Nervous System

There are several central nervous system diseases, including infections of the central nervous system such as encephalitis and poliomyelitis, neurodegenerative diseases such as Alzheimer's disease and amyotrophic lateral sclerosis, autoimmune and inflammatory diseases such as multiple sclerosis or acute disseminated encephalomyelitis, and genetic disorders such as Krabbe's disease, Huntington's disease, or adrenoleukodystrophy. Lastly, cancers of the central nervous system can cause severe illness and, when malignant, can have very high mortality rates.

Specialty professional organizations recommend that neurological imaging of the brain be done only to answer a specific clinical question and not as routine screening.

Peripheral Nervous System

The peripheral nervous system (PNS, or occasionally PeNS) consists of the nerves and ganglia outside of the brain and spinal cord. The main function of the PNS is to connect the central nervous system (CNS) to the limbs and organs. Unlike the CNS, the PNS is not protected by the bone of spine and skull, or by the blood–brain barrier, leaving it exposed to toxins and mechanical injuries. The peripheral nervous system is divided into the somatic nervous system and the autonomic nervous system; some textbooks also contain sensory systems. It is also a part of the nervous system.

The cranial nerves are part of the PNS with the exception of cranial nerve II, the optic nerve, beside with the retina. The second cranial nerve is not a true peripheral nerve but a tract of the diencephalon. Cranial nerve ganglia originate in the CNS. Though, the remaining eleven cranial nerve axons extend beyond the brain and are therefore measured part of the PNS.

Specific Nerves and Plexi

Ten out of the twelve cranial nerves originate from the brainstem, and mainly manage the functions of the anatomic structures of the head with some exceptions. The nuclei of cranial nerves I and II lie in the forebrain and thalamus, respectively, and are thus not measured to be true cranial nerves. CN X (10) receives visceral sensory information from the thorax and abdomen, and CN XI (11) is responsible for innervating the sternocleidomastoid and trapezius muscles, neither of which is exclusively in the head.

Spinal nerves take their origins from the spinal cord. They manage the functions of the rest of the body. In humans, there are 31 pairs of spinal nerves: 8 cervical, 12 thoracic, 5 lumbar, 5 sacral and 1 coccygeal. In the cervical region, the spinal nerve roots come out *above* the corresponding vertebrae (i.e. nerve root flanked by the skull and 1st cervical vertebrae is described spinal nerve C1). From the thoracic region to the coccygeal region, the spinal nerve roots come out *below* the corresponding vertebrae. It is significant to note that this way makes a problem when naming the spinal nerve root flanked by C7 and T1 (so it is described spinal nerve root C8). In the lumbar and sacral region, the spinal nerve roots travel within the dural sac and they travel below the stage of L2 as the cauda equina.

Cervical Spinal Nerves (C1–C4)

The first 4 cervical spinal nerves, C1 through C4, split and recombine to produce a diversity of nerves that sub serve the neck and back of head.

Spinal nerve C1 is described the sub occipital nerve which gives motor innervations to muscles at the base of the skull. C2 and C3 form several of the nerves of the neck, providing both sensory and motor manage. These contain the greater occipital nerve which gives sensation to the back of the head, the lesser occipital nerve which gives sensation to the region behind the ears, the greater auricular nerve and the lesser auricular nerve. The phrenic nerve arises from nerve roots C3, C4 and C5. It innervates the diaphragm, enabling breathing. If the spinal cord is transected above C3, then spontaneous breathing is not possible.

Brachial Plexus (C5–T1)

The last four cervical spinal nerves, C5 through C8, and the first thoracic spinal nerve, T1,combine to form the brachial plexus, or plexus brachialis, a tangled array of nerves, splitting, combining and recombining, to form the nerves that sub serve the upper-limb and upper back. Although the brachial plexus may appear tangled, it is highly organized and predictable, with little difference flanked by people.

Lumbosacral Plexus (L1–S4)

The anterior divisions of the lumbar nerves, sacral nerves, and coccygeal nerve form the lumbosacral plexus, the first lumbar nerve being regularly joined by a branch from the twelfth thoracic. For descriptive purposes this plexus is usually divided into three parts:

- Lumbar plexus,
- Sacral plexus, and
- Pudenda plexus.

Neurotransmitters

The main neurotransmitters of the peripheral nervous system are acetylcholine and noradrenaline. Though, there are many other neurotransmitters as well, jointly labeled Non-noradrenergic, non-cholinergic (NANC) transmitters. Examples of such transmitters contain non-peptides: ATP, GABA, dopamine, NO, and peptides: neuropeptide Y, VIP, GnRH, Substance P and CGRP.

Endocrine System

The endocrine system is the system of glands, each of which secretes dissimilar kinds of hormones directly into the bloodstream (some of which are transported beside nerve tracts) to uphold homeostasis. The endocrine system is in contrast to the exocrine system, which secretes its chemicals using ducts. The word endocrine derives from the Greek words "endo" meaning inside, within, and "crinis" for secrete. The endocrine system is an information signal system like the nervous system, yet its effects and mechanism are classifiably dissimilar. The endocrine system's effects are slow to initiate, and prolonged in their response, lasting from a few hours up to weeks. The nervous system sends information very quickly, and responses are usually short existed. Hormones are substances (chemical mediators) released from endocrine tissue into the bloodstream where they travel to target tissue and generate a response. Hormones regulate several human functions, including metabolism, growth and development, tissue function, sleep, and mood. The field of study dealing with the endocrine system and its disorders is endocrinology, a branch of internal medicine.

Aspects of endocrine glands are, in common, their ductless nature, their vascularity, and usually the attendance of intracellular vacuoles or granules storing their hormones. In contrast, exocrine glands, such as salivary glands, sweat glands, and glands within the gastrointestinal tract, tend to be much less vascular and have ducts or a hollow lumen.

Several other organs that are part of other body systems, such as the kidney, liver, heart and gonads, have secondary endocrine functions. For instance the kidney secretes endocrine hormones such as erythropoietin and renin.

The endocrine system is made of a series of glands that produce chemicals described hormones. A number of glands that signal each other in sequence are usually referred to as an axis, for instance, the hypothalamic-pituitary-adrenal axis.

As opposed to endocrine factors that travel considerably longer distances via the circulatory system, other signaling molecules, such as paracrine factors involved in paracrine signaling diffuse in excess of a relatively short aloofness.

Interaction with Immune System

Extensive bidirectional interactions exist flanked by the endocrine system and the immune system. Cortisol has major immunosuppressive effects, and dopamine has immunomodulatory functions. On the other hand, cytokines produced throughout inflammation activate the HPA axis at all three stages, sensible to negative feedback. Moreover cytokines stimulate hepcidin release from the liver, which is eventually responsible for the anemia of chronic disease.

Diseases

Diseases of the endocrine system are general, including circumstances such as diabetes mellitus, thyroid disease, and obesity. Endocrine disease is characterized by disregulated hormone release (a productive pituitary adenoma), inappropriate response to signaling (hypothyroidism), lack of a gland (diabetes mellitus kind 1, diminished erythropoiesis in chronic renal failure), or structural enlargement in a critical location such as the thyroid (toxic multinodular goitre). Hypofunction of endocrine glands can happen as a result of loss of reserve, hyposecretion, agenesis, atrophy, or active destruction. Hyperfunction can happen as a result of hypersecretion, loss of suppression, hyperplastic or neoplastic change, or hyperstimulation.

Endocrinopathies are classified as primary, secondary, or tertiary. Primary endocrine disease inhibits the action of downstream glands. Secondary endocrine disease is indicative of a problem with the pituitary gland. Tertiary endocrine disease is associated with dysfunction of the hypothalamus and its releasing hormones.

As the thyroid, and hormones have been implicated in signaling distant tissues to proliferate, for instance, the estrogen receptor has been shown to be involved in sure breast cancers. Endocrine, paracrine, and autocrine signaling have all been implicated in proliferation, one of the required steps of ontogenesis.

Other Kinds of Signaling

The typical mode of cell signaling in the endocrine system is endocrine signaling. Though, there are also other manners, i.e., paracrine, autocrine, and neuron-endocrine signaling. Purely neuroscience signaling flanked by neurons, on the other hand, belongs totally to the nervous system.

- ***<u>Autocrine:</u>*** Autocrine signaling is a form of signaling in which a cell secretes a hormone or chemical messenger (described the autocrine agent) that binds to autocrine receptors on the similar cell, leading to changes in the cells.
- ***<u>Paracrine:</u>*** Paracrine signaling is a form of cell signaling in which the target cell is close to the signal-releasing cell, altering the behavior or differentiation of those competent cells.
- ***<u>Juxtacrine:</u>*** Juxtacrine signaling is a kind of intercellular communication that is transmitted via oligosaccharide, lipid, or protein components of a cell membrane, and may affect either the emitting cell or the immediately adjacent cells. It occurs flanked by adjacent cells that possess broad patches of closely opposed plasma membrane

connected by Tran membrane channels recognized as connexons. The gap flanked by the cells can usually be flanked by only 2 and 4 nm. Unlike other kinds of cell signaling (such as paracrine and endocrine), juxtacrine signaling requires physical get in touch with flanked by the two cells involved. Juxtacrine signaling has been observed for some growth factors, cytokine and chemokine cellular signals.

PSYCHOLOGICAL ASPECTS OF BEHAVIOUR

Learning

When we talk in relation to the learning, we usually mean acquiring a new ability, new information or new thoughts. For instance you may be learning to ride a bicycle or play a game or speak a new language. Coming to think of it you have learnt numerous things in the course of your life— from learning to walk and talk, to the learning of history or geography etc., and again to the learning of social behaviour and thoughts in relation to the right and wrong, just and unjust. In information, all your attitudes, values and beliefs, all that distinguishes you as a person dissimilar from others is a result or continuous learning. Everyone of us is exposed to new situations and experiences everyday and all of us are constantly learning from them. Our behaviour strongly depends on the learning we have gone through either by method of training, study or experience. Of course, it does not mean that all behaviour is rational or reasonable. As a child, a person may have picked up unhealthy habits, like not keeping his or her body and clothes clean, or being lazy and slothful. Wrong values are also "learnt", sometimes from family and friends, like considering other people untouchable, or worth despising, basically because they speak a dissimilar language or profess a dissimilar religion. Though, some behaviour is "instinctive", i.e. belonging to human species, even without learning one would do sure things—for instance, a mother protecting a child from injury.

Incentive and Response

Scientists concerned with human behaviour and attitudes, namely psychologists, have tried to understand the vital procedure of learning, starting from easy models and situations. The simplest model is that of incentive and response. The Russian Nobel Prize winner, Ivan Pavlov in early 1900s accepted out some experiments on dogs which were perhaps the best examples of an incentive producing a sure type of response. While learning the physiology of digestion in dogs he wanted to measure the flow of saliva. For this he inserted a tube in the cheek of the dog and placed a bowl of meat in front of it and the dog began to salivate.

This, of course, is a natural response of any dog. He begins to salivate when he gets his food. But a strange thing happened. The dog began to salivate at the sight of the tools or the experimenter even before the food was placed in front of it. Pavlov could have treated this as an experimental nuisance but being a scientist he started asking questions.

Pavlov knew that salivation at the sight of food was a natural reflex action. It happens in every dog since birth, but the other reaction was something new, what we can call a learned reflex. Now he decided to investigate if the dog could be made to associate food with other stimuli.

In a typical experiment, a bell was sounded just before the meat was given to the dog. This was repeated many times. Pavlov noticed that the dog now began to salivate as soon as the bell was rung even if food was not given.

The animal associated the two stimuli, food and bell, therefore, one could be substituted for the other.

Even human beings learn things according to this easy model. If a person has done good to you several times, you may begin to associate goodness with the person. Sometimes, cheats use this technique to first gain your confidence by a few easy acts, and then when your trust has grown, they might run absent with your belonging!

You have to keep in mind that all these are based on common observations on children in Switzerland. Our country gives dissimilar kind of family life to children and hence our children may not exactly conform to these average situations. Again, individuals can be widely dissimilar because of biological factors—some children may be ahead of averages and some may be behind; If you have children approximately you, you may attempt to discover out for yourself some of these stages in their mental development.

On the other hand, the course of mental development from the youngest to the age of 12-15 years shows that there is limitation to what children can learn at dissimilar stages of their lives. This is information of great significance for educationists who design courses of study. If we do not pay any attention to this information and attempt to provide abstract concepts to a child who hasn't urbanized the mental skill to handle such concepts, it will have no option but to memories answers and provide a false impression in relation to the learning. Unluckily, this is very general in our lives and memorization or rote-learning has become more significant in the practice of our schools and colleges, then The learning procedure as a whole.

Creativity

The skill to come up with novel thoughts, is not entirely based on reasoning— because reasoning will lead every person to tread the similar path, and reach the similar conclusion. One has to go beyond reasoning to state a new thought , which then may be tested for its usefulness. Likewise an artists paint a new picture, not because of geometrical thoughts but because of an impulse to make something beautiful. Imagination is said to play a significant role in creativity. People who are able to fluently think of several, and even unusual alternatives in a given situation are said to possess fluency and flexibility of thoughts, which is conducive to creativity. It is this rather unusual skill, dissimilar from reasoning, analysis and synthesis, which are the source of major advances in our understanding of the world, and equally of great works of art which have been universally admired. Newton and Einstein are examples from science, Tagore and Tansen from the arts, and Marx and Gandhi from social science.

It has been establish that those who excel in generating uncommon thoughts are also not rigidly bound to several traditions and rules, they are more independent minded, free thinking and unconventional in their methods. Students who illustrate such qualities are not always the favorites of their teachers, and schools prove even a hurdle to their careers. Since creative people create a big contribution to advancement of society, we should be keen to develop education and schooling so as provide them a chance to illustrate their worth.

Many such tests were devised to discover a connection flanked by the intelligence and creativity of a person. The results showed that there was only a low correlationship flanked by IQ and creativity.

- If a person has a low IQ his creativity was low too.
- If creativity was high then IQ was above average.
- But high IQ did not necessarily mean high creativity.

- Within a group of subjects with above average intelligence, there was no connection flanked by creativity and IQ.

Adolescence

Approximately the age of 12, starts an era when special hormones are secreted in the body and transition from childhood to adulthood takes lay. This is recognized as adolescence, an era of very rapid physical growth, accompanied by a gradual development of reproductive organs and secondary sexual features such as beard for men and breasts for women. The age limits of adolescence roughly extend from approximately 12 to in relation to the 18 years when physical growth is almost complete.

Throughout adolescence, not only is physical growth rapid, but its sex-related character changes the social location of the individual. Cognitive development and knowledge base also reaches a point when a person is able to formulate his or her thoughts, fairly clearly, in relation to the several questions in life. People are able to develop a world outlook or an ideology of their own, and hence personality. At the end, they are no more boys or girls, but they are men and women, usually able to stand on their own. The five or six years of adolescence stage are very crucial for everyone, and since they usually correspond to classes 7th or 8th to 12th or first year of college, they are significant for teachers to stay in mind while dealing with their students. The transition can be clumsy and confusing, too aggressive or too timid for the young person, but it is also a wonderful experience to grow out of childhood and face the world as a confident member ready to change it.

Aspirations, Conflicts and Frustration

An individual has to adjust to new physical and mental circumstances. We often have to create decisions and choices in relation to the how to spend our time, money and power. Sometimes the choices are easy like whether to wear a blue dress or a green one. At other times conflicts may put us in a dilemma, such as, whether to go to the cinema or to study at house? In other spheres of life, such as marriage, religious beliefs, changing jobs, conflicts may be severe and persistent, which may lead to anxiety, or even frustration We often aspire to be something or attain some objective or location, but such aspirations or goal may be limited by many factors which may relate to the family, nature of job or lay of work, or other social and personal circumstances. A potential source of tension is a situation when there is a disagreement flanked by two goals. You may want to become an athlete, at the similar time you may want to attain the maximum marks in your class. For both these behaviors you necessity have a lot of time. You would have to create a decision. Failure to discover a solution or compromise flanked by conflicts can build up to serious psychological or mental disorders.

What happens when you are frustrated? You are upset and angry, which may lead to other kinds of behaviour that are irrational, unpleasant or abnormal. We shall seem into these reactions later. But a feeling of frustration is a signal that there is a problem to be solved. Usually, the problem is not clearly recognized, and the first thrash about is to identify it. One has to search-one's intentions and preferences, and look at where exactly do the impediments lie. It is through these types of experiences that our mental growth takes lay. For instance, a student who did not do well in the examination, fails. He is frustrated, but when he can identify what was it, that caused the failure, whether it was other interests that prevented study, or friends who proved to be a distraction, or if the teacher didn't explain well etc., he can attempt again in a customized situation. Unresolved frustrations can lead to a peculiar behaviour which is described “aggression, or aggressive behaviour.

Aggression

We often have difficulty in dealing with our anger and hostile feelings and this leads to aggression. We need to describe what we mean by that. Aggression is often described as the intention to injure another person either physically or verbally or to destroy property. Notice the word intention has been italicized. If you accidentally step on someone’s foot in the crowd and apologies immediately, the act would not be termed aggressive because you did not step on the foot intentionally.

Instinct or Learned

Having defined aggression let us attempt to analyze if it is a vital instinct or a learned behaviour. Some psychologists consider that aggression is a natural instinct and provide at least two types of arguments for it. Firstly, that it is so widespread. Our history is mainly a history of wars and we hear in relation to the violent acts that take lay daily in our society. Secondly, we know that aggressive behaviour in animals is observable at every stage, we can even breed animals selectively for their aggressiveness, for instance bull dogs, hounds and terriers are more aggressive than other dogs, say poodles. Such dogs are trained for hunting and as police dogs. In the older days, the kings and nawabs bred and trained rams, cocks, eagles etc., for fighting matches. The pedigree was maintained for their aggressiveness. On the other hand, another group of psychologists consider that aggression is a result of frustration and disagreement and is a learned response and it necessity discover an outlet. We will explain this later.

Biological Foundation of Aggression

Studies illustrate that mild electrical stimulation of a specific region of the hypothalamus produces aggressive behaviour in animals. When a cat’s hypothalamus was stimulated by implanting electrodes in the brain and passing an electric current, it's hair stood on end; it hissed and arched it's back and would strike at anything that was placed in its cage.

In higher mammals like monkeys this instinctive pattern is not observed. Their behaviour was seen to be more controlled by the cerebral cortex rather than mere stimulation of the hypothalamus. The hypothalamus may send a message to the cerebral cortex that its aggressive centers have been stimulated, the cortex then chooses the response considering what is going on in the environment, and what has been stored in the memory from past experiences.

We too have centers in the brain that can create us behave aggressively, but the activation is under cognitive manage. Some brain damaged persons may react to stimulation with aggressive behaviour, which would not elicit any response from normal persons. In such cases, it was establish that the cerebral cortex was the damaged region of the brain. In normal persons, we can say that aggressive behaviour is determined mainly by social powers and personal experiences.

Aggression as a Learned Response

A person who is frustrated by a blocked goal may or may not behave aggressively, depending on how he has learned to cope with stressful situations.

To elaborate this further, let us assume that you are preparing for an exam or reading something that requires concentration. Your neighbor plays his radio at full volume. You Would almost certainly first go and request him to lower the volume.

- You could get very angry and exchange some harsh words or,
- You might even beat him up,
- Another alternative would be that you let your temper cool off, or move absent to a quieter lay. This might enable you to take up the matter with your neighbor when both of you are in a reasonable mood.

Out of these three, the response chosen by you would be one that has been the mainly successful in the past in a similar situation. Unpleasant situations often lead to aggressive behaviour. In a study involving two groups, one group was made to work in a stuffy and hot room while the other was made to work in a cooler and pleasant room. A person was made to behave aggressively with each group. The reaction of the group working in uncomfortable circumstances was significantly more aggressive to this person than the group that was working under comfortable circumstances. Children, too, learn to respond aggressively by imitation of elders. In some studies, children who watched an adult behave aggressively learned to imitate him and thus behaved in a more aggressive fashion like, hitting each other or pushing one another approximately. While another groups of children who hadn't been exposed to such adult behaviour showed no augment in their aggressive attitude.

Aggressive behaviour is learned through observation and is often reinforced by its consequences. For instances, if an adolescent who is superior and has more muscle power than Other boys sees that he can get what he wants by threatening or beating smaller boys he will repeat this act as often as he can.

Sometimes we can’t take out our aggression directly on whoever is the cause of our frustrations. What happens then is a case of displaced aggression. For instance, a boy of 15 or 16 wants to go out with his friends for a weekend and his parents refuse to provide him permission. The boy may not be able to do much in relation to it but may, in anger, break a few things in the home or bang the door or go and quarrel with the neighbor.

Sometimes, this displaced aggression can lead to much more serious consequences than what we are suggesting in our instance. A group of striking students or workers may go on a rampage damaging public property, and may hurt even innocent bystanders, just because of frustration in their attempts to cause harm to the power concerned.

Human Factor Engineering

With the advances in science and technology, we have to constantly interact with machines and engineering systems. The range is wide, whether it is a worker in a factory, or a driver of motor vehicles or a farmer using farm implements like threshers and tractors or an individual using a sophisticated computer. In each case it is significant that the machines and manner of their operation should be suited to human abilities, if the maximum work output is to be realized. The study of the efficiency of a person in his working environment is described human factor engineering or ergonomics. The people who are trained in this branch of applied psychology are recognized as human factor specialists.

How was the importance of appropriate working environments and machine designs realized? Throughout World War II, 457 US Air Force accidents took lay in a 22 month era. An analysis of these accidents showed that pilots confused flanked by two manage levers, one related to landing and the other to wings. Often they didn't even know if they had enough petrol to complete their missions. Soon it was realized that selection and training alone would not produce efficient pilots. The equipment itself needed to be redesigned.

For the first time, design engineers started working in collaboration with psychologists to attempt and ensure that the machine systems will suit human necessities and abilities. The forms of the controls for landing gear and wings were so intended, that the variation flanked by them was obvious and chances of mistakes were eliminated. Likewise, the markings on the fuel gauge were changed to indicate fuel quantity as FULL; HALF FULL; EMPTY instead of in actual gallons. You necessity have noticed this in present day buses and motor cars etc. Thus, the essential job of human factor specialists is to see that machine systems are intended with the user in mind, so that they can be run with maximum efficiency and minimum error. For this purpose, they study the effects of work environment such as ventilation, noise and illumination. This leads to improvement in the design of the work lay, to create it more comfortable, safe, and conducive to performance. The duration of the shifts is also studied in relation to manufacture, to see how extensive a person can work with full concentration. The speed of the workers' reflexes and motor movements has also to be taken into consideration.

The result of human factor engineering may not always be obvious, especially if the effect is of convenience rather than safety. The telephone instrument is one machine that can be easily operated by men, women and children alike. So every change in design is preceded by elaborate tests and calculations.

Approximately all of us use the chair for varied lengths of time throughout the day. Some of us use it for more than 8 hrs a day. May be you are sitting on a chair while reading this unit! Jiro Koharo of Chiba University in Japan has studied how chairs affect our body. He establishes that if the seat of a chair is too high or too extensive it may disturb the circulation of blood in the thigh blood vessels. If the back of the chair does not support the spine properly, abdominal and back muscles get tired and cause discomfort. Soft cushions in chairs cause the maximum discomfort because they do not help the body balance, so muscles necessity work continuously to uphold the balance of the body.

We often do not realize it, but mainly of the things we use in our daily life have been intended keeping the human abilities and conveniences in mind. The slabs or shelves in the kitchen for instance, are of a scrupulous height so that the user is least tired while working.

Experiments with Man in Legroom

One is able to create astronomical observations from satellites; get meteorological information; obtain invaluable data on possessions of the earth and the condition of crops and forests. The human urge to know the strange and, if possible see what the circumstances on the moon or planets are like, has also been a great factor in legroom exploration. Human ingenuity and creative power have given us the opportunity to carry out much of this research and exploration with the help of instruments which can be controlled from the earth. For instance, samples of soil from the moon have been brought back to earth by automatic machines and rockets, without actual human attendance on the moon.

Nevertheless, there is nothing like a human eye observing the panorama of the moon, and describing the scenery—beyond what a camera can do through a picture. But, legroom travel for human beings is a very hard proposition, and in order to create it possible, lot of research has been done by sending up other biological organisms and animals, such as virus, bacteria, mice, dogs and even monkeys.

Human beings have to travel in the mainly unnatural circumstances—if there is a single astronaut, he has absolutely no company for as extensive as he travels, and mainly unfamiliar scenes—looking out of the window, he sees nothing except stars. This loneliness, and absence of sensations from outside has been established to be a source of great mental stress. Man is a social animal, and he has to receive sensations through his eyes, ears, nose and skin etc., to feel normal. Traveling in a satellite, one feels “weightless”—if you turn a glass upside down the liquid does not rail out! So, food also does not naturally move down the throat—even water is not easy to swallow. It appears our whole body—(digestive system, and even blood circulation) is accustomed to earth’s gravity, and if it is nullified, we cannot be at ease. Even movement of muscles is hard. The air inside the legroom vehicle is kept under artificial pressure, because outside the vehicle there is close to absolute vacuum and no sound of any type can reach the legroom craft. Of course, there are great troubles in washing, or taking a bath or in passing stools. Obviously any legroom traveler would feel out of sorts — but that is a mild word, he or she can feel absolutely confused, lethargic and psychologically unstable.

But practice is a great help. Modem astronauts go through an extensive era of training. If they know what to expect in legroom, they are mentally and physically prepared for it. Weightlessness is also simulated so that a legroom man or woman can be adjusted to its peculiarities. Communication is now much better, the travelers can receive television pictures and can create telephone calls. They are made to take exercise. It is now the practice to have a group of men, or men and women in legroom rather than single persons. That is how, in one Soviet legroom craft, people have spent more than a year at one stretch without adverse effects. The tasks of manage and communication are also numerous for the spacemen and hence a team is needed.

All this shows that our body and mind are attuned to live under normal circumstances of pressure, gravity, sensations and communication. Abnormal physical environment puts our system under great stress, which shows serious physical as well as psychological effects. But several of these aspects have come to light only because legroom had to be conquered and human beings had to get adjusted to new livelihood circumstances. If a colony is made on the moon or elsewhere, there will be other circumstances to be experienced, and hopefully man will prove equal to the task.

REVIEW QUESTIONS

- Discuss how application of scientific knowledge has made better agriculture possible under difficult conditions.
- Explain why there is a mismatch between man's scientific ability to produce and social incapacity to utilize.
- Discuss food requirements of individuals according to age, sex, activity, body weight and climate.
- Explain why pure drinking water, food, hygienic habits and environmental sanitation are necessary for the prevention of infectious diseases,
- Discuss the reasons for shortcomings of the health services in rural India adopt methods necessary to control the rapid spread of AIDS.
- Describe the structure and functions of a nerve cell.
- Describe the general organisation and major parts of the human nervous system and its working.
- Explain whether aggressive behaviour is instinctive or learned.
- Give reasons for developing the principles used in human factor engineering.

CHAPTER 7

Wonder of Science and Technology

STRUCTURE

- Learning objectives
- Information and communication
- Modes of communication
- Science and technology in industry
- Technology and economic development
- Modern developments in science and technology—I
- Modern developments in science and technology—II
- Perceptions and aspirations
- Science - the road to development
- Review questions

LEARNING OBJECTIVES

After studying this chapter, you should be able to:

- Describe the role of media in creating social, economic, and political awareness.
- Understand the historical perspective in which these media grew and their role and effectiveness in the Indian context.
- Discuss the status of science and technology in India.
- Give reasons for the need for developing our own technology.
- List properties that make light from a laser different from sunlight or light from ordinary sources, such as fluorescent tubes, bulbs etc.,
- State what a semiconductor is and describe briefly some semiconductor devices, such as p-n junction diodes, transistors, and integrated circuits.

INFORMATION AND COMMUNICATION

The All-Pervading Communication

It has been our effort to acquaint you with the interdependence of mind and body. To put it briefly, mind is where all types of information is processed, and on its foundation, all types of thoughts and thoughts are generated. It has centers which regulate the working of the body, and govern its movements. On the other hand, the body not only supplies the power needed for the mind to function, but also all the information which the mind uses. The five senses supply a great diversity of sensations: if a single hair on the human body is touched, a message goes to the brain—in information, the mind has to learn to ignore a lot of information which the several sensors continuously supply to it. Yet the ears and the eyes are, perhaps, the mainly significant connections which the body and the mind have with the external world. All that you read and all that you hear puts you in touch with other people's thoughts, thoughts, and minds—it also enables the mind to get to know our past, our culture, our hopes and aspirations, and our troubles. You have also seen that when man is deprived of these contacts with the external world, when he receives no signals from outside, when he can see nothing, hear nothing, smell and taste nothing, and when the hair on the skin also receive no information, man is ready to have a nervous breakdown. Truly, communicating with the outside world is as significant for human subsistence, as the supply of food, water, and air.

Of course, the mind is not a passive machine merely working on received information from the senses—even though eyes and ears provide access not only to sights and sounds, but also to written and spoken thoughts of great complexity. We have already discussed the power of the mind to continuously learn from all types of experience and to originate thoughts of its own. In other words, it receives diverse information, it generates mixtures of its own, some of which have a new flavor. In the course of years, each person's mind develops its own rules of processing information and drawing conclusions. One may refer to them as attitudes and values. Some may accept or consider all that they read or hear, others may critically check and look at before accepting any thoughts. Some may be “open minded” and flexible, others may be rigid or fanatic in holding their views. Some may evolve an outlook or an ideology of their own, others may remain pragmatic.

The information that it is natural for the mind to receive information, sensations and thoughts from outside— and that human behaviour, to a big extent, depends on this procedure, makes very motivating possibilities, when seen in the light of the great chain of educational institutions where an individual spends a number of years “acquiring knowledge”, or it is also true when seen in the context of millions of books and magazines which are published in all languages, or again when examined in relation to the “mass media”, i.e., television, radio, films, newspapers etc. Obviously, culture has created a tremendous communication network which converges on the mind of each individual. It is possible to “educate” a person so that he has access to broad and varied types of information, so that he learns not to be gullible but to question everything before accepting it, and so that his competence to deal with the family, fellow human beings, and the work he does is improved. It is equally possible to provide a one-sided picture of the world and to encourage blind faith, unquestioning obedience, even fanatics. It is possible to create people consider untruth basically because they may be exposed to nothing else. This happened in Germany before the Second World War, when their government’s propaganda machine spread the thought of Germans belonging to a superior race and Germany being invincible. It is possible, with the help of mass media, to make demands for sure types of goods and to sell the products advertised, even though people may not really need them. Lots of propaganda is done in favor of the policies pursued by governments through radio and TV, and sometimes through newspapers. Books for common reading, and even text books, contain lots of distortions deliberately introduced to confuse or divide people in the interests of ruling groups. People in America often consider that Indians are strange people clad in dhotis or turbans climbing poles or ropes, displaying snakes, believing in a lot of abracadabra. We in India have strange notions in relation to the Africans or white people, or our own tribal people. There are vicious possibilities of structure up passions and prejudices. Let us look at a few facets of this pervasive communication in which we are all immersed.

Functions of Communication

Broadly, the main role of communication in a social system is:

- Getting and conveying information which may be facts, messages or opinions; this may take lay in discourses, debates or discussions.
- Motivating a person getting the message, whether through an individual or through a medium of mass communication like radio, television, newspapers/journals, books, or films, towards a course of action. This can extend from adopting a way of family scheduling, changing one's food habits, to working for a social or political cause.
- Providing education and culture; from a class-room situation where knowledge and skills may be imparted, to dissemination of cultural heritage and values as well as farming of artistic interests.
- Entertaining, whether for personal or communal enjoyment through public music, drama, or sports.
- Influencing opinion to serve sure economic or political interests.

Role of Communication in Creating Awareness

We would talk about the role of communication in the economic development and political and social awakening in our country. But before we take that up, a few broad facts may be useful to recall.

Role of Communication in the Economic Development

India today is a country of almost 800 million people. This is as much as one-sixth of the world's population. In the year 1981,446 million Indians were illiterate, i.e., they could not read or write. The literacy percentage was in relation to the 36%. There are 15 major languages recognized in the

Constitution, but the number of subsidiary languages and dialects may be in thousands. Almost 75 per cent of the population lives in 5, 75,000 villages. A high percentage of the population is not able to get proper food, clean drinking water, adequate shelter, health care, and clothing.

These facts lead to two conclusions in relation to the role of communication in our country. First, all means of communication should be used for economic development, i.e., to augment manufacture and national income and to improve the livelihood average of the people, particularly those sections which are under-privileged. Second, since such a big number of persons are illiterate they will have to be reached by means other than that of the printed word.

It is for these reasons that India chose to develop its economy through a planned system. The Five Year Plans are, broadly, planned to accelerate development in industry, agriculture, etc., through use of the national possessions in a manner that the benefits go to people as a whole; and not only to further enrich those who are already affluent. That is why the role of communication, in this regard, was emphasized in the very First Five Year document in 1952. "Public Cooperation in National Development" it said, ''an understanding of the priorities, which govern the plan, will enable each person to relate his or her role to the superior purpose of the nation as a whole. The plan has, therefore, to be accepted into every house, in the language and symbols of the people, with the assistance of creative writers and artists, which have to be specially enlisted. All accessible ways of communication have to be urbanized and the people approached through the written and the spoken-word no less than through radio, film, song, and drama."

It is in this context, that All India Radio (AIR) and Doordarshan become the two mainly significant media of communication. They cut crossways the barriers of illiteracy and claim to cover big number of people. AIR broadcasts can reach almost 95 per cent of the people, and Doordarshan 70 per cent, of course, if the people have radio and television receivers. The Ministry of Information and Broadcasting has other media organisations, like the Films Division and the Directorate of Field Publicity, which are also trying to reach big sections of the people in remote and distant regions. The objective of the Ministry of Information and Broadcasting as defined, "is to inform, educate as well as entertain with a view to creating awareness in the middle of the people in relation to the nation's potential for development and its troubles, widening their horizon, and soliciting their participation in the implementation of the policies, plans and programmes of the Government for bringing in relation to the economic development and social change, achieving national security and promoting national integration,'

The State Governments have their own field units and extension services to promote state development programmes and schemes, and to motivate people to actively participate in them.

Here, we cannot evaluate the efforts either of the central media or the programmes of the state governments. The point is that the role of communication in economic development has been recognized in this country since Independence. It has also been realized that multi media combinations, i.e., utilizing not only broadcasting through radio and television but also video and tape cassettes, slides, films, books and inter-personal communication, are to be employed to help economic development

Political Role of Communication

Communication has a significant role in political and social awakening. Throughout our freedom thrash about, the leaders communicated with the people directly. They had no access to the India Radio because it was controlled by the British Government, which was, in information, trying to underplay and suppress the freedom thrash about. There was no TV. Newspaper reporting varied. Only a small number of dailies defied the government of the day. But through personal contacts and mass meetings, besides the use of national symbols like the tri-color, the charkha, and patriotic songs, our leaders were able to stir the conscience of our people all in excess of the sub-continent. Mass contacts and inter-personal communication were at their best. They proved as the mainly effective means of inspiring the people to participate in the freedom movement and to create supreme sacrifices.

After Independence we, in our Constitution, accepted the principle of adult franchise. Every adult has the right to vote in elections to local bodies, state legislatures and the Lok Sabh? Thus, every citizen participates in the election of people's representatives to these bodies which formulate programmes and policies. They enact laws. The governments, whether in the states or at the centre, have to get their programmes and enactments approved by the legislatures.

At the time of elections, each adult can decide whom to vote for. He or she can vote in favor of a party candidate or an independent. The parties and individual candidates launch election campaigns throughout which they explain their stand on the mainly significant public issues. They also create many promises. All this constitutes political communication and it enables the voter to create his choice.

The two related questions are:

- How much, and in what methods, does politics power communication?
- How much, and in what methods, can communication power politics?

We, in this country, enjoy freedom of speech and expression. The media of mass communication are partly the means of exercising this right. Of course, it has to be ensured that no law of the land is violated. Newspapers and journals are privately owned, i.e., they are not controlled by the Government. Even AIR and Doordarshan, which are controlled by the Central Government, are governed by a code, under which they have to be objective and non-partisan on political issues. Since 1977, the two media have been giving equal time of broadcast to each recognized political party throughout election campaigns. Even outside the campaign era, the government may use the two media for national purposes and not for party propaganda.

Thus, communication has a significant political role of informing and enlightening the people, in order that they participate in political procedures. In information, it would be correct to say, that democracy and communication, which means freedom of expression, discussion and debate, are totally interlinked. Without unfettered communication there could be no democracy.

Social Role of Communication

Social relevance of communication follows from the economic and political role of communication. We, in this country, have often talked in relation to the using media to bring in relation to the social change. What does social change mean? It is obviously hard to provide a precise definition. But a very common statement will suffice here. Our country has great disparity in incomes, a very small minority is affluent, but the vast majority is poor. Therefore, our policy is not merely industrialization or development of agriculture, but it is to extend the benefits to all strata of our people. Thus, development with social justice is our aim. This amounts to moving towards a new type of society. Our country is inhabited by people who profess dissimilar religions, speak dissimilar languages, and enjoy dissimilar types of culture. In the past, mainly of us were victims of deprivation under a colonial government which encouraged sections of our people to blame each other for their troubles. Now, it is our policy to develop all cultures, languages and societies, and to bring them closer to each other. This will consolidate or integrate our nation and allow us to concentrate on working for a better future. But this again means a vast social change—we say we want to move towards unity in diversity, and we wish our state to be secular where religion doesn't divide, and decisions of the state are rational rather than emotional and partisan. In a democracy, where the citizen is sovereign, we have to go forward on the foundation of persuading people to accept sure thoughts and programmes, and therefore, there is a crucial role for communication in bringing in relation to the a social change. Social role of communication is to build bridges of understanding in the middle of these groups whose objective interests are the similar. This, in information, is the crucial challenge before media in the country.

In the social context also, communication is expected to serve the immediate interests and needs of individual citizens. People have to be served with information in relation to the rights, which under the law of the land, they are expected to enjoy. There are many benefits to which people as citizens are entitled but, if they are not aware of these beneficial provisions, how do they create their claims? To illustrate this with an instance, not very extensive ago, the Indian Institute of Mass Communication mannered a study in selected rural region in the Khanna district of Punjab. This was to discover out whether the agricultural laborers knew that there was a minimum daily wage fixed for them. The investigators went to many villages in which the labour was occupied in harvesting of the crops. The laborers were mostly migrants from Uttar Pradesh and Rajasthan who come to Punjab year after year for employment throughout the season. To their utter surprise, investigators establish that hardly any one of the laborers knew that he or she could inquire for the minimum wage fixed by law. This information never reached them. Obviously there is a part which profits by the ignorance of the laborers. They were, in information, being paid much less than what they were entitled to. Laborers were mostly illiterate and had no means to get information from radio. Even when they had any access to radio listening, such information was not broadcast. This resulted in a clear case of social injustice and economic use. If this was the situation in Punjab, which is a wealthy state and where the communication system is reasonably satisfactory, one can only imagine the state of ignorance in backward and remote regions.

Even in urban centers, lack of information can deprive the citizens of social benefits. Sure sections of the society, women for instance, are often more ignorant of their social rights than others. The question calls for a study in both the urban and rural regions.

The role of communication in social and economic development in our country has, therefore, to be seen against the state of our economic development and social diversities and inequalities. The communication system has also to provide priority to political education in order to strengthen the institutions on which our democratic system is based. In all compliments, the media, whether under government manage or privately owned, have a national responsibility.

The Twenty Point Programme and Communication

It may be useful to have a seem at the Twenty Point Programme (1986), which the Government of India has placed before the people as an agenda of national priorities. The points are briefly listed in the margin. Communication is a significant element in the implementation of the Twenty Point Programme. People have to be informed and they have to be motivated for the success of the programme.

Role of Communication in Promoting Education

Transmission of knowledge and information, which is the first step in education, is obviously possible only through communication. This happens in a classroom situation, in a factory, a workshop or even in a group-discussion. It is through the procedure of communication, that the knowledge is transferred from one person to another or to a group. The training in skills and the technique of doing a job go through the similar procedure. The availability of media, radio, TV, films, slides, charts, or other illustrations, has complemented books and teachers in the task of transmitting knowledge as well as skills. A vastly superior number of persons can now be benefited through the use of mass media. The media like TV, films and video, which have hearing and seeing components, can make impact as well as understanding, which is sometimes not possible in a class-room situation. The mere information of providing illustrations through moving pictures on a TV set or video screen provides to such media great potential.

Media and Educational Environment

Some recent technological developments in media have opened up new horizons. Besides, rising use of media, to support and expand education, has created what may be described an “educational environment”. In this new environment, both young and old may learn all the time. In a wider sense, new opportunities of intellectual development have been created. Media have also extended the benefit of knowledge to deprived men, women, and children. These sections may not be enrolled for formal education in class-rooms but may have access to radio and TV, perhaps at society centers. Thus, communication through media has created a climate in which a new human personality, with a much broader vision, is developing. The easy cause is that the source of information and education are so expanding as to give knowledge on a big diversity of topics and to big numbers.

Media and Aloofness Education

The role of media in aloofness education needs a specific mention. It is implied that teaching is done from aloofness. It is also understood that education is imparted through correspondence, audio-visual aids, like radio, television, and telephone, besides personal contacts. As against a university, which enrolls students of a similar age, has definite time schedule, and is confined to a geographical region or campus, an 'open university' can cater to all types of students—of several ages, livelihood in dissimilar and even distant spaces, who wish to combine education with employment or work at house. It can give a great diversity of courses. Even the pace of learning would be dissimilar for students enrolled in the similar course. The Indira Gandhi National Open University is envisaged as an institution for the whole country. One of the principal objectives of this University is to give education to those who have been denied opportunity for higher education, either because they live in remote and rural regions or because of any other handicap, including financial constraints and family obligations. The 'study centers' with audio-visual and library facilities are a significant part of the University. Here, students can meet their academic counselor and talk about their difficulties. Support from radio and television is also significant in aloofness learning.

Broadcast of Lessons by AIR and Doordarshan

The electronic media, AIR and Doordarshan have played a supplementary role to education at dissimilar stages by supporting classroom teaching. They have experimented with the broadcast of lessons, which are syllabus-based, particularly in school education. Doordarshan also organized, what may be described, "enrichment" programmes, primarily for college students, with a view to supplement classroom teaching and thus, widen horizons of learning. Such broadcasts are not directly related to classroom lessons but their contribution is not small. Separately from college students, the common public can also benefit from such broadcasts. This has been a very useful experiment in higher education, sponsored by the University Grants Commission. Since TV programmes from a single station cannot be received all in excess of the country, the help of a satellite, with special equipment, is taken to carry them to all parts of the country.

All India Radio broadcasts educational programmes from 74 stations. In all, in relation to the 8 per cent of the total time devoted to 'spoken-word' programmes is taken by educational broadcasts. The TV medium is quite obviously more effective than radio, in education, at all stages. The communicator, in this case the teacher, can be seen by the students even though they are not able to inquire questions. But the TV lesson, if prepared with the understanding of the medium, should expect and answer the questions. More than that, visual presentation of experiments, photographs, and models is a potential accessible only to television. Thus, TV is a very effective medium for education.

Doordarshan started with syllabus-based lessons for school children in Delhi, in 1961. The initial aim was to improve average of teaching, particularly in science subjects, because at that time, even in Delhi, not all schools had laboratory legroom, equipment or qualified teachers. Since then, educational programmes, whether for children or for adults or for other groups like farmers, have become regular TV characteristics. It has been noted that AIR or TV programmes give not only direct learning and broad awareness, but they also make a desire to know more and tend to improve the atmosphere in the classrooms. Thus, they play a doubly significant educational role.

Education and the Media in Future Plans

Underlying the need for media support to education, whether related to curriculum or to enrichment, the National Policy on Education and the related Programme of Action approved by Parliament in 1986, call for maximum utilization of radio, television and video. In the middle of the recommendations made are:

- Give maximum Educational Television and Radio programme coverage for reaching out to school children, illiterate adults, women, scheduled castes, tribal regions etc., in all major language zones,
- Set up radio stations in selected universities and colleges,
- Give a separate channel on television for educational needs of several groups,
- Make a dedicated satellite system for educational needs in the extensive-term,
- Give, radio receivers and TV sets in all primary/elementary schools, and • Set up a National Centre of Educational Information.

Role of Communication in Cultural Understanding

In the region of cultural promotion, communication media can be used to meet the two fundamental needs. Firstly, the media like radio; cinema can give information, spread awareness, and make motivation to appreciate the features of our varied culture. These features may be of artistic shapes like music, dance, and literature or of knowledge of history and mythology pertaining to dissimilar regions and peoples of our country. Even traditions as well as taboos have fascination of their own in appreciation of cultural heritage. Secondly, separately from creating knowledge in relation to the culture, the media can be used in the preservation of the heritage. Cultural identity, i.e., pride in one’s cultural heritage, is today a significant factor for keeping the people jointly. This can happen even in a small society like a tribe which has general attitudes, customs, or ceremonies, or at the national stage through bonds of history and sharing of values. In information, a sense of belonging and of national integration can be created through the use of media. The media can be used to foster and to deepen loyalty to the nation. Preservation of culture is, therefore, a significant national task.

Media, Religion, Language, and Culture

Ours is a multi-lingual and a multi-religious society. To a big extent, the states within the Indian union are organized on the foundation of a general language. The several cultural diversities that we have need to be related to this background. Each region or language claims to have its own cultural features. Some of these features are quite separate, i.e., they have characteristics which are not shared by other regions. Several of our literary traditions and festivals belong to this category. There may be an undercurrent linking the several festivals throughout India but in several methods, they are only local or social.

Many of our cultural expressions also emerge from religious beliefs. Although religions are dissimilar yet in centuries of livelihood jointly in a general environment, even these cultural expressions have been influenced by each other. At philosophical stage, each religion stands for humanism, tolerance, justice and other civilized values. Thus, in spite of the information that religious societies here and there adopt a course of disagreement and confrontation, religious diversities and religious regard for each other is a part of our composite culture and custom. Therefore, the media, with their power of carrying messages distant and wide, and also straight to the heart, have a unique role to play in India’s unity and progress.

Media and Scientific Outlook in Culture

Under Gandhiji’s leadership, people belonging to all faiths and coming from dissimilar parts of the country, participated in the freedom movement. Gandhiji himself was a deeply religious man but he also symbolized tolerance and faith in one nation. In information, he was a symbol of our composite culture. Jawaharlal Nehru had a vision of modem India. In his vision, the people of India with all their cultural, social, and religious diversities had to develop a scientific outlook in their personal lives as well as in the affairs of the state. Communication media have an significant contribution to create in creating knowledge of each other’s beliefs, in emphasizing the general bonds of history and in developing an objective—not a prejudiced; a rational,—not an obscurantist and an open minded,—not a rigid or fanatical attitude of mind.

Media and Common Cultural Awareness

How do the media help expand knowledge of the several local and social groups in the country or bring in relation to the synthesis? Even today, in many regions, people come to know of each other only through the media. The valley of Kashmir, for instance, is bounded by 40 mountains. The valley is connected with the rest of the country through air or through road transport; there is, as yet, no rail link. Besides the geographical separation and the lack of rail link, there are climatic reasons, why people of Kashmir do not very regularly travel outside the valley. It is not surprising, that their knowledge of other regions in the country has been inadequate and vice versa. Since early 70s, though, the introduction of television in the valley has made a tremendous variation. Kashmiris are now able to have glimpses of all parts of the country and an understanding of the cultural mosaic of the whole people. It is, therefore, not hard to imagine that Doordarshan programmes would have helped make, in the middle of the people of Kashmir valley, a vision of India as a whole. What is true of the people of Kashmir valley is also true of people livelihood in several parts of the country, which live as in accessible societies in distant locations.

Development of Composite Culture

The All India Radio, Doordarshan, as well as films have the capability of speeding up the procedure of national awareness. National programmes of music, dance and of drama on the broadcast media, i.e., radio and television support the concept of composite culture and of exchange of literary and artistic shapes flanked by one region and another. The power of media, in the development of a composite culture, may have been subtle, but it is a significant factor.

MODES OF COMMUNICATION

Mass Communication

The well-recognized exponent of the role of mass media in development, Dr. Wilbur Schramm, who headed a team of experts to advise the development of infrastructure of information in India and the establishment of the Indian Institute of Mass Communication had a meeting with our first Prime Minister, Mr. Jawaharlal Nehru, in 1962. Later, Schramm described the meeting in these words: "This was on an afternoon when Mr. Nehru was relaxed, happy. He asked me, by the method what is this mass communication? I do not think I understand it very well' and I said 'But Mr. Prime Minister, you are the chief mass communicator of India'. I mentioned the crowds of hundreds of thousands, books, and broadcasting. He threw back his head and laughed, 'Oh that' and said, 7 guess I do know something in relation to it'. Nehru poked fun at the electronic system, the loud-speakers that would not work or go out of order before half of his extensive speeches were in excess of. Then he said something that I never forgot. He said, "This will help us to talk jointly"

Wilbur Schramm, later, underlined the words—'this will help us to talk jointly'. The words are significant, because they bring out the meaning of inter-personal communication in Indian society and indicate the emergence of mass communication, i.e., communicating with a big number of people. As you perhaps know, mass communication in India began without the use of electronic media, like radio and television. The beginning can be traced back to communication within a social group. For instance, a village panchayat has been and continues to be a centre. Likewise, religious gatherings, whether at a lay of worship or when organized on special occasions have, from time immemorial, functioned as centers of communication. Then, there are any number of fairs and melas where people in big numbers gather jointly to communicate on a diversity of subjects.

A Historical Perspective

It necessity be said here, that Gandhiji was the greatest communicator the country has produced. Those of us, who were there to attend some of his prayer meetings, will recall the power his addresses at these meetings exercised on the minds of the people. He was not an impressive public speaker, in the conventional sense. He did not indulge in rhetoric's, but used popular language. His language and idiom were the similar, as of the ordinary people of India. He shared his thinking with his audience; he did not appear to impose his thoughts. He spoke with conviction and with genuine concern for the welfare of all human beings. Sincerity and simplicity characterised his communication with the people. Gandhiji's message reached the length and breadth of the country. It may be recalled that throughout his Satyagraha, Gandhiji was able to involve ordinary men and women from all walks of life. Take the 'Salt Satyagraha' in 1930. Salt is consumed in every house. When Gandhiji decided to launch a Satyagraha against the tax on salt and to create salt from sea-water, it was a unique strategy in communication, of which there are few parallels in the world. The peoples' boycott of the British goods brought into sharp focus the economic and political aspirations of the people and strengthened their resolve to fight against the foreign rule.

Media of Mass Communication Today

Today, while the inter-personal communication continues to play a significant role in our country, we have an urbanized media system. In the media of mass communication, we have All India Radio, Doordarshan, newspapers and journals and films in several languages. A brief reference to the role of each medium may be in order.

All India Radio

All India Radio has had a history of almost 60 years. Today with 91 broadcasting stations and 167 transmitters, AIR broadcasts can reach almost 95 per cent of India's population. What is described the transistor revolution in early 60's, was mainly responsible for expanding the effectiveness of radio broadcasting, because it made receivers cheaper and really portable. The daily programme output from all the transmitters is more than 15.00 hours day, in all national languages and in several dialects. Programmes for women and the rural listeners are accepted by more than 60 stations. A big number of stations broadcast special programmes for youth, children, and other special groups. Since there is no licensing of radio sets now, an exact figure of the number of radio sets in the country is hard to provide, Perhaps the total number of radio sets in the country is approximately 50 million. It has been claimed on behalf of All India Radio, that the number of people listening to radio programmes is in excess of 200 million. The radio sets are comparatively inexpensive and for their operation they do not have to depend upon the availability of household power supply, several of them work on arid cells. All these factors create All India Radio as the mainly extensive medium of mass communication in the country.

Doordarshan

Doordarshan began only in 1959, as a small experimental set-up. It used to have only two programmes in a week for one hour every day. Till 1972, the only TV centre in the century was in New Delhi, with coverage of in relation to the 60 km. radius approximately the station. TV centers in Bombay, Srinagar, and Amritsar came in 1973 and 1974. But the year 1975 turned out to be a land spot in the development of TV in India. Centers were set-up in Calcutta, Madras and Lucknow. More importantly, throughout this year, the satellite mode of transmission of TV programmes was first used in India. The thought was to transmit a TV programme to a satellite which appeared stationary to an observer on the earth; it went round the earth in the similar era of 24 hours as the earth took to turn on its axis. The satellite received these programmes and transmitted them back to the earth so that big regions could receive them. Since the programmes were educational in content the whole arrangement was described the Satellite Instructional Television Experiment (LOCATION). The programmes could be received by special sets installed in six states in the country with almost 400 sets in each state. The states were: Andhra Pradesh, Bihar, Karnataka, Orissa, Gujarat and Rajasthan. A motivating characteristic was that the Indian Legroom Research Organisation (ISRO) was made responsible for the transmitters as well as for the setting up and maintenance of the sets.

The after that milestone in the expansion of TV was the coverage of the Asian Games in November 1982. In order to give opportunities to people in many parts of the country to view the games, 20 low power transmitters were installed. Again a satellite was used to enhance the coverage. In the similar year, Doordarshan started color transmission for the first time. India's own multi-purpose satellite, INSAT-1B, was launched in August 1983. At the time of launching of the satellite, the then Prime Minister, late Mrs. Indira Gandhi said: "We are launching our satellite and developing our television network to take advantage of TV to entertain and enlarge awareness. Radio and Television, particularly in a national network are both ideal media to reinforce national integration. At the similar time, they have immense potential to put new life into local art shapes. Communication poses a major challenge and opportunity to us. We need people of imagination to take this up" This, in a method, sums up the role assigned to the TV medium, to inform, educate and entertain, besides creating national awareness.

The availability of INSAT-1B and the use of low-power transmitters and direct broadcast receivers in some spaces determined the future TV expansion. In July 1983, the Government of India sanctioned a gigantic scheme for the expansion of the network involving 680 million rupees. Before the scheme was launched, there were only 45 TV transmitters, potentially covering 28 per cent of the population. The expansion plan raised the number to 180, and a potential coverage to above 70 per cent. By the end of the seventh Five Year Plan (1990) the number of transmitters and coverage will be further enhanced.

Films

Films are a significant medium for communication. We produce in excess of 800 films every year and are, almost certainly, the main producers of films in the world. The Films Division of the Government of India produces news reels, news magazines, and documentary films, while commercial films are produced in the private sector. Commercial films claim to have social themes, but, in information, mainly of them are entertainment, and that too of not a very high average. Themes dealing with violence and sex in pictorial presentation may draw the audiences for the moment but do not bring in relation to the "a social change" or awareness. This may be a controversial statement and you can have your own views on this subject. Though, there is yet another constraint in the effectiveness of films as a medium of mass communication and that is the limited number of cinema homes in the country. The number is estimated to be only 12,000. For a population of 800 million this is, indeed, Very small.

Newspapers and Journals

Newspapers and journals have a significant role in our communication system. The number of newspapers and periodicals in several languages was in relation to the 22 thousand in 1984 and their total circulation was in relation to the 6 million. Though, there are two points to be measured in assessing the effectiveness of newspapers in communication. First, only the literate population can take advantage of the newspapers, even though in sure situations, the literate persons also share information with others. And, secondly, the reach of newspapers in distant and remote regions is restrained by troubles of transportation etc. Circulation of newspapers is still mainly confined to metropolitan cities and other urban centers. Though, the credibility of the printed word in our society is very strong. People are more gullible than discerning in this respect. Also, the newspapers and journals are mostly free from government manage and claim better acceptance by the people. This statement, can be challenged because a number of newspapers indulge in sensational news and views which may draw the readers, but may not help them to understand news and views in a superior perspective. The essence of the matter is that whether it is radio listening or TV viewing or newspaper reading, the receiver of the message that is people in this case, has to have a critical judgment of its own.

Effective Media in the Indian Context

What then is the mainly effective and appropriate system of information and communication in India? Perhaps an easy answer is that each medium should expand evenly to reach even more vast audiences, and besides providing entertainment, should have social relevance.

The view is significant, because in the present spread of media, there are imbalances and inequalities. Sure regions are served better than the others. States like Bihar and Orissa, which are economically backward, are also inadequately served by the media. There is a noticeable difference flanked by the urban and the rural population. The media of mass communication are centered primarily in the urban regions. The number of radio and TV sets, newspapers and the films, all has a high concentration in cities. The rural population, i.e., 70 per cent of the population of India, has much less share in all these media. This is also the cause for an urban bias in the approach and content. A much higher percentage of programmes, writings and themes concern the urban population.

If we go by our experience, the ideal system of communication may be a combination flanked by the media of mass communication and what has been referred to as inter-personal communication. Let us cite an instance. AIR had launched a UNESCO sponsored experiment of Radio Rural Forum in the State of Maharashtra in 1956. Under this experiment, groups were organized in a number of villages. The groups or forums, as they were described, brought jointly some enterprising farmers to listen to the radio programmes especially intended for them by AIR, Pune. The participants discussed the contents and interacted in the middle of themselves. They sent their reactions to the broadcasting station. According to a study statement, the mainly important aspect of the experiment was “the stirrings it aroused in the minds of the people and the ring of sincerity and the note of inquiry it lent to their voice”. Organized group discussions, on an equal footing for all participants, were an entirely novel experience for these villagers. It was only after first two or three meetings, that the age-old convention was broken off, allowing only the elders and the so-described respectable persons to participate in discussions.

The stimulating atmosphere of group listening enabled the participants to assert their rights. The hundreds of decisions taken, the wells dug, the pure-bred bulls and Leghorns bought, the marketing societies and balwadis recognized, all bear witness to the effective role of the* radio society forum.

The radio programmes were supported by discussions, as well as printed and visual materials on the similar theme. The experiment was a great success. The conclusion, that a modem medium, supported by inter-personal communication and other aids like posters, slides etc., can be mainly effective, clearly stands out.

Technological Advances in Mass Communication

Technology has contributed to major advances in mass communication.

State of Communication in the Past

Those of us who have experience of life in remote villages, distant absent from urban centers, are well-known with such characteristics as poor roads which often become impassable throughout the rainy season, unreliable and irregular postal services, non-subsistence of telephone facilities and a very small number of individuals who can read and write. What could perhaps be the communication links for such a village with the outside world? The answer would perhaps be the radio and visits of extension workers. The radio is also not accessible in every household. In such a situation, it is not surprising, if the people turn inwards and become apathetic or even fatalistic in relation to the economic and social life. Clearly, for a developing country like ours, this is not a very happy situation. Does this situation exist even now?

The scenario is undergoing change. Mainly of our villages have their own institutions like Panchayats and schools which sometimes function as society centers. A number of them may have the facility Of a telephone connection and if they are electrified, they may have a TV set at the society centre or even in a few households. Even so, the traditional shapes of communication like folk music or folk drama, and communication from person to person still control the communication system. These traditional media can also be utilized for economic development and social awakening.

Communication Revolution

It is in this background, that communication revolution is being ushered in our country. In the recent years, the rural people who have access to TV viewing might have seen on the TV screen, Doordarshan's coverage of landing of man on the Moon. They are all too well-known with the Doordarshan's simultaneous transmission of national events like the Independence Day and Republic Day celebrations, i.e., they are watching the programme, at the similar time, as the events are taking lay in the national capital. But the viewers are scarcely aware of the transmission mode through satellite which creates such a thing possible.

Satellite

Satellite transmission is one significant symbol of revolution in communication technology. Besides transmitting picture and sound in excess of extensive distances, it has revolutionized telecommunication, telephone, telegraph etc. Already, from a number of cities in India, we can create extensive aloofness telephone calls not only to other cities within the country but also to many cities in other countries through direct dialing, i.e., without the help of a telephone operator. In information, for remote spaces like Leh, Port-Blair and Aizwal multi-purpose satellites for expanding the communication network in the whole country. INSAT-1A was launched in

1982, but it urbanized technological snags. INSAT-1B was then launched in 1983, and INSAT-1C in 1988. These satellites have been providing widespread coverage to the media, in addition to several other services like in the meadows of meteorology, resource surveys, telecommunication, and research etc.

Social and Economic Impact of Contemporary Communication Technology

Quite obviously a society which will utilize advanced communication technology in the methods would develop an entirely dissimilar social and economic system. It would be a transformed society with an entirely dissimilar life approach. Besides the impact on industry, management, public institutions and social services, even family life would undergo change. Using new technology, newspapers are already being published simultaneously from several municipalities, railway and airline bookings are being made by computers that carry booking information updated every moment, doctors in one country can treat patients in another, conferences can be held with people sitting in their own offices; these are wonderful developments. We have mentioned, how communication and remote manage of devices have made it possible to land a craft on the moon and to fly it back with an example of moon soil, entirely automatically. Whole factories are being run automatically, by robots in the advanced countries. All this communication revolution is there, but the main question, though, is whether the advance communication technology will, in information, benefit all countries equally and all sections of our people equally. There is already cause to consider that the advanced countries not only have a monopoly of technology of communication, but also the power to distort and display information in the method they like. Moreover in any one country, those who already have greater access to information are likely to benefit more than the others—almost certainly creation the rich-poor divide sharper. An easy instance is advertising on TV or other media, which can make a demand for things we do not need, or promote a culture of superficial westernization. Of course, it allows the better firms to beat smaller ones which cannot spend equally on advertisement.

The impact of information technology on our traditional communication system has also to be measured. In other words, what impact will the new communication technology have on our traditions and culture? In our country, traditional shapes of communication have been used for such purposes as dispelling superstition, outmoded perceptions and unscientific attitudes. These have been establishing effective and acceptable to the people because people are well-known with them. Practitioners of the traditional media use a subtle form of persuasion by presenting the message in artistic and yet all too well-known shapes. Examples abound where song, drama, dance groups and the like are used to campaign against social evils or for advance in farming, health, nutrition and family welfare.

The task before our communication system is to use the traditional media whether they are local folklores, ballads and story telling or even such proverbs which have their origin in our mythology. Jatra in West Bengal, Burrakatha in Andhra Pradesh, and Villuppatu in Tamil Nadu, Tamasha in Maharashtra or Alha and Qawwali in Utter Pradesh, all have the capability of being used for eradicating social evils and for encouraging peoples' participation in development programmes. Some of these shapes were effectively used in our freedom thrash about to awaken national consciousness.

We have to look at the implications of the effect of sophisticated communication technology on these shapes which, besides their effectiveness, are an integral part of our cultural and social life.

New World Information and Communication Order

It is quite obvious that information plays a significant role in international dealings. As a means of communication flanked by the peoples of dissimilar countries, information can be an instrument of understanding and sharing of knowledge. It can bring in relation to the amity through appreciation of troubles of the people livelihood in dissimilar societies. To perform this role, information dissemination should be multi-directional, multi-dimensional, and equitable. In other words, information through mass media like radio, television, newspapers, journals, books and films should have a free and balanced flow approximately the world, flanked by countries and flanked by one region and another.

But, if only a few international firms or transnational organisations are in manage of collecting and disseminating information, or a few powerful radio and television networks in the world manage flow and choice of information, the flow of information can neither be balanced nor equitable. It will then tend to serve the interests of those who manage the channels;

The Old Order

Let us seem at the present location. Approximately 80 per cent of the world news-flow emanates from the major transnational news agencies like the Reuters, Associated Press, United Press International and Agence-France-Press. These agencies which are based in UK, USA and France devote no more than 20 per cent of news coverage to the developing countries where two-thirds of the people of the world live. By American, British or French eyes! The imbalance in other information possessions is equally flagrant. In the sharing of the radio frequency spectrum flanked by the few urbanized countries and the several developing ones, the situation has been equally disturbing. The urbanized countries manage almost 90 per cent of the radio spectrum. The countries which arrived late in utilizing radio thus discover that the ground is already occupied by those who arrived early! In television software, the western power is reflected in yet another method. A number of developing countries still do not have the capability to produce television programmes of their own, and they are obliged to broadcast a big number of western programmes which are culturally discordant. In book publishing too, the picture is similar. Even in a country which has great material and intellectual possessions, mainly of the books and journals which are used in universities are in English and naturally symbolize a scrupulous manner of understanding and interpreting reality. If you think merely changing in excess of to Indian languages will help, you should think again. What really needs to be done is top class thinking and research on our troubles, our society and environment. Only then appropriate books can be written in our own languages.

How the Concept of the New Order Urbanized?

This realization of western media power, and a rising sensitivity to the method the Third World countries are projected in the western media, has jointly shaped the foundation of a call for a New World Information and Communication Order (NWICO).

The call for the ‘New Order' gathered momentum throughout the 1970’s even though its beginning can be traced back to the origin of what may be described the “Third Worldism”. The dissolution of the old colonial empires after World War II, was also the beginning of a new awareness in the Third World countries. The Bandung Conference in 1956 was the first forum at which information and cultural imperialism practiced by a few western big powers was questioned by several participating countries. At this conference, it was surmised that the western media, which were powerful and pervasive, were highly biased against the interests and needs of the people livelihood in the developing countries-whether independent or still struggling against the colonial rule. It was strongly felt that the reporting in the western media was negative and unsympathetic to the aspirations of all these people. There was resentment against the western media which were and continue to be privately-owned. These media were used both to support the commercial interests of the media organisations and the global political and economic interests of the big powers.

In 1973, the Non-aligned Summit Conference at Algiers, for the first time, described for co- operation in the reorganization of communication systems with a view to establishing direct and fast communication flanked by the non-aligned countries. The Summit suggested mutual exchange and dissemination of information through national and local channels which would remove or at least reduce the reliance on the transnational agencies. This was rather a mild expression of an otherwise deeply felt resentment against the power of the western media. Therefore, at that time, the western powers and media controllers chose to ignore it.

In excess of the years, though, this stand of the non-aligned countries was further amplified. A more specific concept of cooperation was urbanized and the non-aligned countries decided to set up an institution for exchanging of news in the middle of them. In 1976, the first ever conference of the information ministers and representatives of news agencies of the non- aligned countries, was held in New Delhi. The Conference expressed its determination to rectify the imbalance and concretize arrangements for effective cooperation in all meadows of information, mass media, social and cultural information. Also, for the first time, a linkage flanked by political and economic dependence on the one hand and the information monopoly on the other, was sought to be recognized. The demand for a new International Information Order, through communal endeavors, to safeguard their political and economic independence was thus set forth. The Colombo Summit, that followed, ratified the recommendation of the New Delhi Conference. The Summit also gave a call to all nonaligned and developing countries to co-ordinate their behaviors in this regard in the United Nations and other international forums.

UNESCO's involvement in formulation of the New World Information and Communication Order needs to be viewed against this background. The Common Conference of UNESCO, at its nineteenth session held in Nairobi in 1976, instructed the Director-Common "to undertake review of all the troubles of communication in the modern society, seen against the background of technological progress and recent developments in international dealings, with due regard to their complexity and magnitude". In 1977, the Director-Common,

Mr. Amad-Mahtar M'Bow set up a "brain trust", the International Commission for the Study of Communication Troubles under the presidency of Mr. Sean MacBride. The MacBride statement, as it came to be described, was sent to UNESCO Director-Common in 1980, although its Interim Statement had been submitted in 1978 to the twentieth session of UNESCO's Common Conference. The Interim Statement itself generated some controversy, but what brought UNESCO into focus was the Mass Media Declaration of 1978 — "On Fundamental Principles concerning the contribution of the Mass Media to Strengthen Peace and International Understanding. The Promotion of Human Rights and to Counter Racialism, Apartheid and Incitement to War".

Article VI of this Declaration says: "For the establishment of a new equilibrium and greater reciprocity in the flow of information, which will be conducive to the institution of a just and lasting peace and to the economic and political independence of the developing countries, it is necessary to correct the inequalities in the flow of information to and from developing countries and flanked by those countries. To this end, it is essential that their mass media should have circumstances and possessions enabling them to gain strength and expand, and to cooperate both in the middle of themselves and with the mass media in urbanized countries."

Some of the Western countries expressed strong reservation in relation to the resolution which recommended a direct involvement of UNESCO in international communication. Though, the 1980 Common Conference of UNESCO held in Belgrade approved the Final Statement of the MacBride Commission. The Resolution on the New World Information and Communication Order, which was accepted after hard and protracted discussion sheltered a wide range of issues, such as:

- Elimination of the imbalances in information flow,
- Elimination of negative effects of monopolies,
- Removal of internal and external obstacles to free and wider flow of information,
- Freedom and responsibilities of journalists,
- Improving the capability of developing countries to improve their own infrastructures.

Besides, mention was made on protecting the cultural and social diversities and identities of world public. The point to be underlined is, that while the Resolution described for freedom for all professionals in the media, it reiterated that freedom is inseparable from responsibility.

Controversies Approximately the NWICO

The definition of the New World Information and Communication Order given above has been objected to by some of the Western countries. In the United States particularly, there has been a strong reaction against it. Their interpretation is that the Resolution imposes restrictions on the behaviors of journalists, that it hampers the "free flow" of information as it has come to be recognized and that it legitimizes manage of government on information. Hardliners have described it as "interfering with the fundamental right to be freely informed".

This interpretation, quite obviously, is not correct. The view of the Third World and Socialist countries is that the NWICO only challenges the monopoly enjoyed by the western media, and the projection of their political views, for instance, on peace or cold war; biases, sometimes racist biases and propaganda, plus painting a negative and prejudiced picture of happenings such as floods, famines, political and social troubles in the developing countries, without any regard to either the achievements or sensitivities of the people in ' these countries. On this point one may quote from Mrs. Indira Gandhi's address at the Namedia Conference (1983). She said, "In the media of the West, or indeed in our own, there is hardly any news in relation to the developing countries unless it is of disaster or disturbance. The stupendous task of development, the changes coming in relation to the in our villages, cities, amongst our women, might as well be non-existent. Editors and media managers appear attached to the Northcliffe formula that power, location, money and sex create the news and that virtue, normality, handwork and humility don't. The meek may one day inherit the earth, but not the headlines".

The controversy in relation to the NWICO became so sharp, that the US Government cited this as one of the three reasons for their decision to quit UNESCO in 1984. They held UNESCO responsible for pushing through the NWICO. Great Britain also withdrew from UNESCO, a year later, for the similar reasons. The withdrawal by USA and UK has resulted in a combined loss of in excess of 30 per cent of UNESCO's budget. But all this shows what a powerful instrument or weapon information is for progress and social change.

Progress in the implementation of NWICO has, indeed, been slow. UNESCO's capability to give help has been considerably reduced. Some of the other western countries continue to oppose it. On the other hand, there is some progress in improving channels of communication and mutual cooperation in the middle of the developing countries and there is realization on the part of the western media, of the strong resentment in the third world against their approach of reporting. This has brought in relation to the slight change in their attitude.

Relevance of NWICO in Our National Context

If removing world imbalance in information flow is the primary objective of the New Order, we need to look at and improve the situation within our own country also. The circumstances prevailing in India are in some methods typical and in varying degrees they are also shared by other developing countries. Almost 75 per cent of our population lives in villages where the literacy rate is much lower than the national average of 38 per cent, and yet the media Concentration is in the urban regions. The number of radio receivers may now be approximately 50 million, but three-fourth of the total number is situated in urban regions. Sharing of TV sets would be even more imbalanced. Besides, a high percentage of Radio and TV programmes are meant for the urban population and taste. The similar story is repeated in the circulation of newspapers and the availability of cinema homes for public exhibition. Newspapers and films also mainly cater to the urban population.

To remove these imbalances and to create the media accessible to the whole population on an equitable foundation, a new communication policy needs to be evolved. As a part of the policy, the media should cater to the needs of all sections particularly the sections which are underprivileged, Information relevant for them and useful for them ought to be made accessible in educative as well as entertaining programmes, with a high artistic sense. Removing ignorance, superstition and prejudice of all types ought to be a task of high priority. Programmes to motivate people to organize action in order to meet their multifarious necessities, rather than to depend on the Government for everything should be given priority. National objectives of socialism, secularism and democracy necessity are constantly presented in a great diversity of formats, not crudely and directly but in subtle methods recognized to writers and artists. Thus, our own communication order would create a mighty contribution to India's resurgence.

SCIENCE AND TECHNOLOGY IN INDUSTRY

The Indian Context

Science and technology have totally transformed life from what it was in the beginning of this century, when there were no cars, buses or aeroplanes, no telegraph, telephone, radio or television, and when medicine and surgery-had not advanced to raise human life expectancy to in excess of 50 or 60 years. This has been possible through the development of scientific knowledge, and related skills, as also by the organisation of the manufacture of numerous goods. As the Scientific Policy Resolution (adopted by the Government in 1958) says, such high stages of manufacture of the vital materials needed for a reasonable average of livelihood for all, have made it possible to think of a "welfare" state—which involves management of sharing of goods so that every one can benefit from them. Our Constitution, indeed, speaks of socialism which involves "distributive justice" and equality of opportunity to all. Without the help of science and technology, we shall not be able to produce enough goods for our needs. For instance, we all know that with the help of a tractor a farmer can plough distant more land than she/he can with the help of an ox. Mechanisation increases the region of ploughed land, and thus improves human productivity.

One aspect of the development of science and technology is fuller utilization of the wealth or possessions with which a country has been endowed. Without science and technology, neither : could electricity be generated from the water running in our rivers, nor could the oil possessions buried deep under land or sea be tapped, nor even could our books anti newspapers be printed on the paper obtained from the forests that we have. Science gives the key for unlocking the wealth of our natural possessions.

When we study science, we seem into the laws of nature which, in their turn, indicate the ways of utilizing the natural possessions of the country for the manufacture of the necessities of life and for their efficient sharing. Mere indication of the ways is, though, not enough. To implement the ways indicated, one has to do work, and here again science comes to our aid. Science gives power, machines and apparatus for doing the work; devices of all kinds—those for work involving only muscular effort for work demanding manipulative ability and, in recent years, even for work requiring brain effort. Without such aids the rate of manufacture would be very low and the country would not be able to produce enough to be wealthy by any standards.

We seem at India with in relation to the 35% of its people livelihood under the poverty row. The reasons for the poverty of the masses in India are:

- Ways of manufacture are out of date by and big. In recent years, though, some remedial events have been taken.
- Since 2/3rd of the work force in agriculture and industry is illiterate, the knowledge and
- skills are very poor. This factor affects manufacture.

- In India, where 70% of the people are occupied in agriculture, the use of ways to Improve manufacture from the soil and to protect crops is not in keeping with the actual need.
- In agriculture the small means at the disposal of a farmer and small holdings create it impracticable to use modem technology.
- Industry, in common, and private industry, in scrupulous, has been unwilling to invest its profits in modernizing the machinery. A typical case is that of the jute industry, which is in very bad form now.
- The Industrial Policy Resolution, which had been adopted at in relation to the similar time (1958) as the Scientific Policy Resolution, has not been implemented effectively due to a number of socio-economic and political constraints.

Again, even where the production ways have been sought to be upgraded, our unit cost of manufacture of several items, for instance, steel, is much higher. This is mainly due to the low stages of ability and management in our industries. For instance, Japan and some other countries import iron ore from India. They have high labour cost but because of the efficiency of their manufacture systems, their unit cost of manufacture is lower than ours.

Further, a curious phenomenon is noticeable. We have imported technology for alloy steels some 30 years back. But we have been unable to stay pace with the modem developments in the manufacture of alloy steels through our indigenous efforts. As a result, we still have to import special steels from urbanized countries.

Lead Times of Scientific Development

When we compare the current status of scientific development and technological fall-out from the similar, we discover that the lead time of scientific detection and its applications is much shorter in the urbanized countries. This is because of their constant efforts of research and development for technology up gradation which, unluckily, have been lacking in our country. It is to be admitted that even in urbanized countries there is a wide difference in the lead times of dissimilar discoveries. These lead times may be quite extensive in sure cases and quite short in others. For instance, aluminum was first obtained in pure form in 1825 and it was only in 1886 that the procedure of its big level manufacture was finalized. The lead time in this case was 60 years. On the other hand, the procedure of hydrogenation of oil in the manufacture of vanaspati originated in 1905, and by 1911 Procter and Gamble Company, U.S.A. had placed its hydrogenated cotton seed oil, which is similar to vanaspati, on the market.

Technology in Industry

One aspect of technology is that the latest scientific ways are used in manufacture. This, in turn, depends on the availability of the right kind of scientific manpower. But at this stage it is enough to mention that it might appear easy to import technology from the urbanized countries and use it in our own procedures of manufacture, but it is not, in information, so. It is seen very often that a country from which a technology was imported had access to raw materials of a scrupulous kind which may not be accessible in our country. In other words, it is often necessary, in the absence of a scrupulous raw material, to substitute it by another, or to vary the procedure.

To provide a general instance, earlier the composition of vanaspati, the well-recognized cooking, and edible fat used to be 95% groundnut oil and 5% seasame oil. In relation to the 30 years ago, groundnut oil was accessible abundantly. For instance, we now have oils such as soyabean oil, Canadian rapeseed oil (Cano la) or palm oil imported from U.S.A., Canada, and Malaysia respectively, as the major raw material for the vanaspati industry. But the excellence, appearance and other properties of vanaspati have been kept the similar, because, of stringent government regulations. So research and development efforts had to be made by Indian scientists for this version.

Likewise, imported tallow, which was once a major raw material for our soaps and detergents has been totally banned. Indian scientists had to adopt other oils for preparing the similar excellence of soap, and several procedures have been urbanized. For instance, stearine and tallow substitutes have been prepared from castor oil, (one of our industrial oils) by chemical reactions. Such examples can be multiplied from other industries. Further, it would not have been possible to effectively utilize imported technology in several other significant industries without the help of skilled human resource. In this respect, training of skilled human resource and maintenance of research laboratories and organisations have played a major role.

From our first five year plan onwards, efforts have been made to augment scientific and technological human resource by creation of engineering and technology departments in our universities. We now have in relation to the 200 such institutions as against 21 before independence. In addition to the university departments, six Institutes of Technology (IITs) have been recognized at Kharagpur, Kanpur, Mumbai, Chennai, Delhi and Guwahati. The first five were set up with the help of urbanized countries, such as U.S.A., U.S.S.R., U.K., and West Germany. Even before independence, the three old universities of Calcutta, Bombay and Madras, the Indian Institute of Science, Bangalore, engineering colleges like that of Roorkee and Bengal Engineering College, the National Council of Education, the present Jadavpur University, had created several engineering departments.

Though, in practice, industries have retained a lot of dependence on imported technology. Often industry prefers to have “turnkey” technology, that is, technology and machines which can be installed and can start producing on turning a key or pushing a button. Thus, the pace and character of their development have reduced job opportunities for engineers and technologists who are being trained in our institutions. The result is that several of our skilled technological personnel and scientists have to seek opportunities abroad in urbanized countries like U.S.A., or U.K. This is described "brain drain" Our country loses crores of rupees every year, as the expense incurred on the training of these persons, and the much needed technological human resource is lost to India.

Technology in Small Level Industries

Several people have a misconception that application of science and technology is significant only for big industry. Since India consists of more than 600,000 villages, we cannot ignore the relevance of village and small level industry for giving employment to a big number of our population, who are now dependent on primitive ways of agriculture. Science and technology are equally significant in the handicrafts and small level industry. Agriculture, also, has been modernized with the help of machines like tractors, power tillers, mechanized harvesters, etc. But these attempts have not been very successful, because of educational and financial constraints, size of land holdings and social structures.

Improved technology results in improved productivity in conditions of capital investment and human resource requirement. At the similar time it reduces the job opportunities of a superior number of people. We are faced with a paradox that, whereas on the one hand we need more jobs for the bulk of our population who are jobless, on the other, modem mechanized and automated industries would result in utilizing less traditional human skills. Now, how do we resolve this paradox? One method would be to organize a network of small or medium level industries and village stage industries. Then, this network can be used to feed raw materials or intermediates to big level industries.

The use of electric power and electronics in small level and village stage industries can create efficient excellence manufacture possible, as has been demonstrated in Japan. There has to be, therefore, a scheduling procedure to create the manufacture ways in village stage industries more efficient by the use of appropriate devices and to use the produce from these industries as the feed material for big level manufacture units. This has been done partially in India, in states like Punjab and Haryana in the engineering industry and also, to a smaller extent, in other states. The role of technology in improved productivity will always be a major role and there will be a need for skilled human resource for this. But a part of them may be deployed in training human resource for the village stage industries, miniaturization of machines, and using the right kind of electronic or other devices for working them.

Maintenance of machines in such industries, as also in big level industries, has always been. a neglected region in our country. We have to be very careful in relation to the maintenance at all stages. Infrastructure for creation of skilled human resource already exists in the form of Industrial Training Institutions, Polytechnics and the training centers of dissimilar industries. These have to be strengthened and re-oriented to serve the present-day needs.

Paucity of capital is one of the difficulties in establishing industries, particularly for small and medium level entrepreneurs. Though, after the nationalization of banks and creation of financial institutions such as Industrial Development Bank of India (I.D.B.I.), State Industrial Development Corporations, Industrial Credit and Finance Corporation, Unit Trust of India and other financial institutions, nowadays institutional finance is accessible in the form of loans to any creditworthy industrial enterprise. Both the State and the Central Governments are strengthening these institutions through several savings programmes. The development of such programmes as Science and Technology Entrepreneurship Parks (STEP) in which new entrepreneurs are helped in testing a new technology on a small level through a pilot plant, to gain confidence before they go in for big level manufacture by themselves, is also very encouraging. These programmes are assisted by banks. Therefore, a beginning has been made in the right direction.

Such improvements in manufacture ways as automation and use of robots have been demonstrated to be very effective in reducing manufacture cost and improving the excellence of manufacture. Unluckily, separately from their being capital rigorous, they oppose labour intensity and make lesser job opportunities. In our country, we have to have a balanced approach. We should stay automation for selected regions, particularly, for our export oriented regions, and use somewhat older, but still efficient, ways of manufacture, which are laboured rigorous, in other regions. So, while the advantages are there, the implications in the context of our country have to be kept in view and in excess of mechanization and in excess of-automation at this stage of our development need to be avoided.

TV studio equipment has also been licensed to dissimilar industries. This is just one instance of our research programmes leading to industrial development in related meadows. In every field of scientific action we discover that innovations have paved the method for setting up of new industries and also the development of the existing ones.

In information, the instance of Japan can, to a great extent, be a model for us. In the beginning of this century Japan was a comparatively less urbanized country. They tried to modernize themselves by importing technology but then they improved the imported technology by:

- Creating R&D facilities for version and further improvement of the imported technology,
- Creating and sustaining the improvement of technological efforts through their own scientific manpower originally trained abroad, and
- Creating a base of scientific human resource to improve their educational system and training facilities.

In 1946, the late Sir Winston Churchill, in a very well publicized speech, stated, "The rise of the Soviet Union as a super power has been mainly due, not so much to their political system which might have helped but to the creation of the right kind of institutions for manpower training " Japan has again provided an instance of how, from a comparatively undeveloped technological base, they could rise to be one of the mainly contemporary technological nations, offering technology not only to the developing and undeveloped countries, but even to the urbanized countries like U.S.A. and U.K.

Therefore, for international competitiveness, and even for survival, there is need for modernization through our own research and development efforts and with the help of our own research organisations. One can think of secure cooperative effort flanked by government research laboratories, like those under the Council of Scientific and Industrial Research and the research laboratories of universities and higher technological institutions.

Our government has realized the importance of indigenous research to promote profitability and international competitiveness. A number of policy events were taken to give incentives to induce industries to set up in-home R&D units. They are given sure facilities for import of raw materials, equipment etc., besides some financial incentives.

You can also see from the charts that a major share of the R&D expenditure in our country is borne by the government. This situation is dissimilar from the one we discover in the urbanized countries. In those countries a big amount of R&D work is accepted out by the private industry. The capital spent in financing R&D units is seen as a good and necessary investment towards future economic progress of that industry. In India, industry spends a very minor fraction of total money spent on research.

There have also been a number of cooperative research associations in our country. The first such institute was set up in 1950 in Ahmedabad for the textile industry. There are several cooperative research associations now in meadows like jute, rubber, tea, wool, cashew nut, etc. Since small industrial units are not able to finance a complete R&D set-up on their own, such cooperative efforts are the best method out.

A developing country like ours aims to reduce its technological dependence on other countries. We shall be able to achieve this by raising our R&D efforts. Products and procedures urbanized in our own country will be based on local raw materials and will take into consideration other local factors such as weather. In the procedure, we will also have the requisite manpower for maintenance as well as further improvement of technology. We should match our R&D efforts with the objectives and policies of our country. Separately from the government laboratories, private industry should take more and more active part in research behaviors . The commercial application of scientific discoveries can be accepted out more easily if there is a direct link flanked by the laboratory and industry. In other words, it would be better if industrial units have an R&D set up within themselves.

Our indigenous R&D units should attempt to reduce the threat to our environment through innovations in industrial procedures. Pollution of environment by industries is a very serious menace in the urbanized countries. As you know, mainly of our big industries were set up before the oil prices sky-rocketed in 1973. As a result they rely heavily on oil as their source of power. With the unprecedented rise in oil prices, and also taking into consideration the limited world reserves of oil, we should attempt and seem for alternative sources of power which will augment our profitability in the extensive run. Some experiments are being done with solar power, and it has also been put to use in some spaces. But we haven't yet tapped its full potential.

It may be noted that the concept of modernization is integrally related to the improvement of procedures and products. But modernization as mere gimmickry, for instance, to introduce computers where one can do without them, or installing remote manage communication systems and the like can only augment overheads and lead to handicaps in deal. A balanced approach to modernization appears to be the need of the hour, and we need to strengthen our own R&D efforts for this.

The use of technology also helps us produce goods on a big level. This mass manufacture helps to bring down the cost per unit. If our goods are reasonably priced, they stand a better chance in the international markets.

India should follow the instance of Japan. If we stay importing the latest technologies and do not strengthen our base of R&D, we shall always remain dependent on other advanced countries. And unless we become self-reliant, we shall have to bow down to the wishes of these advanced countries even though they go contrary to our ideals. At the similar time we cannot remain in accessible. We have to imbibe the latest technology to fulfill the vital needs of the whole population and to abolish poverty. If we attempt to acquire the latest technology entirely through our own efforts, it will take a very extensive time, and we may not be able to catch up with other nations.

If some other countries have already urbanized modem technologies, we should attempt and import them to revamp our industry. But once we have imported these technologies we should stay them up-to-date with our own R&D efforts.

There are several reasons for our productivity being lower than the acceptable norms. One cause is that our industry does not use the latest technologies because of the heavy investment needed to install modem machinery. Even where modem machinery has been installed, it is not being properly utilized since the workforce is not adequately trained.

Sometimes entrepreneurs do not realize the importance of constantly adapting their technologies and refuse to finance R&D programmes. This adversely affects their productivity as their counterparts in other countries are able to achieve a higher productivity by the use of new manufacture procedures.

TECHNOLOGY AND ECONOMIC DEVELOPMENT

Technology Policy

We discussed the colonization of India and explained how the ruling country, Britain, was able to develop its science, technology and industrial potential to become a "urbanized" nation of today, while India remained undeveloped and economically dependent on Britain.

Other colonial nations faced similar situations. When they won freedom, they exposed that their economies were very strongly bound to those of their previous masters. For buying and selling their products they were dependent on the "world market" where pricing of goods was not in their hands, and where numerous discriminatory practices lived. Technological progress, of which they had been deprived, enabled the industrialized countries to offer superior goods at lower prices. And when these ex-colonies wanted to upgrade their technology by their own research and development effort, or even by purchasing foreign technology, the response from mainly of the urbanized countries was not helpful. Obviously, 'technological superiority ensured dominance in excess of the markets, and hence, technology could not be given to the colonial countries just because they needed it! On the other hand, technological deficiencies of the newly independent countries, prevented them from raising productivity and meeting even the vital needs of their people. This often made the governments of these countries weak and unstable.

The question of technology has, thus, become a crucial question for all developing countries. There appears to be only one answer, and that is to develop our own technology, appropriate for our needs and fitting into the pattern of our natural human possessions. This requires identifying our priorities, and steadily pursuing the path that will help us achieve them. A clear national technology policy is needed, from which there should be no deviation, irrespective of pressures from the urbanized countries or the corrupting power of their trading partners in our own countries.

In 1983, a Technology Policy Statement was issued by our Government and its very first sentence is "Political freedom necessity lead to economic independence and the alleviation of the burden of poverty". A crucial paragraph produced below neatly summarizes many significant characteristics of the Policy:

- "The use and development of technology necessity relate to the people's aspirations. Our own immediate needs in India are the attainment of technological self-reliance, a swift and tangible improvement in the circumstances of the weakest sections of the population and the speedy development of backward regions. India is recognized for its diversity. Technology necessity suit local needs and, to create an impact on the lives of ordinary citizens necessity provide constant thought to even small improvements which could create better and more cost-effective use of existing materials and ways of work. Our development necessity is based on our own culture and personality. Our future depends on our skill to resist the imposition of technology which is obsolete or unrelated to our specific necessities and of policies which tie us to systems which serve the purposes of others rather than our own, and on our success in dealing with vested interests in our organizations: governmental, economic, social and even intellectual, which bind us to outmoded systems and institutions."

The paragraph mentions “attainment of technological self-reliance” as our immediate need. This refers to the competence of our scientific and technological personnel, who should be well-versed in contemporary knowledge and “know-how". They should be able to innovate technology according to our need, and develop new technology. For instance, they should be able to harness sources of power, such as solar power, in which our country abounds: or they should be able to effectively use the raw materials that we possess in plenty.

Technological self-reliance also implies capability in our institutions to support technology development through their infrastructure and skilled manpower. Self reliance means, we should be able to foresee and forecast our needs so that development work can be undertaken at appropriate centers. It means, we should not be helpless watchers of new technology emerging from other countries. If it is decided to import new technology, we should be in a location to develop it further in order to save the country from importing similar technology again after a few years. Self-reliance implies subsistence of industry to produce the goods we need.

So you see that "self-reliance" is an easy word, but. in practice, it means developing our own capabilities through scheduling, coordination, education and research. We now provide another excerpt from the Technology Policy Statement, in which its aims and objectives are listed.

"The vital objectives of the Technology Policy will be the development of indigenous technology and efficient absorption and version of imported technology appropriate to national priorities and possessions. Its aims are to :

- Attain technological competence and self-reliance by creation the maximum use of indigenous possessions, to reduce vulnerability, particularly in strategic and critical regions;
- Pprovide the maximum gainful and satisfying employment to all strata of society, with emphasis on the employment of women and weaker sections of society;
- Use traditional skills and capabilities, creation them commercially competitive;
- Ensure maximum development with minimum capital outlay;
- Identify obsolescence of the technology in use and arrange for modernisation of both equipment and technology;
- Develop technologies which are internationally competitive, particularly those with export potential;
- Improve manufacture speedily through greater efficiency and fuller utilisation of existing capabilities, and enhance the excellence and reliability of performance and output;
- Reduce demands on power, particularly power from non-renewable sources;
- Ensure harmony with the environment, preserve the ecological balance and improve the excellence of the habitat; and
- Recycle waste material and create full utilisation of by-products."

Thus, we see that the policy stresses attainment of self-reliance in technological development and utilization of our own possessions for indigenous technology. The aims of the technology policy also illustrate the government's concern for the environment. Environmental thoughts contain the following:

- ***Creation the air less polluted:*** This can be done by controlling the combustion procedures. One should ensure the complete burning of coal or other fuel. Where combustion takes lay, the chimneys necessity be high enough to ensure that the gases don't spoil our environment. These chimneys necessity also be fitted with pollution reducing mechanisms.
- ***Disposing of solid waste:*** For instance the ash from thermal power plants or the waste from cement factories should be properly disposed of.
- ***Treating industrial effluent:*** Effluents, that are discharged from chemical factories into rivers or oceans should be appropriately treated to create them free from toxic materials.
- A Ganga Pollution Manage Power has been created by the Government of India for cleaning the river Ganga throughout its stretch by using appropriate treatment plants.
- ***Prevention of soil erosion:*** Through social forestry farm forestry, grassland and wasteland development, events necessity be taken to manage soil erosion, which has several untoward consequences.

The Department of Environment was set up in 1980. It conducts research, makes public awareness and runs training programmes related to the environment. For implementing the Technology Policy Statement, a Technology Policy Implementation Committee (TPIC) was constituted by the Government. A special plan to give funds to institutions of higher education on a selective foundation is now being implemented by the University Grants Commission. The aim is to enable the institutions to strengthen and modernize their infrastructure for undertaking work in front row regions in science and technology. The Department of Science and Technology (DST) has been the focal organisation for supporting research of a multi-disciplinary nature.

Several of the States have been persuaded to set up separate councils of science and technology. The DST has been providing secretarial support to the Scientific Advisory Committee of the Cabinet since March, 1981. The research programmes supported by the DST are being utilized to improve actual manufacture procedures.

Technology Transfer

We stressed self-reliance and mentioned that sometimes it becomes necessary to import technology from other nations. Import of technology is one of the shapes of technology transfer.

There are three methods in which we can transfer technology

- Import of technology,
- Transfer of technology from the laboratory to the field, and
- Export of technology from India.

Although India's aim is to be technologically self-reliant, in the initial stages of our development we may have to depend heavily on imported technology in sure cautiously determined meadows. We necessity generate our own technology, but we necessity also have the skill to absorb imported technology and build on it so as to advance more rapidly.

Import of Technology

This form of transfer involves transferring the essential expertise associated with the capabilities of more urbanized nations to the lesser urbanized nations, who require it for accelerated industrialization. This can be done in many methods: through licensing, joint ventures with foreign firms, direct foreign investments, etc. Its efficiency depends on several factors like the supplier's skill and desire to transfer, the recipient's capability and desire to absorb, the recipient's socio-economic and cultural environment and communications procedures.

Clearly, technology import could be advantageous. A major gain is that it would help to save considerable time, money and power by skipping the stages which other countries had to pass through to achieve the present stage of development. But, in practice, the import of technology has a lot of troubles and disadvantages. Here we spell out some of these.

The buying of technology may be very expensive. Take, for instance, the buying of the latest defense aircraft from France. Though we have saved money on going through the several stages of research and development, we still have to pay big sums of money to buy these aircraft outright. This is because the price comprises the developmental expenditure that France incurred in this connection! So, we end up paying for research and development, and that too, in foreign exchange. Further, the R&D structure within the country also remnants undeveloped.

- Imported technology often comes with restrictions or "political strings" attached to it by the supplier. For instance, India used to import enriched uranium from the United States to use in its fission reactors. A time came when the US Government insisted that we sign the Nuclear Non-proliferation Treaty, otherwise they would stop the supply. India refused to do so and argued that this was not a condition in the original agreement. Though,
- India's argument was of no use, and the US stopped the supply.
- The supplier often unloads obsolete technology on the recipient, sometimes at a very high cost. Since the getting country does not have the technology, it may not even know how outdated the offered technology may be. An instance is the automobile industry in which we continue to be saddled with models that are no more in demand in the urbanized countries or in the parent country. Also, since the end of World War ll, one of the major regions of industrial development has been that of domestic conveniences, such as air conditioners, refrigerators and electronic goods like the TV, VCR, etc. Once the

domestic market in Europe & USA was saturated, markets were created in the developing countries for the finished products, and later, for the sale of related technologies. Since, in these regions, the technologies are quick change ones, what is transferred to the developing countries is outdated.

- The getting country may permanently have to depend on the donor country, especially in crucial regions like defence equipment. The donor may sell a modem defence aircraft, but with the condition that the receiver always buys the spares and ancillaries from them. This method the getting nation will not be allowed to be self-enough.
- When a country imports technology from more than one country for an industry, then the spare parts may not fit into several models. As you know, the technology for Maruti, Fiat and Ambassador cars was imported from three dissimilar countries, namely, Japan, Italy and Britain; and the spare parts of one don't fit into the others. So the level of manufacture of spare parts will vary, thus rising the cost of manufacture.
- A multi-national corporation of a urbanized nation may provide technological know-how to a developing nation with the restriction that the knowledge is not to be shared with other developing nations. This ensures their direct hold in excess of dissimilar countries.

Lab to Field

It has been the policy of the Government of India, from the time of Independence, to achieve self-reliance by developing indigenous technology in as several regions of industry as possible. We, therefore, had created a chain of laboratories in all regions. The National Research and Development Corporation of India (NRDC) were set up in 1953 for facilitating the transfer of technology from the laboratories of national R&D institutes to the field. These institutes offer their procedures for commercial use to NRDC.

If indigenous efforts are not measured adequate at the policy-creation stage of the dissimilar ministries, a new policy is formulated for updating technology and for the import of technology from the urbanized countries. The Department of Science and Technology, Scheduling Commission, Science and Engineering Research Council and several Scientific Advisory Committees attached to the ministries monitor the technological needs of India.

Export of Technology

India has gained experience and expertise in several meadows of technology. Thus, we are in a location to assist a lot of developing nations in the procedure of technological advancement. India exports technology to a big number of Asian, Middle-Eastern, African & Latin American nations.

Current Technological Developments

In recent years R&D efforts in the meadows of pure and applied chemistry, mathematics and physics have helped a great deal in our progress from agro-based industries to the regions of heavy industries, chemicals, steels, textiles, sugar, pharmaceuticals, computers and electronics. To provide a few examples, the developments in the field of metallurgy have depended on the applications of the principles of chemistry, physics and engineering. A big number of manufacturing operations in the chemicals, steel, textile, sugar and pharmaceutical industries depend on chemical conversions. The development of computers and electronics has been based on fundamental physics and mathematics with the help of electrical, mechanical and manufacture engineering. Research in materials science has led to experiments with fiber glass. This can be used in creation lighter aircraft and lighter luggage, in the middle of other things.

One has to keep in mind that the whole procedure of technology involves the processing of raw materials into useful and profitable products. These products are used both as consumer goods and as an intermediate for further chemical and physical modifications to yield consumer products. For instance, in the chemical industry, in relation to the one-quarter of the total chemical output is utilized in the manufacture of other chemicals.

The Council of Scientific and Industrial Research (CSIR) have a chain of laboratories in approximately all regions relating to the national development effort: fuels, ceramics and glass, chemicals, metallurgical and electro-chemical products, etc. Silk & Art Silk Manufacturing Research Association (SAS MIRA) in Bombay and Indian Jute Industries Research Association (IJIRA) in Calcutta, which are maintained jointly by the collaborative efforts of the Government and the industries concerned, are active in their meadows. Local research laboratories maintained by the CSIR at dissimilar spaces like Trivandrum, Jammu,

Hyderabad', Bhubaneshwar and Jorhat, seem after the local research and development needs.

Before dealing with current technological changes in some industries, let us seem at the thrust of our developments in the region of power.

Power Sector

The power related developments have been in the direction of power saving and search for new power sources for present and future needs.

It has been estimated that in 1850 coal, oil and gas were responsible for 5% of the world's power, while human and animal labour did in relation to the 95% of the work. Today, coal, oil, gas and nuclear sources explanation for almost 94%. water power in relation to the 1% and human and animal labour the remaining 5% of the world's power. While this is the overall picture of the world, in our country the picture is quite dissimilar. Human and animal power and burning of wood and dung cakes accounts for a much higher proportion of power in India. Our nuclear power generation is just gaining momentum.

You know that in the middle of the power sources accessible in India are fossil fuels (like lignite, coal and petroleum) the sun, wind, geothermal power (for instance, hot springs) water (hydro-electric power) and human and animal labour. The cost of power varies. It is the lowest in the case of direct combustion of biomass and peat, which is wet, partially decomposed organic matter. The cost of power is also quite low in the case of fossil fuels. Big deposits of lignite have been establish in Tamil Nadu. But it costs more than coal, as it has to be processed into briquets before it can be used. Gaseous fuels and manufactured gas, such as fuel gases like coke- oven gas, water gas, producer gas, etc., cost much more. There have been attempts to prepare ethyl alcohol by biomass conversion and methane by fermentation. Vegetable oil, in recent years, is also being used as a replacement for diesel.

In the middle of the other power sources, nuclear power is measured to be one of the proven alternative power sources, and, in some countries, such as France, 70% of their power is now derived from nuclear sources. In the Bhabha Atomic Research Centre, separately from uranium, thorium, obtained from monazite sands from the beaches in Kerala, has been successfully used to produce nuclear power. The first such reactor has been commissioned in Kalpakkam close to Madras There arc in excess of 550 nuclear power plants all in excess of the world.

India, at the moment, has only five A few more power plants are soon to be put into service. Other power sources which have received considerable attention are geothermal power, wave and tidal power, solar power, ocean thermal power and electro-chemical cells which generate electricity. Conversion of biomass into biogas needs scrupulous mention. In India, at present, fossil fuels, hydro-electric power, biomass conversion, and nuclear power are the ones which are being used. Others still remain more or less in the experimental stage as distant as practical utilization is concerned.

Some Key Industries

We will now talk in relation to the recent developments in some of the key industries, namely, the textile, sugar, pharmaceutical, steel, chemical and electronic industries.

The Textile Industry

A current development in the textile industry has been the extra ordinary development of synthetic fibres. Naturally occurring cotton, wool and silk are being replaced by man-made fibres. At present, synthetic fibres symbolize in relation to the 50% of the world's fiber manufacture. In 1981, 14 million tons of man-made fibres were produced in the world, while natural fibres prepared amounted to 17 million tons. Earlier urbanized fibres like rayon were based on cellulose. Nylon was the first wholly man-made synthetic fiber. It chemically belongs to the group described polyamides. The after that fiber to be urbanized was polyester, commonly recognized as ethylene.

Today, the range of synthetic fibres has been enlarged and also comprises glass fibre. Multi- component fibres, which are superior to fibres spun from only one of the components, are also being manufactured. These fibres are prepared by spinning two or more polymers jointly

The manufacture of any synthetic fibre begins with the preparation of a polymer consisting of a very extensive chain of molecules. By controlling the average chain length of the molecules, a single polymer can be used to create a number of fibres with widely differing mechanical properties. They can be made weak and stretchable or strong and stiff.

Beside with the synthetic fibres, mention should be made of the fibres which have been urbanized from cellulose raw materials like cotton. Examples of fibres made of these materials are raw nylon or viscose. Viscose is made from wood pulp by chemical procedures. Polymeric films like cellophane are also manufactured from cellulose by a special procedure. A recent development has been the manufacture of carbon fibres which may be prepared from rayon or polyacrylon. These carbon fibres can withstand high temperatures and are used for manufacturing heat shields for nose cones of rockets, particularly those that return to earth from legroom voyages. It has also been possible to prepare such fibre from coal-tar or petroleum pitch. Carbon fibres are used for reinforcing engineering plastics and plastics which are used for sports goods.

Cotton or woolen textile industries are major traditional industries in India. Recently, some developments have taken lay improving their spinning, dyeing, bleaching and printing ways, and also in the ways for giving special finish, such as for crease recovery, dimensional stability, resistance to microbial attack and ultraviolet light, flame resistance, etc. Treatments are also aimed at changing their properties to improve their usefulness. For instance, it is possible, through appropriate treatments, to achieve flame proofing by application of sure chemicals. Mildew proofing or rot proofing can be done by the use of several organic and inorganic compounds. There are special chemicals which can be used to produce a water repelling property. Shrink proofing of wool can be done by applying several chlorinating procedures or by coating the fibres with a melamine formaldehyde resin.

In recent years chemical finishes have been used to react with fibre material such as cotton for changing its properties.

Sugar Industry

The sugar and starch industries in India are considerably significant. Sugar is necessary for the power it provides. Of course it is liked for its sweet taste also! Sugarcane is the main source of sugar in India. The states which are significant for our sugar industry are Maharashtra. "Uttar Pradesh. Karnataka. Bihar. Andhra Pradesh and Tamil Nadu.

The way used in India for manufacturing sugar from sugarcane has not changed in excess of the years. But the use of bagasse, the residue left after cane juice extraction, has changed. It used to be utilized as a raw material in manufacturing paper. A recent development is its use for fermentation to produce alcohol. Raw sugar is decolorized with bone charcoal or activated carbon. A decolorizing chemical additive has now been urbanized. For removal of inorganic salts, a recent development is the use of ion exchange resins.

The other raw material for obtaining sugar, which is now in the procedure of development in

India, is sugar-beet. The sugar-beet differs from ordinary table beetroot. It is much superior and is not red. The sugar-beet industry is being sought to be urbanized in such regions like Sundarbans of West Bengal and a few other spaces. But sugar-cane is likely to remain the major source of sugar in India.

The Pharmaceutical Industries

This is a major industry in India. India is meeting 70% of its requirement of bulk drugs, and approximately all its requirement of formulations. The products are usually classified according to chemical structures, or by chemical reactions needed to manufacture them, or by their use. There are in relation to the 50 commonly prescribed drugs.

Some of these drugs are prepared by separation from natural raw materials. For instance, Serpasil, a drug given to patients suffering from high blood pressure, is obtained from a plant described Rauwolfia Serpentina. A drug against blood cancer, Vincrystine, is obtained from a general plant, Vinca-Rosea. Digitalis, a drug for heart patients, is got from the fox-glove plant.

But several drugs are prepared by synthesis. For instance, Aspirin, the general analgesic, is obtained from salicylic acid. Antibiotics like Penicillin or Streptomycin were originally prepared by fermentation, or through a procedure of biosynthesis. Now they can be prepared synthetically. Again, the chemical compound, Isoniazide, is one of the mainly potent and selective medicines against tuberculosis. One of the significant developments has been in the manufacture of Insulin, an anti-diabetic drug. Earlier this was being produced from the pancreatic glands of animals.

Steel Industry

In India this industry has urbanized significantly since Independence, and is now under a central power, namely, Steel Power of India Limited

(SAIL). Some steel plants come under the public sector, such as those at Durgapur, Bumpur, Bokaro, Rourkela. Bhilai, etc. Some are in the private sector such as the Tata Iron and Steel Company at Jamshedpur. The mainly important development has been the use of a multi-pronged approach in getting technology from a number of urbanized countries. The earliest Tata plant was put up with American technology. Now we are using Soviet technology at Bokaro and Bhilai, and German technology at Rourkela. The Tatas are trying to develop indigenous technology.

Chemical Industry

Under this heading we contain the manufacture of caustic soda, chlorine, cement, carbon, coal, urea, nitric acid, super phosphates and gases like hydrogen, oxygen and nitrogen. We have a sizeable glass and ceramic industry, surface coating industry, food and food by-product industry. Our agrochemical industries have urbanized indigenous technology for the manufacture of pesticides and insecticides. Our soap and detergent industry manufactures soap, detergents and glycerine. Our oils and fats industries manufacture vegetables and animal oils and fats. A major breakthrough has been achieved in the field of petrochemicals. We have a number of petroleum processing plants and petrochemical industries, the major being in Baroda. India produces two-thirds of her petroleum necessities. The rest is imported from countries of the Middle East, the Soviet Union, some East European countries and some South American countries. We have a number of petroleum refineries situated in Bombay, Visakhapatnam, Assam, Bihar, West Bengal and Kerala. Some more are expected to come up throughout the present plant era.

Electronic Industry

In recent years the whole world has seen a revolution in electronics. It is a very significant part of practically every industry, as well as several spheres of human action like communications, transport, education and entertainment. The computer industry has been radically altered in recent years due to a shift from the analogue to the digital technology. This has led to a very big change in communications technology. A combination of analogue and digital technology has made distant or remote manage of machines possible.

Computerization has also helped in several meadows of engineering. In the old days, in mechanical, civil or chemical engineering, it would take an extensive time from the first stage of designing to the last stage of creating the actual product. Since the advent of computers, through computer-aided designing ways, much of the labour and cost involved is saved.

Also, with the help of the computer, the sensitivity, accuracy and dependability of a scrupulous design can be tested quite easily.

in computer and electronics based industries, the percentage of employees involved in research and development may be anywhere flanked by 33% and 50%, because, in these regions, the competition is high and development of new materials and new technology is very significant for maintaining a lead in excess of other competitors. There may be a new model of a computer design every 2 or 3 years.

India's annual electronics manufacture stage is more than Rs. 1,00,000 million. India has started producing:

- Electronic switching systems;
- VLSI (Very Big Level Integration) circuits, which form the foundation for modem electronic systems;
- Polysilicon to meet the necessities of integrated circuits, and to harness solar power;
- High-power microwave tubes, which form the foundation for radar systems;
- Computers.

One of the mainly significant programmes in education that has been introduced is GLASS, computer literacy and studies in schools. In this programme school children are being taught to use and appreciate computers, which have been installed in relation to the 4000 schools in India.

The common outlook of the electronics industry appears to be bright. There has been substantial development rates recorded in computers, office equipment and software exports. In the coming years the communication sector is expected to grow rapidly.

To conclude, it can be said that industries in India are progressing, but we have distant to go. Often, we need to import current technology. According to one estimate, 35% of drugs and pharmaceuticals, 70% of agricultural machinery, 75% of electronics, and approximately all petrochemicals and fertilizers are products of foreign technology. This location has to be changed by conscious policy and careful scheduling combined with rising support for education, research and development.

Limited Access to Technology

India has made rapid advances in technology since Independence. A lot of technological innovations are accessible here. But, for a number of reasons, the weaker sections of our society have not been able to benefit from these technologies. Two significant reasons are lack of awareness of them and lack of access to them.

Let us first talk about the lack of awareness. A major cause is the lack of even primary education. In our country in relation to the 48% of the population that is in relation to the 48 crores people are illiterate. Schools are not accessible to everyone within a convenient aloofness. On top of it, the huge poverty in a big part of the Indian society does not allow them enough time to go to school, even if the school is nearby. All the members of a poor family have to work and thrash about for the vital necessities of life.

Again, because of a lack of communication, the illiterate people feel that technological progress is beyond their comprehension and not of any use to them. There have been attempts through the media, like radio and T.V., to reach our population who live in villages and tell them in relation to the benefits of contemporary technological innovations that are accessible in India. But these are not enough.

Often, when people know in relation to the technological advancements that are accessible, they are reluctant to utilize them. This is due to prejudice because of religious beliefs, superstitions and old customs. For instance, although vaccinations have been accessible to us for almost 100 years, there are people in our society, even in the municipalities, who are opposed to vaccinating their children against DPT (Diphtheria, pertussis, typhoid). Likewise, it is recognized that water can be polluted and cause disease. Though boiling the water can easily prevent several water borne diseases, mainly people in the villages, where pure drinking water is not accessible, don't bother to do it. This is because of old customs as well as lack of fuel.

Thus, we have in the country today, the urban society which has had an exposure to modem thoughts through education. They have accepted technological innovations as a means for progress. But the majority of Indians remain indifferent. Elementary scientific knowledge or exposure to science is not accessible to them. The only method to right this wrong is to spread elementary education and science education. This can be done through radio and T.V. But, these are not accessible to all the rural masses. It may be necessary to approach them through their own social hierarchy and village stage organisations like Panchayats. This aspect of society's transformation has to be kept in view in our mass education programme if the inter-relationship of science, industry and technology is to be brought house to them. Through rural development programmes and rural science programmes, it can be shown, how easy labour saving devices can reduce their daily load of work, or how, for instance, solar power or wind power can create lighting or irrigation possible. The efforts should be concentrated, therefore, in spreading awareness to this deprived part of our population so that they understand the benefits of technology, which can bring a change in their lives.

But is awareness enough? You may be aware of a better technology for irrigation, but if you do not have enough funds to obtain it, the awareness will not help you. In India, there are millions of people who can't benefit from advanced technology only because it is beyond their budget. This is where the government can help. It can subsidise the technologies that will aid the weaker sections of our society. It can also market them to ensure that these technologies are accessible wherever they are needed. Such a strategy would certainly create the advantages of technological progress accessible to more and more people.

MODERN DEVELOPMENTS IN SCIENCE AND TECHNOLOGY—I

Laser; Putting Light to Work

LASER stands for Light Amplification by Stimulated Emission of Radiation. It's a fairly extensive string of words. Well, don't let it stop you from reading further. What we wish to bring out here is that lasers produce a very special type of light. The light that lasers produce has many useful properties that create it dissimilar from ordinary light. It is because of these properties that laser light can be put to work in a number of methods.

Each wavelength produces a dissimilar color. These colors mix and form ordinary light. We have all seen colors in the sunlight separating out to form a rainbow in the sky after a rainy day. Moreover, light waves from an ordinary source of light are all jumbled up and uncoordinated in their movement.

Laser light is made up of waves of the similar wavelength. What is more, all the waves in a laser beam are organized to proceed exactly in step (in stage) with each other. This property of lasers is described coherence. It reminds you of contingents of smartly dressed men moving in unison in the Republic Day parade. Or of the uniform movement of oars in boat races of Kerala held on Onam. Does it not? As a result of coherence, light waves in a laser beam can travel big distances without spreading separately. Because a laser beam does not spread out, there is a big concentration of power per unit region on the substance on which the laser beam falls.

Applications of Laser

Due to its properties, laser light can be put to a number of uses in industry, medicine, communications etc. We will briefly describe some of these uses. Because of the high concentration of power, a laser beam can quickly bum tiny holes, a few millimeters wide, even in a strip of steel. Lasers have an advantage in excess of all other traditional ways of cutting and welding. Using lasers you can cut any type of material, such as paper, plywood, plastic or cloth, as also the hardest of metals, ceramics and glass with greater efficiency and accuracy. Lasers can, thus, create an ideal tool for metal workers, carpenters and tailors, separately from engineers.

Military Applications

Another region where the properties of lasers are being used with a 'deadly' precision is that of military applications. Lasers have been pressed into the service of the global war machine. A whole range of laser weaponry has come into being, for use on land, on sea and in legroom. X-ray lasers that can carry enormous power have been urbanized. Efforts are on to install deadly laser weapons in satellites. The similar technology could be used to destroy factories, forests, farms and environment. It is certainly a matter of concern to see so much human effort and wealth being used to turn the laser technology into an instrument for mankind's destruction. Every effort should be made to stop this misuse of technology.

Healing Touch of Lasers

Contrast the application of lasers with their uses in medicine where the laser is working wonders.

A laser can be applied with approximately perfect precision in surgery. It can bum absent diseased tissue without damaging the healthy tissue nearby. The tissues are cut neatly and without any oozing of blood, and they can also be joined jointly. Lasers are totally sterile, because bacteria cannot survive exposure to a laser beam. Today, lasers are routinely used in eye surgery to treat detached retinas and to destroy abnormal blood vessels that form in the retinas of diabetic patients. Earlier these diseases would result in blindness. For such patients, laser is indeed a “miracle light”. Lasers have become average equipment for ear, eye and other delicate shapes of surgery. From removing brain tumours, to stopping bleeding from ulcers, and treating cancer of the bladder, lasers discover a wide use in medicine.

Communications

Lasers have also become a significant means of extensive aloofness communication. Traveling through hair-like glass fibres, laser light can be made to carry thousands of times more information than electric signals in conventional copper wire. Thousands of telephone calls can be transmitted on a single fibre.

Other Uses

Lasers may be used to measure the aloofness of objects like the moon from the earth. Here, time taken for a laser beam to reach the moon and be reflected back to the earth is measured. As you know, light travels at the speed of 3 x 105 km per second. Thus, the aloofness can be establish from the easy formula: aloofness = speed x time.

In the middle of other things, scientists use lasers to monitor small traces of chemicals polluting the atmosphere because these molecules disturb the passage of the beam and thereby reveal themselves. Efforts are being made to transmit power by means of laser beams. Laser beams are used to etch music and video pictures on records which seem like ordinary gramophone records. Such records can be played back by a laser beam and, thus, they never wear out. If you happen to visit a science museum you will see holograms of several objects. These are life-like three dimensional images created by laser beams.

Thus, you see that lasers can be put to endless uses for the benefit of human beings. These uses appear to be limited only by the imagination of the scientists and engineers. And the best is yet to come.

Fibre Optics

The songs you hear on your transistor, or the pictures you see on your TV are accepted from the studios to your house on radio waves. Telephone calls you create, on the other hand, are transmitted by electric current flowing in copper wires. In the recent past, new technologies have appeared for transmitting several types of electric signals on glass fibres. This has been possible due to the advances in fibre optics technology.

Fibre optics is the technique of transmitting light waves through glass wires as thin as human hair.

These wires described optical fibres could be made of glass or transparent plastic, quartz, nylon or polystyrene. Optical fibres are thin hair-like solid strands that carry light beside their length, by a procedure of multiple total internal reflections.

In this procedure the beam of light entering at one end is transmitted beside the fibre, without loss of intensity, whether the fibre is straight or bent in a curve.

Applications of Optical Fibres

Fibre optics discovers several applications in regions like medicine and communications which we will briefly describe. We will also talk about its advantage in excess of traditional technologies.

Viewing Inaccessible Regions

Instruments made of optical fibres, described endoscopes, are used to see the internal organs of the human body, such as the interior of the stomach, or the bronchial tubes. Inserted into the body, some fibres of the bundle carry light so that the internal organ is lit up. Other fibres are used to return light so that the image of the interior is accepted to the observer outside. Endoscopes are often linked to a camera or TV monitor. Since these fibres are very fine, they can be inserted easily in the body. The images are very useful in heart and brain surgery and in diagnosis of some other diseases.

Freeing Crowded Cableways

The use of optical fibres has been very advantageous in telecommunications. Signals of voice, text, computer data or picture transmissions are superimposed on laser beams. The modulated laser beams are then guided beside optical fibres, to several points where they are received. At the getting end, one is able to hear the voice, read the data or see the picture.

The signal carrying capability of light waves is much greater than that of radio waves or waves beside copper wires. Therefore, the light waves traveling in fibres can carry thousands of dissimilar signals. For instance, a pair of glass fibres can carry 1300 telephone calls at the similar time, as against 24 for copper wires.

The fibre optics technology has several advantages in excess of the traditional technology. An optical fibre cable, the size of an ordinary electrical cord, can replace copper cable hundreds of times thicker. Optical fibres are light and sturdy. They are much less expensive than copper wires for the amount of information they carry. Because optical fibres carry light beams, they are free from the disturbances, such as you hear on the radio due to nearby electric disturbances. Fibre-optic communication is also advantageous for military communication because it cannot be “jammed”

There may come a day when optical fibre cables enter several of our homes carrying not only telephone calls but also television programmes, communication from computers and electronic mail sent from person to person.

Legroom Technology

In a flat arid plain described the Sea of Tranquillity on the moon, is a footprint. This footprint was left there by Neil Armstrong. He was the first human being to walk on the moon. He was a member of the 3-man crew accepted to the moon by the American spacecraft Apollo 11 in July, 1969.

It was a dream come true for mankind — a dream of flying into legroom and visiting another body in the universe. Since then great strides have been made in legroom technology. The first step in this direction was the development of rockets.

Rockets or Launch Vehicles

Every flight into legroom begins with a rocket launching. The rocket can lift a satellite or spaceship carrying human beings and equipment into legroom. Therefore, it is also described launch vehicle. The rocket has been recognized to mankind for centuries. Rockets used as firecrackers are a general sight on festive occasions in our country. But the rockets that launch legroom vehicles use highly advanced technology, and, of course, they are distant more powerful.

When the fuel in the rocket is set to fire, a stream of hot gases is expelled at a high speed from its rear end. As a reaction to the thrust of the gases, the rocket moves in the opposite direction. As extensive as the fuel in the rocket burns, shooting out gases, the rocket continues to accelerate forward, and acquires great speed.

No single rocket fired from the earth can attain in one go the high speeds needed to orbit the earth, or to escape its pull. Higher speeds are reached by using big and small rockets, in stages, in the launch vehicle. As the big rocket soars into legroom and uses up its fuel, it is separated from the smaller rocket and drops off. The smaller rocket already going at high speed is then fired to accelerate it to an even higher speed. Three-stage rockets are usually able to achieve speeds appropriate for mainly purposes in legroom. The final stage of the launch vehicle carries the payload.

Action

Verify the principle of rocket motion by releasing an inflated balloon with its neck open.

The dissimilar types of payloads that rockets carry into legroom contain artificial satellites and legroom probes to nearby heavenly bodies. The satellites and probes themselves carry communication and research equipment.

Artificial Satellites—Tireless Servants in the Sky

The legroom crafts that move in an orbit approximately the earth are described artificial satellites. Mainly satellites go approximately the earth once in relation to the 90 minutes at a height of a few hundred kilometers. But it is possible to launch satellites with a proper speed at greater heights (approximately 36,000 kms). They would then move approximately the earth once in 24 hours and hence appear to be stationers.

Our own INSAT series of satellites are geostationary satellites Every night, towards the end of TV news on any channel, we are shown pictures of clouds in excess of India. These pictures are taken by INSAT satellites and televised to the earth. Separately from monitoring the weather, INSAT satellites are used to receive and retransmit telephone calls Television programmes are also relayed via these satellites.

Satellites carry equipment to survey the earth's natural possessions and monitor weather.

India's satellite programme has also provided useful information on agricultural land and prospecting for ores and minerals. Recently, the satellite IRS 2D in the IRS (Indian Remote Sensing Satellite) series has been launched to survey India's natural possessions by remote sensing ways.

The effect of livelihood in legroom on plants and animals is also studied in satellites. At present, Russia has a legroom station described Mir going round the earth as a satellite. Crew members and supplies are regularly sent to this station where three or more persons work at time, for eras as extensive as a year. Satellites can pinpoint sources of pollution, spot forest fires and locates regions of disease in crops and forests. Weather circumstances can be monitored by satellites enabling us to predict storms and prevent damage. Satellites also help in locating and guiding ships. But the maximum use of satellites is made for communications. Legroom Probes—Journeying to Neighboring Worlds

If a spacecraft is directed to move out in legroom, absent from the earth, it is described a legroom probe. Many unmanned legroom probes have either passed by or landed on the planets Mercury, Venus, Mars, Jupiter, Saturn, Uranus and Neptune. They have sent back valuable data and photographs of all these planets. So we have come to know what these planets seem like from close to, what they are made up of, and what physical circumstances prevail close to them.

Dividends from Legroom

When the legroom programme began, its primary aims were research, adventure and national prestige. As it expanded, the investment in it also grew.

It is now a highly expensive undertaking. A natural question to inquire is, how it benefits humankind.

There have been several benefits from legroom programme. In meeting the challenge of legroom travel, scientists and engineers have come out with a stream of innovations. These are equally useful on the earth. Some examples are—new materials for use in industry, e.g., light but strong alloys, better steel, plastics and adhesives. Highly reliable and tiny electronic components made for spacecraft are now used in TV and other electronic goods. Computers have become compact. Medical instruments made for astronauts are used in hospitals. New technology for food preservation saves power. Ultra sensitive fire alarms and fireproof fabrics have 6een urbanized. The list is very extensive.

If you add to it the benefits derived from a satellite, like weather forecasting, prospecting or communication, it becomes truly extra ordinary . The satellites are being used in a big method not only for news and information but also for education. Programmes initiated from a few spaces can reach people situated in distant and inaccessible locations. Mainly parts of our country can now be reached through satellite supported television.

As it is with all scientific endeavors, legroom can also be misused. Either bombs, laser machines or other types of weapons can be stationed there. There is a world-wide and strong opinion to prevent the use of legroom for war-like purposes.

Perhaps the futility of war-mongering is realized mainly if one looks at legroom travel from another view. Traveling in legroom has given man an entirely new view of his house, his planet Earth. It has shown the earth as a beautiful planet, rich in color, movement and life. Our planet is a “closed system", dependent only on the sun for power, with limited possessions that cannot be replaced. It is a spaceship itself, fragile and in accessible in the vast universe—a flicker of life very valuable. Certainly, the planet Earth demands preservation as a single environment. We have only one world. We necessity protect it from those who because of their greed or ignorance would use science and technology to destroy it.

Nuclear fission and fusion technology is another such technology which can be pull to destructive use. Though, strong public opinion approximately the world has served to curb its destructive use to some extent. Let us now look at this technology and several issues related to its use.

Fission and Fusion Power

'The Italian navigator has arrived in the new world'

This coded message announced the beginning of the atomic age on 2nd December 1942.

The 'navigator' was the Italian-American physicist Enrico Fermi. That afternoon, in a squash court under the stadium of Chicago University of USA, Fermi and his team of scientists succeeded in taming the atom for the first time. In the heart of the first atomic furnace, atoms were made to split, under strict manage, to produce power. Fermi had indeed ushered in a new world. Today, in the giant atomic power stations approximately the world, or in nuclear weapons.

Nuclear Fission: Splitting the Atom

You know that atoms are made up of a nucleus and electrons moving approximately the nucleus and the nucleus are made up of protons and neutrons. The principal actor in the fission drama is the uranium atom. The nucleus of the Uranium 238 atom has 92 protons and 146 neutrons. In relation to the one atom in 140 atoms of uranium have 143 neutrons in its nucleus. It is described Uranium 235. It is the Uranium 235 that is mostly used to give fuel for nuclear furnaces.

Before the Second World War, two German scientists exposed that if neutrons were shot at the nuclei of Uranium 235, the nuclei split into two and produced other neutrons to repeat the procedure. This is described nuclear fission.

Release of Power

When the atom splits, the masses of the fragments and the neutrons produced do not add up to the mass of the original. A tiny amount of matter disappears. This lost matter turns into power. The amount of power ‘E’ generated by the lost matter of mass ‘m’ is given by the well-known equation due to Einstein:

$E = mc^2$, where c is the speed of light.

c is big (in relation to the 300 million meters/sec) and c2 is enormous (in relation to the 90,000 trillion m2/sec2).

Thus, a small amount of lost matter would get converted into very big amounts of power.

Chain Reaction

When the atomic nucleus splits, it not only provides off power, but also throws out two or three more neutrons. These new neutrons can, in turn, split two or three other atoms. This method they release more power and more neutrons, which will split more atoms. In other words, once the splitting of the nuclei starts, it becomes self-sustaining. This whole procedure is described' a chain reaction. If the chain reaction is allowed to go on, it would lead to an explosive release of power. Manage it by absorbing the extra neutrons and you have the slow, smoldering reaction of the “nuclear reactor”. This serves as a source of power much like a thermal power station.

Nuclear Reactor

Nuclear fission can be maintained as a controlled chain reaction in a nuclear reactor to produce power. Fermi had establish from experiment that slower moving neutrons were more effective in causing nuclear fission. But mainly neutrons produced by the splitting of the nuclei are quite fast. A method was required to slow them down. It was establish that sure materials slow down the neutrons. Graphite, a pure form of carbon, is one such material. Such materials are described moderators. There was still the problem of controlling the chain reaction so created, that is, to stop the reaction or allow it to proceed at will. Materials which absorb neutrons would serve to manage the reaction. The neutrons absorbed by such materials would be removed and would no longer split atomic nuclei. And the reaction would be controlled. The material usually chosen as an absorber of neutrons, is cadmium or boron steel.

The graphite block slows down neutrons to enhance the chain reaction. Manage rods of cadmium are also inserted into the graphite block. When pushed out, they absorb fewer neutrons and the reaction is speeded up.

The problem, then, is to remove the heat and use it to generate electrical power. This is achieved by circulating water, or liquid sodium to absorb the heat generated in the graphite block. This heat may generate steam, which can turn a turbine (a wheel with slanting blades) and the linked electrical generator.

Today we have reactors capable of yielding power upto 500 Megawatts. Smaller reactors which provide 1 to 5 Megawatt power are mostly used for research work. The big ones are used for producing electricity, and driving submarines, or ships. From the uranium rods used in the reactor, another fissionable material like Plutonium 239 may be obtained. Thus, a reactor set up to generate power can become a source for obtaining material for creation a bomb. India is committed to the use of nuclear power for peaceful purposes.

Hazards of a Nuclear World

The picture painted above appears rosy. Yet, it does have a few shades of grey. There are several risks associated with the use of nuclear fission power. These risks have caused world- wide debate, controversy and at times fear. Accidents have happened in nuclear power plants everywhere in the world.

In 1986, there was a major nuclear accident at the Chernobyl Nuclear Power Plant in the then USSR. Unusual as they are, such accidents raise demands fora complete ban on nuclear power plants. Though, an unbiased assessment of the past accidents designates that this is not the answer. A better solution lies in the need to reassess plant safety, devise improved ways of avoiding or containing the extent of mishaps. In India, there has been heated discussion on this issue, but on the foundation of many precautions and safety events, it has been decided to go ahead with the programme of generating in relation to the 4000 Megawatt power by this way, by the year 2000 A.D.

Another major problem is the disposal of radio-active waste material from the spent uranium rods of the nuclear reactors. Many alternatives are being tried out everywhere in the world, for instance, burying it thousands of feet deep in the earth or in the ocean bed. Some western countries were recently accounted to be dumping the highly injurious radio-active waste in African or South American countries.

From mining of the ore, to nuclear waste disposal, each step in the nuclear fuel cycle carries risks. The risks and benefits of each step depend mainly on a strict watch in excess of malfunction and human error. The challenge is to eliminate the risks and to augment the benefits

Nuclear Fusion: The Ultimate Source of Power

An power hungry world views with envy the glowing power of the sun and the stars, which are based on a slightly dissimilar nuclear procedure described nuclear fusion. Nuclear fusion takes lay when two light atomic nuclei join or fuse jointly to form one nucleus.

Well then, what stops us from tapping this source of power? The cause is that high temperature, equivalent of millions of degrees centigrade, is required to start fusion. And once the gas has been heated, it necessity be prevented from expanding; it necessity be contained. But no container walls can withstand such temperatures. Hence, entirely new techniques have to be urbanized. Much action is going approximately the world to generate power through nuclear fusion. The development of fusion power has proved to be, perhaps, the mainly hard task ever tackled. Nevertheless, if fusion reactors come into being, humankind would never again face an power shortage.

The Other Face of the Coin

The atomic nucleus, on the one hand, holds promise for unlimited power. On the other hand, it also poses a threat to the very subsistence of the livelihood as well as the non-livelihood world.

Mankind still rues the fateful days of August 6 and 9, 1945 when two atom bombs, which were given the nicknames, the Little Boy and the Fat Man were dropped by America on Hiroshima and Nagasaki in Japan. In a flash, the municipalities crumbled to dust. Hundreds of thousands of people died or were fatally injured within a few minutes. Several more thousands of survivors and their descendants are still paying the price for what may be described an unpardonable crime committed against humanity. They are not only suffering themselves but also they often provide birth to deformed or mentally retarded babies. The horrifying specter of the mushroom cloud which was observed in excess of the two municipalities haunts us to this day.

The first bombs led to the manufacture of more bombs. America was soon joined by the erstwhile USSR, and an arms race commenced with stockpiling of even more deadly weapons. Hydrogen bombs based on fusion, inter-continental ballistic missiles (each one carrying several bombs), and neutron bombs have been added to the nuclear arsenal. It is estimated that more than 50,000 nuclear weapons have been deployed approximately the world. Situated in silos, mobile trains or trucks on land, in ships and submarines under the sea, in bombers riding the sky, they are capable of destroying the world several times in excess of

And seem at what we lose in the bargain. The world spends more than I trillion dollars (in rupee conditions more than Rs. 15 lakh crore) in a year or. creation arms. The USA alone accounts for more than one third of this amount. Much of this expenditure is incurred by the developing countries like ours. Every one appears to be arming and buying from the few big sellers in the world. If money were not used for arms we could feed and clothe the whole world population, change our hovels to proper homes and remove illiteracy of our people.

The arms race causes a whole lot of economic troubles in all countries, because this is unproductive. The public all in excess of the world is worried and agitated in relation to the threat to its subsistence, and the grave economic difficulties faced by it. Only throughout the last 3 or 4 years, a ray of hope has been seen. Through a series of treaties, the USA and Russia have agreed to dismantle some nuclear missiles. Negotiations arc going on to bring in relation to the nuclear disarmament on a better level. India and the then USSR had given a call in 1986 for the creation of a nuclear weapons-free and non-violent world. With such devastating arms, countries have to learn to settle their disputes by negotiation, and have patience and mutual trust to do so. Biotechnology is another emerging technology which holds promise of unlimited benefits if utilized properly.

What is Biotechnology

Biotechnology is, perhaps, best defined as the industrial utilization of biological systems or procedures. In a sense, therefore, biotechnology has lived for thousands of years. The mainly ancient biotechnological art is fermentation. Livelihood micro-organisms have been used for centuries to create curds, condiments, cheese and vinegar, to prepare dough for bread or bhaturas. and to brew alcohol. But today we know much more in relation to the these easy procedures. With the help of powerful microscopes and cautiously done experiments in the laboratory, we have come to understand that the tiny microbes involved in these procedures are small biochemical factories. And they can be used for a diversity of purposes, related to health, medicine, food, pollution manage etc.

The skill to manage and manipulate microbes and use them for several applications has resulted in the current biotechnology. We will describe two main techniques of the new biotechnology, namely genetic engineering and enzyme immobilization.

Genetic Engineering

The contemporary biotechnology revolution is based on the understanding and manipulation of the structure of DNA. DNA is a intricate organic molecule that directs the synthesis of proteins in all livelihood organisms. Thus, it controls the physical structure, development, reproduction and function of all livelihood beings. The programme for controlling protein synthesis is coded in the chemical structure of DNA. The detection of the code, and the synthesis of DNA in test tubes, was significant milestones in genetic engineering. Though, the base of genetic engineering was laid by the detection, that DNA supplied from outside is accepted by micro-organisms.

DNA thus inserted into the cell taken from a micro-organism, enables the cells to create the proteins specified in the codes of the inserted DNA. These new cells can be cultivated or cloned, until a important number of cells are accessible to produce specific desired protein molecules.

Though, this is not so easily done. When a foreign DNA molecule enters a cell, special enzymes, described restriction enzymes, rapidly destroy it This problem was solved by the detection of the information that small rings of DNA other than the main DNA strands exist in the cells of bacteria. These circular DNA molecules are described plasmids.

A technique was urbanized to insert foreign DNA fragments into plasmids taken out of the cells. This is recognized as gene splicing and plasmid becomes a vehicle or a vector. Once the foreign DNA is joined to the plasmids, and inserted back in the host cell, the restriction enzymes fail to destroy it. When the cell reproduces, the foreign DNA is also replicated.

When the cell carries on its normal functions, the synthetic DNA in the plasmid directs the manufacture of the protein coded in it.

Thus, through genetic engineering techniques, it is possible to introduce a foreign DNA into a host cell and synthesize any desired protein. Big quantities of scarce biologically important proteins which are not easily accessible from natural sources can be manufactured in this manner. For instance, insulin needed by diabetic patients can now be produced on a big level using this technique. Just as cattle are bred for specific functions like high milk yield, or pulling heavy loads, now-a-days scientists breed bacteria for carrying out special functions. By selecting appropriate bacteria, and using genetic engineering techniques, new diversities of bacteria which can eat man-made artificial products like plastics are being urbanized. Otherwise plastic materials, discarded and thrown in garbage, arc hard to get rid off. These special bacteria are affectionately described Bugs'.

Enzyme Immobilization

The use of enzymes as catalysts is well recognized in a number of industries, such as baking or wine creation. But purified enzymes are soluble in water. It is, therefore, not easy to remove them from the final product. Further, it is hard to re-use them. Thus, enzyme action is lost in one cycle of the chemical reaction. These difficulties led to the development in the late 1960s of immobilized enzymes. The trick is to link an enzyme chemically to a big molecule, such as gelatin. It can then be used as a catalyst, and it can be extracted with the big molecule, for use once again. Immobilized enzymes have been successfully used in the manufacture of semi-synthetic penicillin and in the big level manufacture of fructose from maize. Fructose is sweeter than glucose, yet it has the similar calorific value and is used as a low calorie sweetener.

Biotechnology may be dominated by microbial and enzyme technology but it is not synonymous with them. Both animal and plant cells have their due share in its development. Biotechnological use of animal cells lies behind the commercial manufacture of viral vaccines and many proteins of high therapeutic value. Likewise, the culture of cells, tissues and organs of plants, as also breeding of improved plants are some of the regions where biotechnology is being applied. Work is also being done on the problem of nitrogen fixation by the help of bacteria establish in the roots of leguminous plants, such as peas, beans, dais etc. Thus, developments in biotechnology, agriculture and medicine are likely to undergo vast changes in the years to come.

In the similar measure as biotechnology can be useful, it, too, can be misused for developing Harmful vaccines, chemical mediators to defoliate (i.e., get rid of leaves) crops and forests, or new breeds of rodents which could cause much destruction. Humanity has to be watchful in the case of all new advances that they truly help solve human troubles rather than compound them and be a threat to human subsistence

MODERN DEVELOPMENTS IN SCIENCE AND TECHNOLOGY— II

Semiconductors

By now you have studied more than half of this course. You may have been to the study centre a few times. You might have taken lessons on audio cassette-recorders and watched video programmes on the television set. You may even have heard some programmes on the radio. All these gadgets that you have come crossways, the radio, television, tape recorders, video cassette-players are products of the semiconductor technology.

Semiconductors are the foundation of all the sophisticated electronics we have today. Digital watches, calculators, aircraft, spacecraft, satellites, telephone exchanges, lasers and several more devices have components or equipment made up of semiconductors. There is hardly a tool, appliance or thing of communication, extensive aloofness transportation, entertainment or defense that does not use semiconductor technology. These products and the semiconductors which are used in them have created great impact on several characteristics of our social, cultural and economic development. Therefore, you may like to know what a semiconductor is.

What is a Semiconductor

You also know that several materials like wood, plastic or quartz do not conduct current. Such materials are described insulators. A semiconductor, as the name designates, is a material whose skill to conduct electric current is greater than that of an insulator but less than that of metals. Silicon and germanium are the mainly commonly used semiconductors. Some other compounds like gallium arsenide, indium antimonite are also used.

The skill of semiconductors to conduct electricity depends critically upon their purity, or rather their impurity. A pure crystal of silicon or germanium acts more or less as an insulator. Though if an impurity is added to the crystal it becomes more conductive. By the method, “impurity” does not mean a 50-50 mixture or even one part of impurity in ten parts of silicon. In useful semiconductors, a ton of silicon may have 1 mg of the element arsenic. Even the tiny bit of arsenic contributes surplus electrons to silicon, which then becomes a better conductor. Such a piece of silicon would be described an n-kind semiconductor. On the other hand, a like amount of boron would cause a dissimilar type of conduction to take lay and the piece of silicon so treated would be described p-kind semiconductor. The word ‘doping’ is used by scientists to describe introduction of such small impurities.

Computer Technology

You may not have seen a computer yet. But their attendance in your life is a information that cannot be ignored. Your school spot sheets may have been prepared on a computer, the electricity and water bills that you receive may be made on a computer. If you book your railway ticket in a big municipality like New Delhi, it will be done on a computer. The cheque books issued by banks are computerized. Indeed, computers have entered several characteristics of our lives

A few decades ago, there were only a few computers in our country. They were enormous and expensive machines. They were often used for special scientific purposes. Thus, they had little direct impact on the lives of mainly people. But, because of the advances in semiconductor technology, things have changed now. Thousands of computers, from small relatively cheap units to big and expensive computers can be establish in offices, factories, schools, hospitals, banks, airports, railway stations and houses. Plans are already afoot to equip each district headquarter in India with a computer which will he connected through satellite communication with a big central computer. This computer "network" will uphold all types of up-to-date information for the whole country. Indeed computers have become a method of life with us. They have tremendously increased our capability to exchange information, undertake scheduling down to the grass roots stage and facilitate solution of very intricate troubles.

Computers at Work

The computer is a easy machine and should not be held in awe. Basically, a computer basically accepts information and stores it. It then procedures information, for instance, arranges it in some order, adds numbers or multiplies them. Finally, it produces the desired information on an output device, for instance, on a screen where it can be seen, or on paper. This is much like what we ourselves do daily. We absorb information through our senses, our brains store and procedure it and then we act. To provide an instance, if we are asked to multiply two numbers, our brain accepts the input through our eyes or ears, stores the numbers and carries out the multiplication. The answer may then be told orally or recorded on a piece of paper. The only variation here is that a computer can do all these tasks much faster than us.

Calculations and paperwork that would take weeks, months or years for us to do, can be done in a few seconds or minutes on a computer. For instance, the average individual can create 5 to 10 easy calculations per minute. The average computer can create 10,000 intricate calculations per second. Fast computers can create millions of intricate calculations in a second. And there would not be a single error in any of these calculations.

Computers can also store a big amount of data. It is because of these factors that the computers are being used in approximately all walks of life.

There are two major characteristics of computers, hardware and software, All the intricate electronic circuitry and several other magnetic and mechanical devices create up computer hardware. Computer software consists of a set of instructions or programmes which run the computer hardware. A programme is a set of instructions which the computer executes step by step. We will now describe these two characteristics in brief.

Computer Hardware

The computers used today are several and varied. But each one of them has five vital units. These five units are shown in a block diagram. You have put down input as one. If you were to use the computer, you would feed in your information and instructions using an input device such as a typewriter-like keyboard.

The information and the programme will be lodged in a computer memory which could be something like a gramophone record (described a "floppy disc" because of its flexibility) or on a tape. Once the programme is fed in the computer, the manage unit takes in excess of. It selects the instructions, puts them in a sequence and directs other units to carry out their operations. It acts like the central nervous system of the computer body.

For instance, the manage unit directs the memory to supply sure numbers to the arithmetic and logic unit (ALU) and tells the arithmetic and logic unit to add, subtract, multiply or divide numbers as the case may be. The manage unit and ALU jointly are described the central processing unit (CPU). This is the mainly significant part of a computer. Numerous transistors and components constituting integrated circuits (ICs) create up the electronic circuits of a CPU.

Finally, the manage unit enables the output to obtain finished results. The results could be displayed on a monitor like the TV screen, or could be printed on a paper by the printer. They could also be transferred to a floppy disc. The overall manage is exercised by the person operating the computer. Lights, switches and buttons enable the computer operator to monitor what the several units of the computer are doing at any moment.

Computer Software

Computer hardware will do nothing until we tell it what to do. In other words, we necessity provide it a programme to execute. A computer will do only what it is programmed to do and nothing else. It cannot think the method we do. Through proper programmes, a computer can be instructed to carry out not only easy arithmetical operations, hut also very intricate calculations and reasoning, separately from keeping accounts and creation out bills etc. There are 52 two kinds of computer software, the application software and the systems software:

Application software is a set of programmes to solve troubles or produce information or data. These programmes are written in special code or notation or languages . They are given names such as VITAL. FORTRAN, COBOL, PASCAL etc. Some are more appropriate for accounting, others for mathematical calculations or logical procedures. The systems software gives the link flanked by computer hardware and application software. The code or programming language is converted into appropriate electrical signals necessary for the operation of the hardware. The systems software is not controlled by the user, it is built into the system.

Micros, Minis, Mainframes, ‘Monsters’ and their Uses

Computers come in several sizes and have a big range of computing abilities. The classification of the diversity of computing systems in conditions of size, cost and performance is a rather hard task. Yet one does hear or read in relation to the microcomputers, minicomputers, mainframes and supercomputers (or ‘monsters'). This type of a classification is quite arbitrary. The cost and performance capability of dissimilar machines are likely to overlap. For instance, a powerful computer sold as a mini by its maker may do more computations, store more data and cost more than a small mainframe computer. Or often you may come crossways a powerful microcomputer which performs better and costs less than a minicomputer.

Small computers for use at house, office or business are described microcomputers or personal computers (PCs). A big diversity of tasks can be done on a PC. Its capability to store and handle big volumes of data has establish several uses in business. Bills and statements can be processed in much less time and with much less effort now. PCs help managers to organize and handle financial data, and plan accordingly.

A computer aided design (CAD) programme enables engineers to design and test their proposed product on the computer. In this method they are able to correct all the flaws in the trial design and come out with just the right product to manufacture. Interestingly, the intricate ICs that create up the computer hardware are themselves intended on a computer.

We use PCs as "word processors'' to kind and correct the manuscripts of the courses you read. With a typewriter, changing one misplaced word or deleting a paragraph might require retyping the whole page. In a PC, the text is stored on a floppy disc, and can be displayed on a screen, at will. We can create as several corrections, additions or deletions, as we want. We need to print the copy only after we are fully satisfied.

PCs can be connected with mainframe or supercomputers. Thus, users are now able to run their programmes on the mainframe computers and obtain results on their own PCs. As the integrated circuits technology has improved, PCs have become an inseparable part of our daily lives. Already people use PCs for preparing household budgets

At the first station, a robot pastes on each casing a computer printed label. The label tells which parts are to be fixed into which casings. At each succeeding station, robots read the label and follow the instructions. Finally, a laser printer prints the information in relation to the product onto the casings. They are then automatically sorted, packaged and shunted off to the shipping dock.

Does it appear to be a scene from 2050 A.D.? Well, it's not. This is a real scene from a computerized factory in USA. The workforce in this factory is made up of robots. Robots work under the overall manages of only four human technicians and produce 600 units per hour. What are these marvelous machines that are described robots?

An Insight into Robotics and Robots

The science of designing, structure and using robots is described robotics. And what is a robot? Several people think of robots as mechanical people that can see, hear, feel, walk and talk. This type of a robot is yet a distant dream. The robots in use today are basically computerized machines.

They can be programmed to do a diversity of tasks. Let's take a seem at a few examples that will help us understand what robots are.

A robot can be made to do a big number of jobs. For instance, a robot can drill holes of many dissimilar sizes. Robots are also made to sort vegetables, shear sheep, pluck chickens, form rice cakes and assemble mechanical parts. Robotic trains carry commuters to and from work. Robots can even assemble delicate watches and computer components. In factories, robots do spot welding and spray painting.

A robot can also be programmed to change from one job to another and can be 'taught' to handle new tasks. For instance, the similar robot could drill a hole as well as lay bolts into the holes drilled by it. A robot can do one thing for a while, then another and then yet another. For instance, it can select English character keys and put them into a few typewriters, then put Hindi keys into another few and then Arabic keys into a third batch. An industrial robot described 'T' can select its own apparatus from a rack, drill holes accurate to 0. 005 inch and measure the perimeter of 250 dissimilar parts. It helps build F-16 fighter planes.

From these examples, it should be clear that a robot is a computerized, multifunctional, and reprogrammable machine that performs a big diversity of tasks.

Though, there's more to a robot than what we've learnt yet. Through the use of artificial intelligence systems, robots have been given a wide range of human abilities. We will describe some of them in brief.

Giving Robots Sight

Robots can be made to 'see' an substance or a scene. Optical sensors in a robot record the varying brightness of light coming from the substance. To identify an substance, the computer compares its brightness at each point, with the brightness at dissimilar points of an image stored in its memory. If the brightness matches, it "sees" the substance and carries out the task it is programmed for.

Robotic vision is tailored for specific jobs. In industry such vision systems help robots to install car windows or pick objects and lay them elsewhere. 'Seeing' robots are used for easy inspection jobs, such as verifying whether bottles are filled to the proper stage. A robotic excellence manage system can be used to detect flaws in products and remove the rejected ones.

Like every modem technology, robots are also used for modem warfare. An instance of 'seeing' robots is the Tomahawk cruise missile which can carry many nuclear warheads and drop them on a target with deadly accuracy. It can be launched from a ship, a submarine or a ground unit, many thousand kilometers absent from its target. Stored in its computer memory are a series of images of the landscape beside its planned flight path. The missile surveys the landscape, matches the images with the ones stored in its memory. If it is drifting off course, it creates correction in its path. It creates a final adjustment before heading for the target.

Robot Arms in Action

A robot can be intended to act like a human arm. Robot specialists draw on the skills and possessions of both computer science and mechanical engineering to build robots with "arms" In the course of a work, the joints of a robotic arm may have to move into several positions. Hundreds of thousands of numbers corresponding to these positions are stored in a robot's memory.

Special mechanical devices in the arm translate those numbers into elementary movements.

Typical robot arms do not have fingered hands. Instead, special purpose devices are fitted to serve as arms. With the help of these devices, the similar robot could spray paint using a spray gun, or weld metals, or pick up objects to put them in an order.

Walking Robots

Sit back for a while and attempt to think of a few advantages our legs have in excess of wheels in moving approximately. Wheels can't climb stairs. They can't also step in excess of obstacles or go through narrow spaces or move on soft or uneven ground. Humans and animals can choose the foot-holds that offer the best support, especially in mountains. In information, in relation to the half the earth's surface is such that it is very hard for wheels to move on it. Creeping, climbing, balancing, walking and running are all possible for legged creatures. Our legs can also bend at knees which creates adjustment easy.

Therefore, a robot necessity is given legs so that it is able to move approximately easily. Creation legged robots has proved to be a demanding job in robotics. Although computers have been built into legged vehicles, the troubles of balance, coordination and walking on rough ground have proved hard to solve. Beside with robot movement, structure in natural flexibility, manual, touch and hearing skill in robots are active regions of research in robotics these days.

Naturally, robot eyes, ears, hands and legs have a extensive method to go before they can approach human skill. Robotic skills of sensing and thinking are elementary at best. Do not forget The fuels are other types of materials—either in solid or liquid state which have to be light, provide off a lot of power on burning, and necessity be such as to bum fast or slow according to manage. These materials have allowed loads of something like 200 tons to be lifted off from the earth by a powerful legroom rocket. 200 tons is the weight of 200 average sized cars!

Great developments have taken lay in materials which are described' polymers, and consist of extensive chains of small molecules joined end to end. Plastics arc one type of polymers used extensively in machines and devices, and so commonly even in rural regions—in the form of cups, buckets, ropes, bags, rain-coats and other clothing etc. Rubbers are also polymers. and so are ceramics from which china-ware and all types of insulators are made. There has been great development in this field. Ceramic car engines are being urbanized which will be much lighter than the present cast steel and will be able to operate at a higher inner temperature and pressure. Engine weight may be reduced to a quarter of what it is today, and power may be increased four times. Ceramic magnets are now in general use: the ratio of the magnet's force to its weight has been increased more than a hundred times. Tiny magnets have now the strength of big old-time magnets.

An region of considerable excitement is the development of ceramic superconductors working at much higher temperatures than before. It was recognized for several years that sure materials became superconducting, when they were cooled to in relation to the minus 270 degrees Celsius, i.e., a small voltage caused a vast current to flow in them, or their resistance to flow of current became almost zero. The property was of academic interest only because reaching 270 degrees below freezing temperature was itself a very hard job.

Recent excitement is based on the that that the temperature at which sure ceramics become superconductors has been establishes to be almost 170 degrees higher! This strongly suggests that with customized ceramic materials we may. one day, have superconducting materials at room temperature. That would be wonderful, as it would revolutionize all electric power generation because machines would become tiny as compared to present heavy weights. Power transmission would change radically because there would hardly be any loss of power on the wires, and so would communication systems. It could create electric trains much cheaper to run, and perhaps lead to electric cars and trucks. Then it would be possible to replace the present pollution producing and non-renewable resource (oil) using vehicles.

Without going into details of other kinds of materials used in medicine and agriculture, some produced in chemical or drug factories and others by biotechnological means, it should be clear that new technologies and new materials go hand in hand — progress in one depends on the other. The motor car could never have succeeded without great advances in metallurgy and precise machining, lubricating oils and greases, petrol technology, electrical systems, and manufacture of wear-resistant rubber, pneumatic tires, synthetic materials etc. Materials have become a subject of research and development in their own right, and science has so advanced that we are close to the location of creation materials with any desired set of properties.

Technology Forecasting

With such power of science in relation to technology, and consequently to satisfy social need, the question arises, can technologies of the future be forecast? Can one say what type of devices, machines, weapons etc. will be accessible ten years from now? This has become a relevant question from the point of common scheduling, let us say in a country like India. But equally, the answer to the question of future technologies is of interest to private manufacturers because their profits would depend on it.

The question is more intricate than it appears at first sight. The path from science to technology and then to useful devices and goods in society is not straight forward. Scientific discoveries sometimes took many decades before society made use of them as devices, and, thus, produced the need to improve such devices, and add to technology and science. It. was Faraday who exposed the laws of electric induction in 1831, on which all electric * generators and motors are based, but the generators or motors were not needed. People were doing without them. You may think why they did not use electricity for lighting houses and street. The answer is easy. The bulb had not yet been invented. When the first hot filament lamp was invented, it could not bum for several hours because good vacuum pumps were not accessible. The greater hurdle was, though, the skill to sell electricity and create profit. This was cleared only in 1881 when Edison urbanized the electric power station from where electricity could be distributed, like water, to houses and factories. Its first extensive use was in factory lighting so that workers could work for longer hours after sunset. So, the thought or detection made by Faraday had to wait for approximately fifty years before other technologies and devices were urbanized, and business could create profits from sale of electricity and longer hours of factory work.

Although waiting eras flanked by detection and application have shortened now, in some technologies they are just a few years. There is scientific research in several branches; some of it is abstract or theoretical, some applied or practical and it creates sure technologies possible. But other technologies from other regions of research and development may be needed to convert the possible into likely to be successful technology. The society necessity also be ready to utilize it, or the market necessity be there to create profit (or it necessity be created by advertising), before the likely becomes an actually accessible technology.

Of course, this is a highly simplified picture. For instance, time delays have not been shown, but they are involved at each stage, and the connections could be several more than shown here. You also know, at this stage of the Base Course, that today's great multinational corporations use advertising in a big method to make a market, to create people buy things which they could do without. They may be made ready to buy a thing basically because it is made to appear as a status symbol, or just because the neighbor has it.

The other face of the picture is that in order to foresee the technology of tomorrow, one has to stay an eye on the several regions of scientific research, as well as on social and economic characteristics—not only in one country, but in the world at big. And one who is effectively able to do so stands to gain tremendously. More scientific research and technological development can be directed so as to obtain highly useful products—unluckily, also weapons! A great amount of money is being spent by countries on research and development in order to stay ahead of others. Some countries spend a few percent of their gross national income on this enterprise.

PERCEPTIONS AND ASPIRATIONS

Science and Society Interaction

We are nearing the end of the Base Course on Science and Technology. It is time to sum up and get an overview of the connection flanked by human society and its endeavour which is described science and technology.

On the foundation of the units you have studied so distant, it would be obvious to you that science and technology are an integral part of human action and society; they were, indeed, founded when the first human beings acted to procure food or shelter. They have grown into a magnificent body of tested knowledge, and this knowledge is rising continually. Science and technology power society by improving the ways of manufacture and by bringing a change in social outlook. In its turn, circumstances prevailing in a society affect the path and the rate of development of science and technology. Let us further talk about these two characteristics.

Science Powers Whole Social Edifice

Science and technology are involved in all the procedures of manufacture, and, therefore, with all the goods we have at our disposal. The pen you write with, the paper you write on, the food you eat, the clothes you wear, the medicine you take, are a few examples. To produce these articles, work is done at house or in factories, or in the meadows and forests. Since millions of goods are needed to sustain society, manufacture has become a highly organized action. Dealing with the History of Science, how dissimilar types of social organisations arose as the ways and means of manufacture changed in a society. For instance, when individuals could not survive due to difficulty in procuring food and facing wild animals, they had to live in groups. Since they had no method of preserving food, they had to share equitably whatever was gathered by method of food. This "primitive" society changed when agriculture was exposed.

The great diversity of goods produced through industry or agriculture has to reach buyers or consumers. For that, deal and commerce and a system of transport are necessary, which science and technology have provided. You know of the detection of the wheel, which made animal drawn carts possible in the olden days. Nowadays, we have jet aircraft traveling faster than sound, and vast ships transporting grain, oil or machines from one country to another. From inter-tribal exchange of goods, we have come to have international deal. In a sense, the world has shrunk. Once upon a time, 500 km was "too distant" and one could not contemplate such a journey, then perhaps 2000 km was too distant, because the earth was thought to be flat and you could just drop off the edge, and now one can go from Delhi to London by regular airlines in eight hours!

The great manufacture system, supported by an equally great and intricate deal and transport system, has brought people and countries into greater interaction. Therefore, a system of communication has had to be urbanized using science and technology. Here again, tailings have changed from shouting to one another, or signaling with arms or lighting fires, to communicating by telephone, radio or computer. Our whole "cultural" life has thus been altered, or enriched, by contemporary means of communication. When decisions are to be made, information is needed, and that is now increasingly stored by computers and retrieved as required.

With change in the means of manufacture, social organisations have also changed. Troubles of managing big societies have continuously been tackled by evolving new ways and patterns of governance. Thus, society has evolved from the early stages of primitive society livelihood to slave societies, kingdoms, republics, capitalism, and socialism.

Science and technology have played a vital role in the transformation of human society. They have allowed us to use the possessions of the earth, the oceans and the air, and to harness the power which creates the wheels of manufacture or of transport to move, and communication to take lay.

We also need education and training for the people to man the vast network of manufacture, sharing, communication and management. Therefore, there is the need to continuously advance knowledge and to improve all products and systems for the benefit of humankind. Men and women of thoughts are needed, whom an educational system suited to a scrupulous society could help to train. Such an education system itself would be based on science and technology. For, instance, printing presses to produce books, factories to produce paper, audio-visual aids, all types of tools needed for laboratories are products of science and technology. In addition, science and technology would also power the thoughts, philosophy and attitudes prevailing in our times.

Society Powers Scientific Development

But just as science and technology give all the "nuts and bolts", as well as several of the thoughts that hold our society jointly, society itself gives the environment and atmosphere for science and technology to either grow fast, or stagnate or even decay! Science and technology do not exist independent of the society, its culture and the value system. They are a part of the socio-economic and political framework of a given society.

Motivation for the practical application of science and, hence, its development and use comes from the economic needs of the society. The economic scheduling and policy of a society determine its social programmes and the purposes and goals of societies manufacture action, which in turn gives the incentive for scientific development. Though, answers to questions like what type of economic policy will be pursued, whether the social programmes will be implemented, and to what extent, depends on the political and social organisation of a society. Thus, science and technology can be more directly influenced by the common policies and social structure of a society.

For instance, when economic development is purely determined by market demands, artificial demands for goods are created by advertising, even though there is no pressing need for them Thoughts of people are sought to be molded by propaganda accepted on by radio or television or even by education. The competition to produce more goods, augment profits or the desire to give fancy goods to an influential part of a population results in one type of development of science and technology. On the other hand, if a society desires and plans to improve rural life or provide priority to public health or give a sure stage of nutrition to all citizens, the tasks and consequent development of science and technology should follow a dissimilar path.

Still another instance is the question of spending money on weapon of offence or defense that naturally affects science and technology. It is recognized that the world today is annually spending Rs. 15 lakh crores

(15xl012 rupees) on weapons and their development. This not only takes absent money needed to feed, clothe or give health and shelter to people, but it also prevents the development of science and technology for constructive purposes.

Need for a Systems Approach

Science and technology cannot be advanced by viewing them in separation. The whole social, economic, and political system will have to work in unison so that all round advancement can take lay.

Primacy of Social Objectives

Furthermore, we see that every thing has two sides — the good and the bad. Science and technology can benefit people; we can protect our environment, create good use of earth’s possessions, give enough food for all, and cure diseases. On the other hand, one could develop weapons of mass destruction; in information, the world arsenal of nuclear weapons is so big that just 1% of it, used deliberately, or by some error, can destroy all life on earth. The choice is to be made by human beings constituting society.

Society can be so organized as to maximize profits or to maximize human welfare. Society may put emphasis on “economic development” which may create the rich richer and the poor poorer, or it may choose to combine development with egalitarian sharing of benefits. Society may emphasize industrialization, irrespective of what impact it has on human environment or the finite possessions of the earth, as has been happening in some countries ever since the Industrial Revolution in the middle of the 18th century. Or society may choose such technologies or such industries as tend to preserve our possessions and livelihood environment.

It is obvious, that first of all, any country, such as India, necessity clearly spell out a constant set of social objectives that it wants to achieve. Then, the tasks can be set for several sectors, such as industry, agriculture, transport, communication, health and education etc. The science and technology either accessible or to be urbanized can then be visualized. Scheduling and gradual attainment of targets are necessary to get to the desired goals.

Healthy social thinking which reflects one's concern for others, and a responsible social action stemming from that are needed. And if this Base Course in Science and Technology has helped to generate such thoughts, it has served a truly educational purpose

With this overview, you would be able to read the following short account of scientific and social development of our institutions.

Development of Science and Some Social Thoughts

In antiquity, when human beings picked up a stone, and threw it at another animal, either to kill it or to save themselves, the first step in the development of science was taken. With the rising use of detection and invention, their pattern of development became markedly dissimilar from that of other animals, and a intricate set of social institutions grew approximately them. This also posed before them two sets of troubles, which beset them even today:

- Manage of the material world, and
- Manage of human beings.

Manage of the Material World

Human culture has evolved through a number of significant steps: from use of stone implements to use of copper (c. 5000 BC) to the invention of wheel (c. 3500 BC) to use of iron (c. 1500-1000 BC), and to more recent developments in the use of several metals. On the power front, fire was exposed extensive ago. Traditionally power has been supplied by human and animal muscles, wind and flowing water. Use of steam in the 18th century ushered in the industrial revolution. Now of course, other sources of power such as nuclear fission have become accessible.

The experience gained in dealing with the world of materials resulted in creation of knowledge, which when abstracted and systematized became science; and when applied to develop new articles and the procedures of creation them, became technology.

Manage of Human Beings (h2)

The art of acquiring knowledge, and using it for creation the articles needed brought dissimilar people jointly in a general endeavour. With rising complexity of jobs to be performed, the problem of initiating and directing people to perform the jobs came to be of critical significance. The task was divided into two broad regions; actually doing the work, and directing it. Consequently, people were also divided in two categories, those who did the work and those who directed them. With the advent of agriculture, it became possible for human beings to produce more than their need, and, thus, it became possible for some to live without actually doing any work. The invention of writing, further strengthened the division. Those who directed others to do the work became guardians of knowledge. As this division hardened, the question of creation people do things which were required to be done, became more and more significant. Techniques had to be urbanized to create people acquiesce into the scheme of things organized by the guardians of knowledge, who existed on the surplus produced by those who labored, without doing the work themselves.

Looking back at the development of human society, it appears that three approaches to manage human beings have been followed:

- Obtaining voluntary co-operation
- Through disciplining, such as in the army, and
- By instilling fear.

The use of a scrupulous technique depends upon the kind of society. To organize an equitable and just society, the technique of voluntary cooperation was adequate. This technique meant an understanding, on the part of citizens, of the issues involved, and dissemination of the existing knowledge. In the past it was, sometimes, done by religious leaders and later by political parties. In societies in which a few existed at the expense of others, cornering all the gains to themselves, the other two techniques were used. To augment the efficacy of these techniques, a number of stratagem were employed. Severe punishment was prescribed for breaking the prescribed rules; fatalism was encouraged; rewards were promised in the after-world that is after death; and myths were created to justify and perpetuate superiority of a small segment in excess of the vast majority.

The problem of controlling people created a dual vision: of an equitable and just society as preached by religious prophets, social reformers and political thinkers, and of unlimited manage of a few men in excess of a big number, to create them obey their command and do things at their bidding. In this procedure, it may appear ironical that the manage of material possessions (which created the foundation for bringing people jointly) became secondary to manage in excess of people. The more was the society patterned and command, the greater became the use of materials to manage them through propaganda machinery and weapons of coercion and war. Though, manage of human beings has been establish to be distant more hard than the manage of materials of all types.

Relevance of Past to Present

One may question the relevance of all this to modern society. Why should one be concerns at all with what has gone before? Is it not better that attention be directed to the troubles of the present rather than go back into history?

Our contention is that, though the level of the present day troubles is dissimilar, they, nevertheless, are in essence a continuation of the age old dilemma of the manage of human beings. Should it be done through voluntary effort, by creating an understanding of the troubles and in the light of existing knowledge, by motivating people towards a general cherished goal and to arrive at decisions by participation of the people? Or, should men and societies be controlled for the benefit of a few, maintaining a high stage of ignorance and fear? The form of the future society would depend on the decisions which are taken now.

It is a information of history that the crisis of each of the earlier societies led to their total disruption. An unjust society, maintaining inequality, cannot last extensive. The wasteful use of materials makes an economic crisis which cannot be overcome without reforming the society. Each reform or re-arrangement of society created the hope and vision of a just society, soon to turn sour, leading again to a new unjust society based on inequality.

Several countries of the world, today, are passing through one or the other stage of a crisis Before a closer seem is taken at the present crisis, it may be worthwhile looking at how some of the characteristics of the present society have appeared since the Industrial Revolution

Science and the Creation of New Vision

Rapid development of science in Europe, almost 350 years ago, when the working of the material world began to be clearly understood, created a great sense of confidence in human intellect. And it generated a hope that cause would be used in social matters too in order to solve troubles and improve circumstances of livelihood for all. It created the possibilities of a new prosperity and brotherhood of men. The development of technology generated new possessions, particularly in conditions of steam and electric power and it provided to people, materials and products hitherto outside their reach. Each new step, each new success, created new aspirations and hopes, and generated the feeling that a world-wide fair and just society, bestowing dignity to man, would be created.

In the procedure, results were achieved and startling new opportunities were created, but soon the vision and hopes turned sour. The capabilities generated by the development of science and technology started being misused for the purpose of use of human beings and whole societies, and for the purpose of conquest and destruction. The beneficial uses which should have been shared by the people at all stages of society were limited to, and served, only a small group of people and a few countries. For instance, inequality in the middle of people sustained unabated in England, the use of the Indian possessions and dumping of British goods in India created greater poverty here and ruined Indian handicrafts and industries. Freedom of the Indian people was trampled upon. Numerous wars were fought for the possession of colonies, and this became more and more destructive because of advances in technology of weapons.

In the last five decades, several countries have thrown off the colonial yoke. Though, since they still depend on the urbanized countries for scientific and technological know-how

they are now able to create their choices in relation to the method they want to develop. A rising realization of this situation has appeared in the middle of the people of these countries.

New Perceptions and Aspirations

These developments and disappointments with the social outcomes of scientific advances have served to awaken scientists to a new dimension of troubles which had been glossed in excess of so distant. It is instructive for us to have a glimpse of what new perceptions are arising.

Contrary to the belief held until a few decades ago, that man, society and environment have infinite capability to absorb technology, it has been establish that serious damage is being caused to all three. Therefore, alternatives are being thought of.

In the last few hundred years, greater emphasis has been laid on the rights, privileges, intellectual development and the like of the individual. At the similar time, technological innovations have been aimed at meeting individual necessities, in information, even individual fads and fancies. All types of goods, whether they are clothing or fashion items, or food and smoke or even entertainment are intended, with numerous alternatives for each, and advertising is done for promotion of their sale. It has come to be realized that in doing so, a heavy cost has been paid in conditions of wasteful utilization of scarce possessions, consumption of power and other troubles linked with urbanization. Let us take the instance of creation motor cars each one more beautiful, better and shinier than the other. It involves spending a great deal of petrol for the need of one person. Besides, roads are being choked with traffic, and the environment is being loaded with fumes, while mainly people travel in crowded buses with great discomfort. It is being felt that to fully utilize manufacture capacities and to avoid wasteful consumption and other troubles, individual options have to be limited and social solutions have to be establish and promoted.

There was a time when scientists pressed unconditionally for more money to be spent on scientific research. But in this case also, the situation is changing. Vast amounts are being spent on research; either on weapons, like more powerful bombs or on systems of delivering them by planes, rockets and missiles. It is being increasingly felt that this type of research and the use to which it is put only threatens humanity, while not enough is being done to eradicate diseases. Firstly, the opportunity was seized by some in advanced countries to attack science itself, rather than its misuse. Science is portrayed as if by nature it is a disrupter of human values and societies and an instrument of use. The other trend is to assess technological solutions in conditions of their human, social and environmental consequences, and to subject the choice and application of technology to such a total assessment.

One can say that these developments spot the end of the euphoria towards science and technology and the emergence of more sober and mature views on technological developments and their applications.

In the era when technology was measured an unmixed blessing, it was whispered that technological developments had an inevitable direction, starting from the simplest to the mainly complicated. For instance, the historical development of the manufacture of power was measured to be “progress” from the use of wood to nuclear power, through several inevitable intermediate stages. Though the power crisis and the health and environmental hazards related to big industries pumping pollution into the air, rivers and the sea, and rapid consumption of finite possessions of the earth, such as coal, wood, oil etc. have directed attention to the non-conventional sources of power, which used to be utilized extensively prior to Industrial Revolution. There is a realization that it is no longer possible to continue to use possessions indiscriminately, on the level at which they have been used so distant. This has directed attention to the use of raw materials and generation of power from renewable sources, such as wind, water, biogas, sunlight etc.

In conditions of scientific research, this has given great significance to research in new meadows, in order to develop new technologies.

Such perceptions in relation to the science, technology and society have establish reflection in the rising aspirations of the peoples of the developing world. The developing countries have in the recent years tried to bridge their social barriers to set up relationships which help them in breaking the vicious circle of under-development. Their peoples have raised demands for self-reliant development and a sure minimum excellence of life for all sections of the population. Realization has also grown that science and technology can be harnessed to meet social goals.

SCIENCE - THE ROAD TO DEVELOPMENT

Quest of Prosperity for All

There is an all-round desire to make a society where every one can equally draw the benefits of development and is provided a minimum decent average of livelihood. As we have said earlier, science and technology by themselves do not ensure social justice or equity; these are goals of a society and a people, in the pursuit of which, science and technology can be of great help. In India, the Parliament passed a Scientific Policy Resolution in 1958, which is said to have been drafted by our first Prime Minister, Jawaharlal Nehru. This point was made in the document by saying that the very thought of a welfare state (which became popular in several countries) is based upon the skill of science and technology to help us produce enough of everything-food, medicine, clothing, housing materials and so on, so as to be able to fulfill the needs of all.

Internationally, though, there is hardly any movement or desire to create the benefits of science and technology accessible to all inhabitants of the world, cutting crossways national and political boundaries. The world remnants divided. There are now two well-defined categories of nations: industrialized or urbanized countries; and others, optimistically described "developing" countries (in lay of the more blunt conditions such as poor or semi- industrialized or non industrialized countries. The developing countries are also recognized as Third World countries, although there is no "second world".)

The disparities flanked by the urbanized and the developing countries are tremendous, and by all accounts they are only rising, because of the advanced stage of science and technology possessed by the urbanized countries. There are several methods of expressing these disparities. For instance, three quarters of world's income, investment, services and approximately all research are in the hands of these urbanized countries, which symbolize one quarter of world's people. Per capita grain consumption in the USA increased from 700 kg in 1965 to 900 kg in 1975- an augment of 200 kg per: head- which is approximately the total per head consumption in India per year. Likewise, power consumption per head in the United States is so high that if the whole world consumed at that rate, the planet's non-renewable possessions would be finished in a decade. The disparities were built mainly in the colonial era, as explained earlier, but the advantage once gained has been increased with the help of science and technology.

Technology as a Tool of Power

Manufacture of knowledge and its dissemination through books, journals, magazines etc. is very mainly in the hands of the urbanized countries. It is estimated that these countries spend in relation to the 98% of all money that is spent on scientific and developmental research. In the remaining 2%, all the more than 100 developing countries including our own, have a share!

We, in India, have hundreds of research laboratories, and we are proud of this- but when we compare our effort with that of the urbanized countries, we realize our limitations. Our expenditure in R&D is not as productive, because much of it goes into maintaining personnel and laboratories. The equipment, which has to be mainly bought from the urbanized countries, is not the latest. Besides, our science and technology lacks the linkage with the procedures of manufacture. The productive system in our society is still so backward usually, that it does not create several demands on our indigenous R&D. At the slightest necessity we import technology, machines or other equipment, at times even when such needs can be met indigenously.

Furthermore, we are affected by the phenomenon of brain drain. It is estimated that secure to a million scientists, technologists and medical persons from the developing countries are livelihood and working in the urbanized countries. The reasons are several. The urbanized countries have more challenges and better opportunities to offer. There is lack of demand on high excellence sophisticated science and technology at house and, therefore, employment opportunities are scarce. This flow of trained human possessions to the urbanized countries is of more value, even in monetary conditions, than all the aid the developing countries receive from them.

It is not surprising then that all new inventions emanate from urbanized countries They make technological wonders, and we have only to wonder! For everything we want to do in an up-to-date manner- create special kind of steel, of fertilizer, or aircraft - we have to seem for technology from the urbanized countries. If we produce goods with out-of date technology, we will not be able to sell them in a competitive market.

Much of the science and technology being urbanized in the advanced countries is in regions which do not even exist in mainly of the developing countries. Even a country like ours, which is bit forward, cannot take full advantage of the major developments in several regions of science, either because of secrecy or because the techniques used are too sophisticated. The urbanized countries spend billions of dollars per year on synthetics, plastics, fibres, glasses etc. In several cases, these products tend to displace the raw materials produced by the developing countries, such as rubber, cotton, tin, vegetable oil etc.

Furthermore, the technologies evolved in urbanized countries are capital rigorous and use much less labour. Thus, by importing such technologies, we end up spending more capital, our labour force is under-utilized and the goods produced have a higher price so they cannot sell in the international market. Thus, the superior excellence of science and technology in the advanced countries has a none too healthy effect on our own science and technology. It also perpetuates our common backwardness, through the benefits do accrue to a small privileged part of our population.

A important change has taken lay in the world. The collapse of the Soviet Union has made the word unipolar, with USA as the solitary superpower. Throughout the last few years, India has been creation concerted efforts to liberalize its economy to integrate it with the world economy at big, and to permit ever-rising interplay of market forces.

In the changed circumstances, it would be necessary to strike a balance flanked by purely economic forces on the one hand and social forces on the other. It is imperative that all obstacles in the path of rapid industrialization and structure of strong infrastructure are removed, that competitiveness, excellence and profitability become the mantra of our factories and manufacture centers. At the similar time, it is imperative that people and their troubles are not ignored, that extensive-standing troubles pertaining to poverty and social justice are solved quickly. The key phrase of the new economic era should be manufacture of industrial wealth accompanied by social justice.

New International Economic Order

The developing countries mostly threw off the colonial yoke in the 1940s and 1950s, and ever since they have been struggling to stand on their feet for the type of development which would benefit their people. You would have realized that a crying need of our times is development which would satisfy the national needs as well as the aspirations of the general people of the developing countries. Right now, there exists a cumulative backlog of poverty, ignorance, ill-health, unemployment and untold misery in the middle of vast sections of populations in these countries. These troubles are mounting day by day. Lack of resource for all-round human development is recognized to be continuing cause of explosive development of population and environmental pressures. Several of the countries have tried to reconstruct a society where satisfaction of the minimum needs of the whole population would be the first priority of development. But this development has mostly eluded us.

We have not been able to create policy choices in keeping with our national needs and aspirations. The strategic, industrial and commercial interests of the countries criss-cross in the highly interdependent world of today. Experience has shown that the developing countries are forced by circumstances to do what suits the urbanized countries mainly. For instance, to defend ourselves, we have to buy contemporary weapons from the urbanized countries, and replace them as new weapons are introduced by them; we buy modem goods or import technologies from them to produce those goods.

This has given rise to discussions in the developing countries in relation to the adopting a totally dissimilar path of development, i.e., a path of development which would not be an imitation of the stages through which the urbanized countries have passed. The term “alternative development strategies” is used for this purpose. We would not be copying any one, we would be finding our own method of satisfying the mainly urgent needs of our people.

We would like to evolve a new economic and political system, which would combine competition and enterprise with human welfare and scheduling. A strategy would have to be urbanized in which the character, content, direction and pace of development would be firmly under national manage. The strategy would need to be followed by a plan to rearrange manufacture, to mobilize possessions and allocate them to all relevant sectors.

Steps would have to be taken to generate and put to use appropriate science and technology for national development.

Internationally, such feelings were so strong that, in 1974, the United Nations passed a resolution described the “New International Economic Order Declaration and Programme of Action”. We provide you just a few rows from it, which reflect the circumstances which prevail.

Para 1 of this resolution say, “The greatest and the mainly important attainment throughout the last decades has been the independence from colonial and alien power of a big number of peoples and nations which has enabled them to become members of the society of free peoples. Technological progress has also been made in all spheres of economic behaviors in the last three decades, thus providing a solid potential for improving the well being of all peoples. Though, the remaining vestiges of alien and colonial power, foreign job, racial discrimination, apartheid, and neocolonialism in all its shapes continue to be in the middle of the greatest obstacles to the full emancipation and progress of the developing countries and all the people involved. The benefits of technological progress are not shared equitably by all members of the international society. The developing countries which constitute 70% of the world's population, explanation for only 30% of the world's income. It has proved impossible to achieve an even and balanced development of the international society under the existing international order. The gap flanked by the urbanized and the developing countries continues to widen in a system which was recognized at a time when mainly of the developing countries did not even exist as independent states and which perpetuates inequality."

Para 4 spells out the principles on which the New International Economic Order can be based. To quote, " The new international economic order should be founded on full respect for the following principles ... full permanent sovereignty of every state on its natural possessions and all economic behaviors . In order to safeguard these possessions, each state is entitled to exercise effective manage in excess of them and their use with means appropriate to its own situation including the right to nationalization or transfer of ownership to its nationals, this right being an expression of the full permanent sovereignty of the state. No state may be subjected to economic, political or any other kind of coercion to prevent the free and full exercise of this inalienable right", and further

"Just and equitable connection flanked by the prices of raw materials, primary products, manufactured and semi-manufactured goods exported by developing countries and the prices of raw materials, primary commodities, manufactures, capital goods, and equipment imported by them with the aim of bringing in relation to the sustained improvement in their unsatisfactory conditions of deal and the expansion of the world economy."

This should given you and thought of the type of situation which prevails in the world economic dealings, which if. to the great disadvantage of countries whose industry, science, technology and social development should receive a boost now.

Exploded Myths

Experience has shown that some thoughts which were popular soon after the Second world war (1939-45) are not valid in practice. It was thought that the highly industrialized countries, or the urbanized countries, would serve as a “bank” from which capital, skills,

technology and management could be transferred through “aid’ which could raise life to a better excellence in the developing countries. It was the common belief in the middle of scientists that modem science and technology could flow freely to our developing countries for the benefit of our people. These thoughts or premises have been establish to be mainly invalid.

As summarized in an significant international symposium, Pugwash on Self-reliance, “the information [is] that the [supposedly global] technological revolution has been conceived, planned and executed so as to enable the attainment of the economic and security goals of the highly industrialized countries; what is more, it has also been contributing greatly both to the unprecedented scarcities of vital possessions and to serious misdistribution in their use, with a steadily superior share being consumed by the industrialized nations”.

In this connection, it would do us well to keep in mind the information that the key of human progress is Knowledge. After we were able to win our freedom, the urbanized countries were no more in a location to put any restriction on the spread of knowledge in our countries. But they have played a part in maintaining a great variation in the stage of knowledge accessible to them and that accessible to us.

Even in science and technology, knowledge is restricted in its flow due to potential application, which could lead to developing countries creation new types of products. There are deal secrets, as also government imposed restrictions on spreading knowledge in relation to the fresh scientific and technological discoveries. In superconductivity, for instance, what is being freely published is just a fraction of what is being exposed in the laboratories of the urbanized countries. So is the case with biotechnology, lasers, nuclear science, electronics and several emerging regions. They don't want us to be able to convert some of the thoughts into products, which may discover markets in their countries, or shut off our markets to them.

Not only that, there are many instances to illustrate that if a developing country like ours develops its own technology in a scrupulous field, all efforts are made to scuttle it. It is not unusual to discover frustrated researchers in our country whose dedicated efforts were put to waste by importing the procedure or the product at the last moment.

Self-Reliance

On the foundation of this historic lesson on harsh realities in relation to the science, technology and national development, a new concept of "self-reliance" has become popular, particularly in the middle of the developing or the third world countries. It is realized that for the developing countries, freedom of action is crucial, which is impossible in a state of dependency, in which the individual or the nation will always be at the mercy of the benefactor. Therefore, a country has to build up its science, technology and economy in such an integrated method that it can take and implement decisions independently, in its own interest, irrespective of external pressures, while at the similar time participating in the global order. Self-reliance can also be said to be a state of mind that promotes confidence in oneself, and one's skill to determine one's destiny. The thought can be given meaning by expressing it in dissimilar methods. For instance, if there are choices in economic or social objectives, those should be given precedence, which can be fulfilled with a minimum of dependence on other countries. If there is a choice in setting up industries, those should be preferred which can be set up with our own effort. If there is a choice flanked by technologies, those should be adopted which rely on what is accessible in the country and so on. Naturally, this has to be accompanied by scientific and technological development in our own institutions, backed up by appropriate education, training and research. Thus, the regions of our choice should be constantly enlarged.

Self-reliance does not mean shutting ourselves off from the world of science and technology, or stopping import of whatever is essential or unavoidable, but to constantly strives and plan to enlarge the scope of "avoidable". The implication is that luxury goods, whether in manufacture or in import, ought to have the lowest priority. To run trains at 200 km/hr is not as urgent, since materials and technology would have to be imported; as running more trains or opening up more routes to distant absent parts of our country. In matters of national defense, the scope of what we can produce by our ever-advancing technology should be enlarged, but then whatever is left and needs to be updated can be bought.

Perhaps, you can see that self-reliance as a policy admirably fits with the objectives of tackling troubles which concern big masses of people. 70% of our population lives in Villages and hardly uses anything which requires imported goods or technology. Even if pulses or edible oil are imported today, we can easily augment our own manufacture. Our big population does not need so several types of tooth pastes, shampoos, electric shavers etc; but it does need food, medicine, clothing, shelter and the like. Economic and technological effort directed to uplift their condition would not require leaning on other countries and exposing ourselves to their blandishment or pressure or foreign exchange. On the other hand, betterment of the circumstances of livelihood of the general people is bound to contribute towards greater satisfaction and consolidation of the nation, rising our inner strength. It can be said with justification that such self-reliance would be in accordance with what father of our Nation, Mahatma Gandhi preached, and personally practiced. His word for it was Swedish.

Propagation of Swedish was an significant ideological weapon in our freedom movement. Besides the enlistment of economic circumstances and improvement of common welfare, it brought in relation to the an awakening which afforded Indian people the strength, unity and above all the deep love and respect for their culture and heritage. This type of weapon was used by Gandhiji from district stage down to the village stage, and the whole country was roused.

You can perhaps also see that self-reliance of the type we are discussing involves choices made and actions taken at dissimilar stages, the individual (self-confidence and fulfillment of personality), village, district and State or shapes, factories, schools, research institutions. So, it has to become a movement in which people participate - and for the country as a whole, it becomes a new strategy for development.

Science and Technology for National Development

Science and technology are a major national resource and a vital element in the task of achieving self-reliance. With the ideal of self-reliance, what role can science and technology are made to play for national development? As you know, the needs for food, shelter, clothing, health and education for all are still the mainly pressing needs of our society. A rapid fulfillment of these needs would need new advances in agriculture, food technology, health science and medicine, structure materials, clothing, tapping new possessions etc. Solution of troubles relevant to our own society or economy poses a fundamental challenge before our scientific and technological action. And in pursuing this challenge, new questions and new answers, new technologies and new regions of scientific work are bound to emerge To tackle the troubles experienced m such an endeavour would need the ingenuity and possessions of men, materials and thoughts.

In India, we have a great potential of material possessions and intelligent people. We have also a democratic system where thoughts can be tested and the best can prevail. The task is to optimize knowledge of all types, whether in social science, natural sciences or technology, by creation it accessible to the main number. It would do our society well to produce at all stages of education, creative and critical thinkers who can use the scientific way to question the social reality on the foundation of relevant, data and troubles. There is a need to re-look at thoughts which have been uncritically accepted by the people as well as the political and administrative set-up in our society. The task of getting out of the vicious circle of under-development should not be under-estimated. Science, technology and other types of knowledge have played a crucial role in establishing the present structure of societies, their deal, industry and sharing of benefits. Let us hope that they will also be made to play an rising role in taking our country to the right path of future development.

REVIEW QUESTIONS

- Discuss briefly the role of media in extending educational opportunities, enriching learning experience, and creating a learning environment.
- Describe the role of technology in mass communication.
- Describe the role technology can play in improving productivity, leading to economic development.
- Discuss the aims and objectives of our technology policy and also explain the different aspects of transfer of technology.
- Explain the functions of rockets, artificial satellites, and space probes.
- Describe nuclear fission, nuclear fusion, and a nuclear reactor.

- Describe briefly the working of the five basic units of a computer, and distinguish between computer hardware and software.

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