OVE 105

THE SCIENTIFIC METHOD

"If they do not depend on true evidence, scientists are no better than gossips."

- Penelope Fitzgerald

"It is a good morning exercise for a research scientist to discard a pet hypothesis every day before breakfast. It keeps him young."

- Konrad Lorenz

"It is a capital mistake to theorize before one has data"

- Sir Arthur Conan Doyle

2.0 INTRODUCTIC

Science may be defined in terms of either knowledge or method. Scientific **knowledge** is the total body of factual material, which has been accumulated (by scientific **method**) relating to the events of the material world.

Scientific investigation may begin in response to observations made by scientists or in response to some internal 'inductive' process on the part of scientists. Those aspects of knowledge which are described as scientific must, as contemporary philosopher of science Karl Popper has stated, be capable of 'refutation'. This means that the facts of scientific knowledge must be testable and repeatable by other scientists. Thus it is essential that all scientific investigations are described fully and clearly. If investigations yield identical results under identical conditions, then the results may be accepted as valid. Knowledge which can not be investigated as described above is not scientific and is described as 'metaphysical'. **Facts** are based on **observations** obtained directly or indirectly by the senses or instruments, such as light or radio telescopes, light or electron microscope and cathode ray oscilloscopes, which act as extensions of our senses. All facts related to a particular problem are called **data**. Data can be values derived from scientific experiments, most often expressed in numerical form, or data may be considered factual information – especially information organized for analysis or used to reason or make decisions. The word data originated as plural of the Latin word *datum*, meaning "something given." Scientists use data to test what has been observed in nature. Observations may be **qualitative** (that is describe colour, shape, taste, presence and so on) or **quantitative**. The latter is a more precise form of observation and involves the measurement of an amount or quantity, which may have been demonstrated qualitatively.

Scientific knowledge is obtained fundamentally by careful observation of the behaviour of Nature. A particular natural event is called a **phenomenon**. The scientist, in seeking understanding of how a phenomenon takes place, first uses his training and background in making an intelligent guess as to what is really happening. This guess is called a **hypothesis**. Hypotheses are scientific hunches. Scientists use hypotheses to formulate a logical explanation for a single event, pattern of events or a phenomena. Scientists who formulate hypotheses state formally what they predict will be the outcome(s) of a given experiment before beginning the research (Barhydt & Morgan, 1993). Scientists state hypotheses so

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they can test the "hunch" against reliable observations (i.e., data). Support for a hypothesis occurs when research findings advance the predicted outcomes. In other words hypotheses are neither right nor wrong; rather, they are supported by evidence or unsupported by evidence. Hypotheses can be tested by experiment; based upon the results of this research, hypotheses are sustained or denied supported or not. The scientist then undertakes a series of experiments in which he permits the phenomenon to occur over and over again under carefully controlled conditions. On the basis of these tests he gathers evidence, which either supports his hypothesis or causes him to reject or modify it. When the weight of evidence seems to indicate that his hypothesis is sound, he then announces his findings as a **theory**. If his theory is subsequently proven to be a non-varying performance in Nature, he is said to have discovered a natural **law**. Theories and laws are then applied to other phenomena to increase understanding of them and to adapt them in refining or creating products for man's use.

A highlight of the steps in the scientific method to discover scientific knowledge is as follows:

1. Make a clear statement of a problem
   - Try to understand the problem for which you seek a solution.
2. Collect information or data that relates to the problem
   - Obtain as much information as you can from the organized knowledge that is found in books and other written records.
3. Form a hypothesis
   - Form your own hypothesis or 'best prediction based on available information'. A hypothesis is a proposed solution for a problem. Do this after carefully studying the facts and ideas relating to the problem.
4. Test the hypothesis
   - Design and perform some experiments to see if your hypothesis is acceptable. You may be able to reason your way through some problems. However you will have to test your ideas by trying them.
5. Accept or reject the hypothesis
   - Acceptance or rejection of your hypothesis should be based upon evidence obtained in an experiment. However in some cases you may change a hypothesis to fit the facts uncovered by testing.
6. Communicate the results
   - You must inform others of your work, so they can reproduce your work thereby test your experimental results.

Another version of the scientific method can be seen in Figure 2.1.

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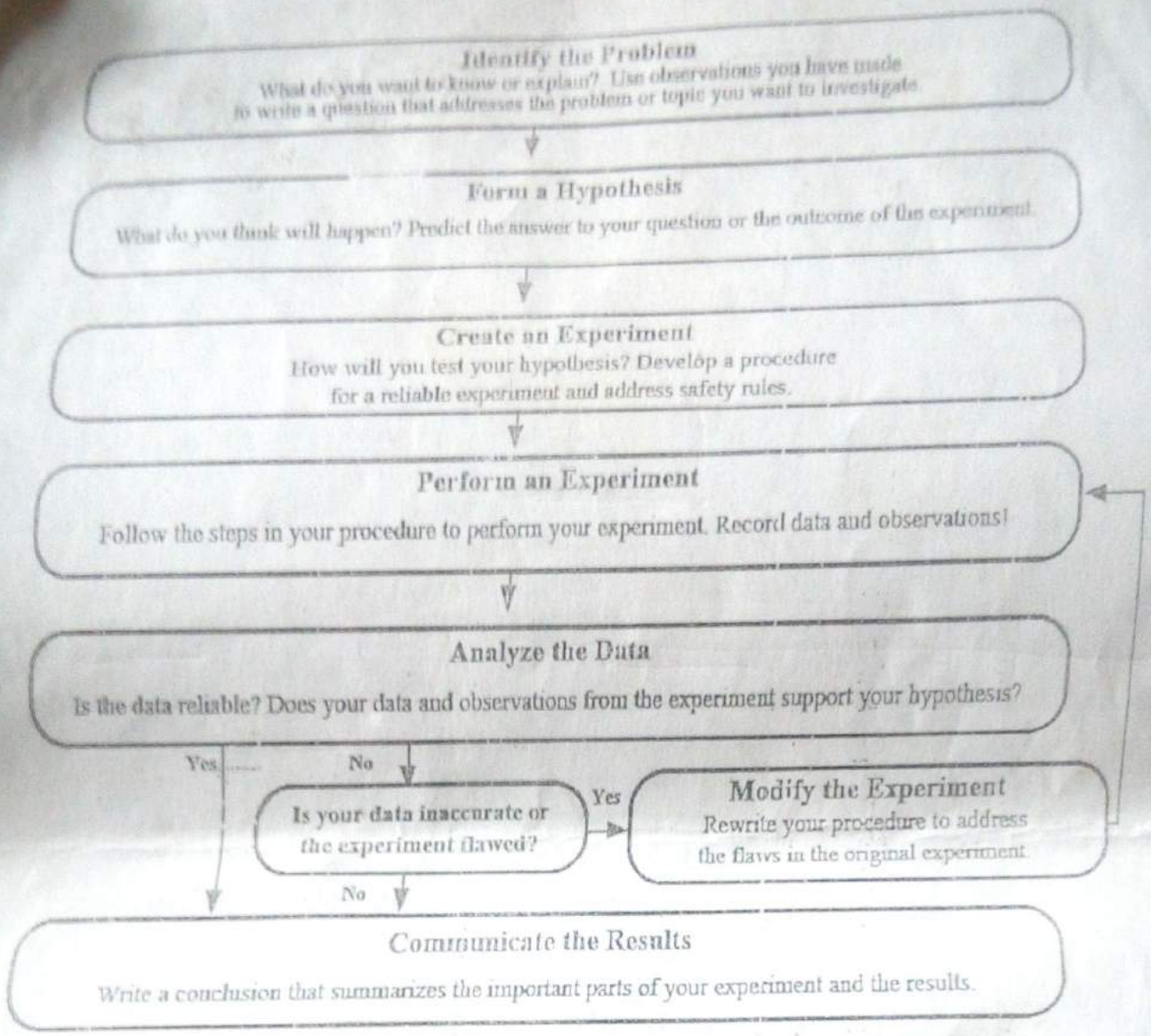

Figure 2.1: Illustration of the Scientific Method

In actual practice, these methods might not be followed in the order listed here. Studies of the work of successful scientists show that the process of problem solving is not a step-by-step process. Scientists are creative people and they approach their work in varying ways. Skill, luck, intuition, serendipity, trail and error and intelligent guessing are also involved in their success.

In the early days of science, it was common for one man to carry on this entire process alone. The contributions of these early scientists to man's knowledge and understanding of Nature were monumental, and yet, because of the limitations of the conditions under which they worked, erroneous theories and even false laws were generally accepted for a time. As the number of skilled men carrying on the work of science increased, errors became less common and knowledge of Nature was rapidly unfolded. Today it is much more common for teams of skilled scientists to work together on a single project, each member contributing to the

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solution of the problem from his own special background. The work of these teams is called **research**. Basic research is concerned both with checking and rechecking of apparently sound theories and with the persistent search for deeper understanding of the behaviour of Nature. Applied research, on the other hand, is concerned with the application of scientific knowledge to the development of new and better products for consumers.

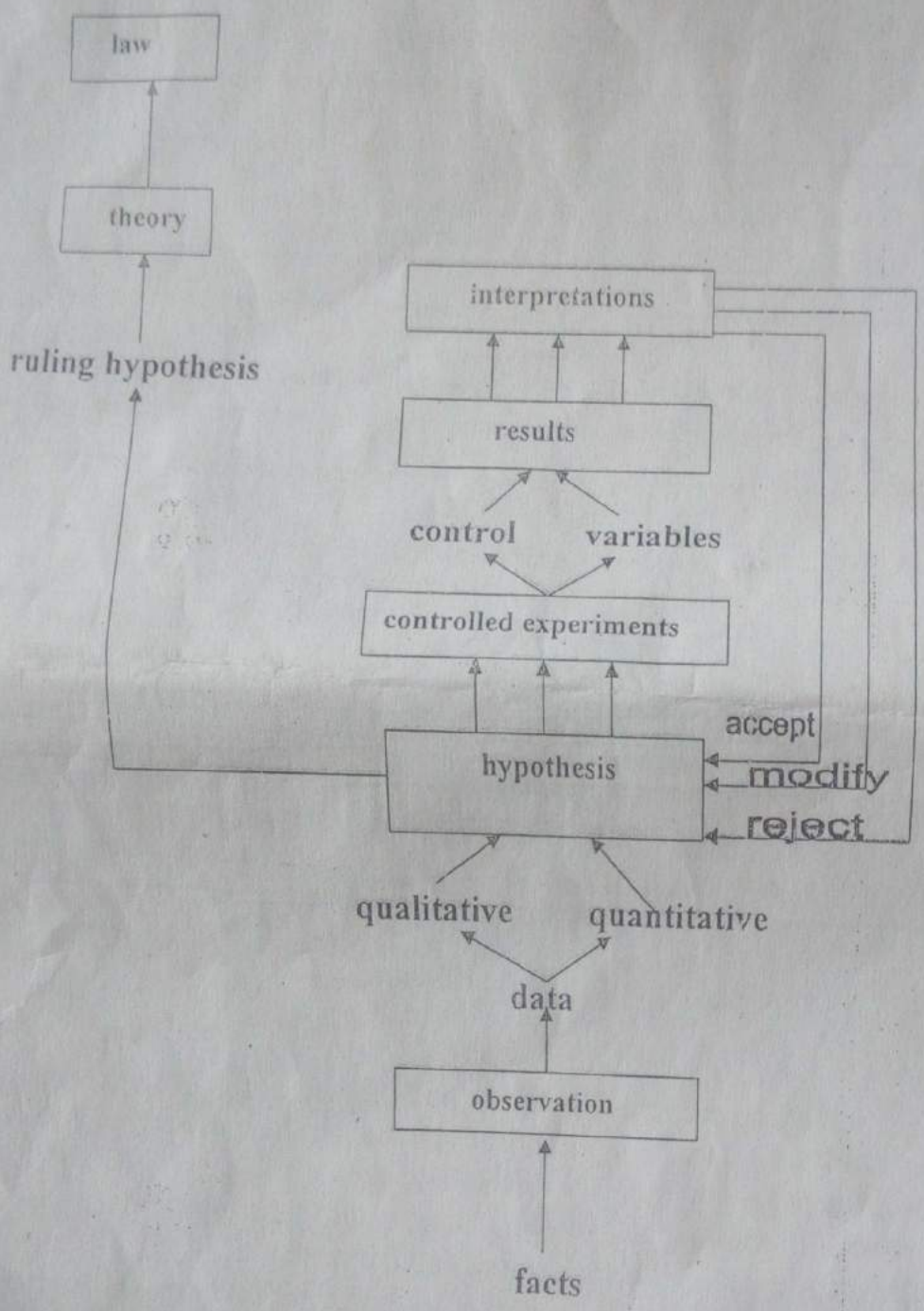

Figure 2.2 Summary of the scientific method

It is significant that the attitude of scientists is that no theory or law represents absolute truth. They feel, rather, that each new discovery has brought man nearer to truth, but they are always ready to modify their concept of the behaviour of Nature should conflicting new evidence be uncovered.

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scientists do not work alone; research is to a large extent a communal endeavour, where individual action is strongly influenced by social goals and norms.

Scientific knowledge/information (Facts) can only be acquired by very deliberate action that is by observation. Major scientific disciplines, such as palaeontology or human anatomy, would make little progress without the skills of observers who have been trained to scrutinize objects carefully to notice significant details, and to record them accurately. Expert observation is not only one of the arts of scientific investigation, from the point of view of the practising scientist it is a major constituent of the scientific method.

2.5 PROBLEMS ASSOCIATED WITH THE SCIENTIFIC METHOD

- **Inadequate Evidence:** Unfortunately, scientists at the frontiers of new knowledge or technology run into the problem of inadequate evidence for new hypotheses or new theories regularly. "Either the proper evidence has not yet been uncovered, or our present methods are not yet capable of finding the required evidence" (Carr, 1992). Thus, these scientists generally proceed with caution and subject their methods to the most rigorous mental scrutiny before conducting a physical test.

- **Preconceptions:** A preconception can be understood as an existing knowledge set or expectations. McCormarck identified this condition as an "initial state idea" that a student or learner holds concerning a specific event or phenomenon (McCormark, 1992). Dealing with preconceptions is an important problem for scientists.

- **Prejudice/Bias:** All observers carry with them biases and prejudice about the events they observe. Bias is defined as a particular tendency or inclination, especially one that prevents impartial consideration of a question. Prejudice for the purpose of scientific inquiry, is a roadblock to clear, objective thinking. Prejudices typically are negative opinions or feelings formed before an investigation without evidence, knowledge, thought, or reason. Bias is responsible for much in correct work.

Good science requires both students and scientists to be as objective as possible so that their observations, hypotheses, and interpretations of data will not be distorted.

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3.0 NORMADIC AND POST NORMADIC ERA

Right from the time of the existence of man on the earth, began the quest by man to combat the harsh conditions of the environment to meet the basic need of food, clothing and shelter: Man began to hunt for animal flesh and gather fruits as food, animal skin and plant fig as clothes, plants and physical shades for shelter. This trial and error approach led to the accidental discovery of domesticated animals, which led to the organized agricultural practice of sowing, planting and reaping. Fire was discovered so that food can be cooked rather than eaten raw or dried.

Man's social structure was transformed from the wandering normadic to organized settlements or post normadic era. This developed out of the need to have agricultural communities and protection for each other. The soil cultivation resulted in the sudden stoppage of wandering and of periodic food supply. This agricultural discovery brought about rough division of labour where man does the heavier task while the wife and children do the lighter domestic tasks. The settlement development brought out the creation of new ideas and needs of the society in terms of security, organization and efficiency in doing things. This led to a more efficient system of production and occupational division of labour and introduction of trade by barter. Markets were formed for the exchange of surplus food and other items.

3.1 THE STONE AGE

The earliest period of human culture, when tools were made of stone, bone, antler, or wood, and before metals were first used. Bare hands were man's first tools followed by wood, bones, stones and metal tools in this order. The term "Stone Age" encompasses almost the whole of human existence, because it starts with the very earliest tools detectable in the archaeological record, but ends only a couple of centuries ago in some parts of the world, such as Australia or Polynesia, where metal was not used until the arrival of Europeans. This "Stone Age", which preceded the Bronze Age and Iron Age, was eventually subdivided by the British naturalist and politician Sir John Lubbock: in 1865 he coined the terms *Palaeolithic* (from the Greek palaeo, old, and lithos, stone) and *Neolithic* (from neo, new) for the periods of flaked stone and polished stone tools respectively.

hunting age

farming age.

adzes

Sickle

Figure 3.1 Flint Tools Flint was the primary material for tool-making in the Stone Age. It is relatively common and produces sharp edges when fractured, making it ideal for tools and weapons. The adzes (left and centre) were used for shaping wood and the sickle (right) was used in harvesting during the late Stone Age. *Note:* The wooden handles are reproductions.

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For grinding flour

harvesting cereals

Ventilate bread ovens

Clearing

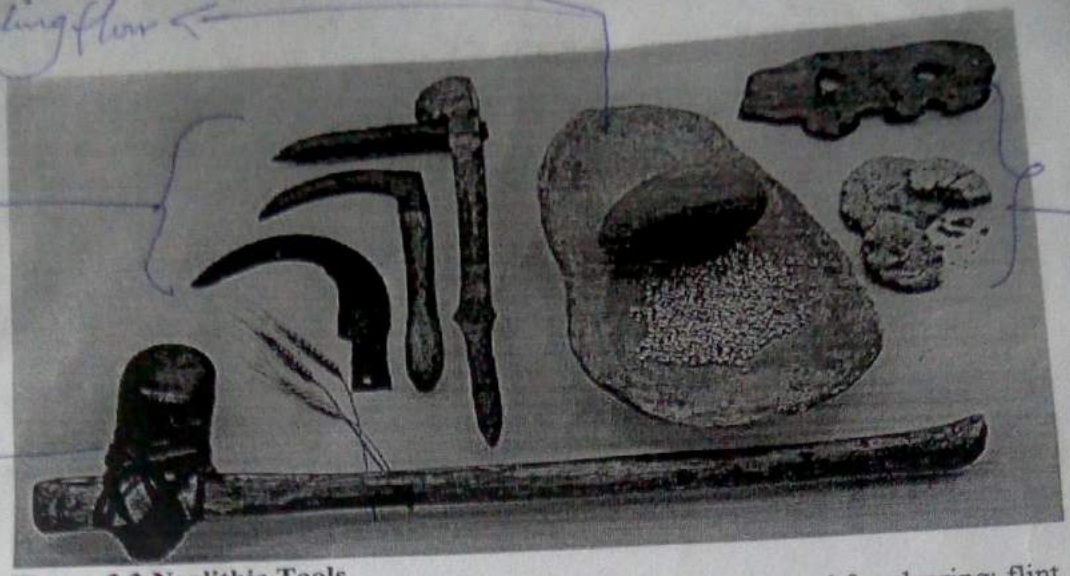

Figure 3.2 Neolithic Tools

These early farming tools date from about 6000 BC. The axe, *bottom,* was used for clearing; flint sickles, *left,* were used for harvesting cereal crops; a flat rock and rounded stone, *centre,* were used for grinding flour; and perforated clay slabs, *upper right,* were probably used to ventilate bread ovens.

3.2 THE BRONZE AGE

The period in antiquity that corresponds to the introduction of metallurgy, notably bronze-working, for making tools, weapons, and ceremonial objects. In Europe the Bronze Age spans the period from about 2000 to 700 BC

The primitive age paved the way for more technical activities in the Bronze Age where bronze, an alloy of tin and copper, was man's first hard metal utilized in the making of weapons, tools and other domestic utilities. Many technical innovations were developed in this era. These include introduction of tongs for handling hot metals, bellows for metallurgical processes and development of wax process for castings.

The agricultural way of life that had become established in the preceding Neolithic period continued. Ploughing appears to have become widespread, as shown by remains of implements as well as plough-marks under barrows, and depictions of ploughing in the rock art of the period. As populations grew and expanded, pressure on land increased, and agriculture spread. Soil erosion also increased: for example, in Cyprus a combination of deforestation, intensive agriculture, and pastoralism destabilized the fragile soil-cover on hillslopes in the early Bronze Age and led to the rapid deposition of sediment along coastal valleys.

Another trend towards the end of the Bronze Age was a growing emphasis on fortifications, hillforts being constructed in many upland areas of Europe. Bronze armour and helmets, and new types of weapons such as the very effective slashing sword, suggest that warfare had come to the fore.

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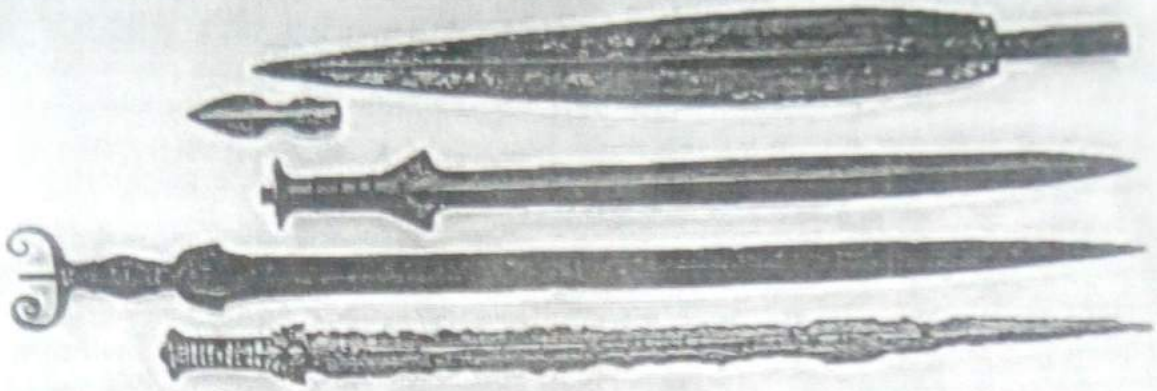

Figure 3.3 Bronze Age Weapons

Bronze Age weapons include slender spearheads, swords, and knives. Those shown here come from Europe. The sword at the bottom of this group comes from Denmark and has been cleaned to show its original colour.

3.3 THE IRON AGE

In Europe the term "Iron Age" denotes the period between the end of the Bronze Age (700 BC) and the spread of the Roman Empire (27 BC-AD 68), that is, the last stage of European prehistory before the Romans brought literacy and imposed a radically new way of life.

The first solid hard metal called iron was accidentally discovered by man who saw glooming glow from a stone in fire, which produced a solid black form after cooling. The major advantage of iron over bronze was that the ores from which it could be obtained were widely available and hence inexpensive when compared with bronze. It needed no alloying, and was an admirable material for the manufacture of saws, axes, hoes, and nails. However, it was much more difficult to process, and in prehistoric times a temperature high enough to melt it for casting in a mould was never achieved. Once iron had been adopted for heavy tools and weapons, bronze was used mostly for decorated personal items, such as pins or mirrors. Gold and silver continued as prestige materials, for example to make torcs, the heavy neck rings worn by Celtic warriors.

The limited animal skins to meet the growing human population for clothing led to the development of textile machines for spinning cotton; and wool and the looms for weaving.

3.4 GREEK PHILOSOPHY/SCIENCE AND THE MIDDLE AGE

Greek Philosophy is the body of philosophical concepts developed by the Greeks, particularly during the flowering of Greek civilization between 600 and 200 BC. Greek philosophy formed the basis of all later philosophical speculation in the Western world. The intuitive hypotheses of the ancient Greeks foreshadowed many theories of modern science.

Considered the first true mathematician, **Pythagoras** established a movement in 6th-century BC southern Italy that emphasized the study of mathematics as a means to understanding all relationships in the natural world. The followers of this movement, Pythagoreans, were the first to teach that the Earth is a sphere revolving around the Sun.

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Socrates was a Greek philosopher and teacher who died in Athens around 400 BC. He profoundly altered Western philosophical thought through his influence on his most famous pupil, Plato, who passed on Socrates' teachings in his dialectical writings. Socrates taught that every person has full knowledge of ultimate truth contained within the soul and needs only to be spurred to conscious reflection in order to become aware of it. His criticism of injustice in Athenian society led to his prosecution and a death sentence for allegedly corrupting the youth of Athens.

Plato, one of the most famous philosophers of ancient Greece, was the first to use the term "philosophy", which means "love of knowledge". Born around 428 BC, Plato investigated a wide range of topics. Chief among his ideas was the theory of forms, which proposed that objects in the physical world merely resemble or participate in the perfect forms in the ideal world, and that only these perfect forms can be the objects of true knowledge. The goal of the philosopher, according to Plato, is to know the perfect forms and to instruct others in that knowledge.

Aristotle (384-322 BC) was born at Stagira, a Greek colony. His father was physician to the monarch of Macedon. At seventeen Aristotle became a pupil of Plato at Athens. The most ancient body of systematized knowledge about the forms of matter dates back to the Greeks. Aristotle taught that all things are made up of four "elements": air, earth, fire, and water. Aristotle's writings cover the whole area of knowledge. The earliest are biological. These were written, or at least drafted during his residence in Asia Minor (347-342 BC). We must always remember that the whole of Aristotle's science, and indeed the whole cast of his mind, was deeply influenced by his biological experience. Others believed that matter could be subdivided into tiny "atoms". Among those who held this view were **Democritus** (460-370 BC) and **Epicurus** (341-270 BC). Both views were supported by complete system of logic, for which the Greeks were famous. Almost 2000 years passed before the study of energy was undertaken again in an organized way. **Galileo Galiliel** (1564-1642) studied the behaviour of falling bodies and formulated laws describing this behaviour. He investigated the pendulum and put it to use in a clock. At about the same time, **Johannes Kepler** (1571-1630) discovered that the orbits of the planets were elliptical in shape and that their motion could be generalized in the form of a mathematical formula that could be used to predict their future motions. These same laws of Kepler are used in calculating the flight paths of today's space vehicles. **Isaac Newton** (1642-1727) developed the laws of motion and gravitation that explained the observations of many scientists who had preceded him. He also made basic discoveries concerning the nature and composition of light. During the 18th century, a beginning was made in the scientific study of heat and electric energy. **Benjamin Franklin** (1706-1790) and **Michael Faraday** (1791-1867) did much of the pioneer work in electricity, while **Count Rumford** (1753-1814) and **James P. Joule** (1818-1889) put the study of heat on a scholarly basis.

Pythagora's → Mathematics
Socrates → Greek philosopher
Plato → 1st person 2 use of term philosophy (Love of knowledge): theory of forms
Aristotle → Element: Air, earth, fire and water (biological experience) "tiny atoms"
Democritus & Epicurus → System of logic
Galileo Galilied → behaviour of falling bodies
Johannes Kepler → Shape of ~~of~~ orbits of ~~of~~ planets (elliptical) & motion
Isaac Newton → Laws of motion & gravitation
Benjamin Franklin & Michael Faraday - Electricity
Count Rumford & James P. Joule → study of heat

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3.5 INDUSTRIAL REVOLUTION – 19TH CENTURY

The industrial revolution started in the 19th century and still remains the hallmark of the modern technological civilization. The economy and social system of the era contributed principally to the great achievements of that time. It was the era when influence, power and money are acquired mainly by technological means. There was a great shift of Energy/Technology orientation from scholarly theories about the Universe to research and development relevant to the domestic economic growth. Through more invention and development, more complex and fundamental engineering systems were evolved. Trade in real business commenced and other contrivances such as wheel, steam engine, steamship, and radio were made. The great invention of the 19th century was the railway. The first person to use high-pressure steam to power a vehicle was Richard Trevithick in 1801, but the first engineers to usher in the railway era were a father and son, George Stephenson and Robert Stephenson. By 1855 there were over 12,870 km (8,000 mi) of track, and all the great cities, some of them—such as Birmingham, Sheffield, and Manchester—industrial centres, had been linked.

The successful making of cheap steels—there was soon to be a whole range of them—marked a turning point in the history of the first Industrial Revolution. Henry Bessemer, developed a new process in 1855 for converting crude iron into steel. Air was blown through Bessemer blast furnaces to burn away impurities. British inventors developed other processes that, ironically, were more quickly adapted to overseas iron fields than to those in Britain. The United States, with huge deposits of raw iron and other metals, now forged ahead. Steel was a more adaptable metal than iron, and its efficient production came to depend increasingly on applied science.

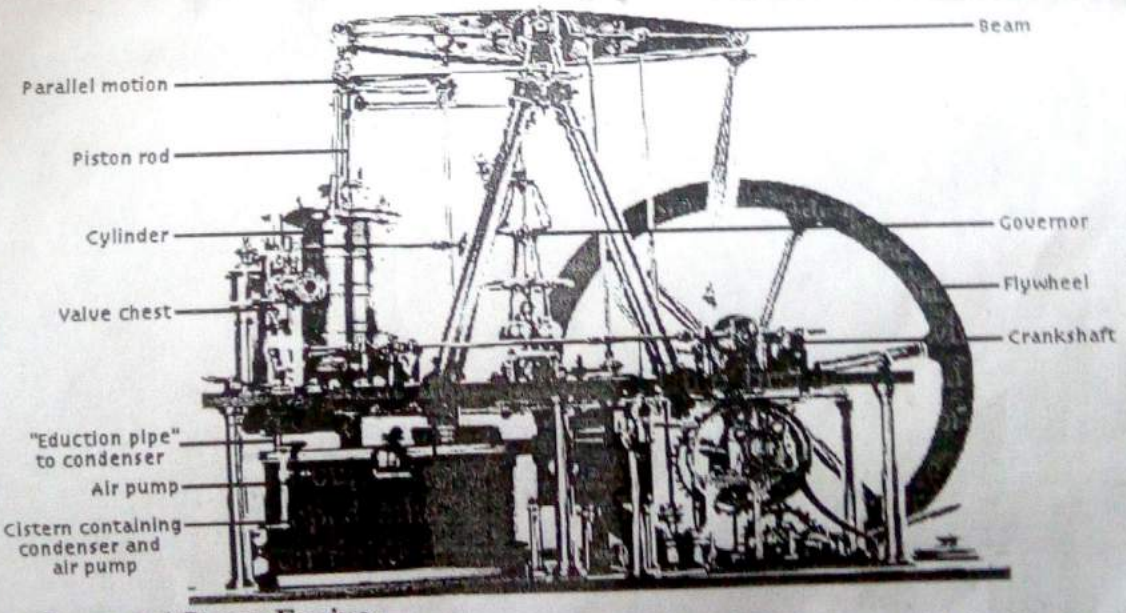

Figure 3.4 Steam Engine

Harnessing the power of steam marked a highly significant step in technology and the introduction of the steam engine led to many new inventions in transport and industry. Steam engines were built as early as 1690, but it was not until 70 years later that James Watt arrived at the design of the modern steam engine, paving the way for the Industrial Revolution.

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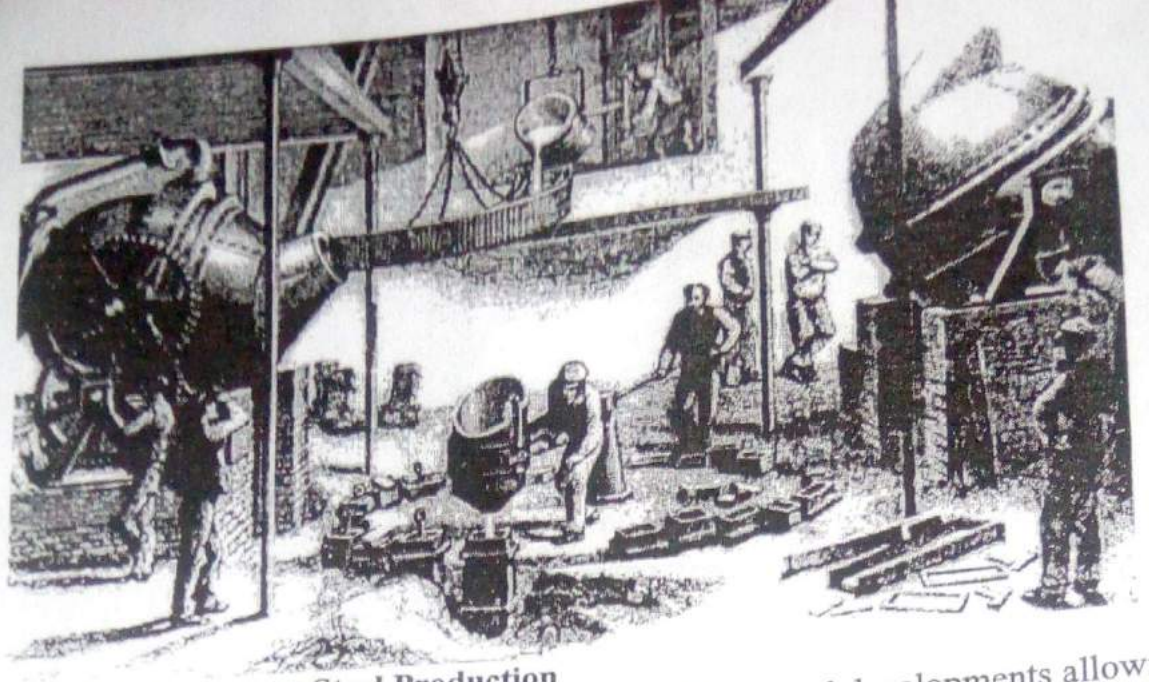

Figure 3.5 Bessemer Steel Production

The Industrial Revolution was accelerated by new metallurgical developments allowing bulk production of iron and steel. This engraving of a steel factory illustrates the process developed by Sir Henry Bessemer in 1855. In order to convert molten pig iron (crude iron) into steel in the Bessemer furnace, air was blown through it to burn away impurities.

3.6 ATOMIC, NUCLEAR AND SPACE ERA – 20TH CENTURY

In the early 20th century, attention moved to space exploration pioneered by a Russian by the name of Konstantin K. Tsioikovsky and an American called Robert H. Goddard and a German called Hermann Oberth. The soviet launched its first satellite named Sputnik I in October 1957 around the earth orbit. A month later, Sputnik 2 with a live dog named Laika went to prove man's survival in the earth orbit. Three month's latter, the Americans launched Explorer 1.

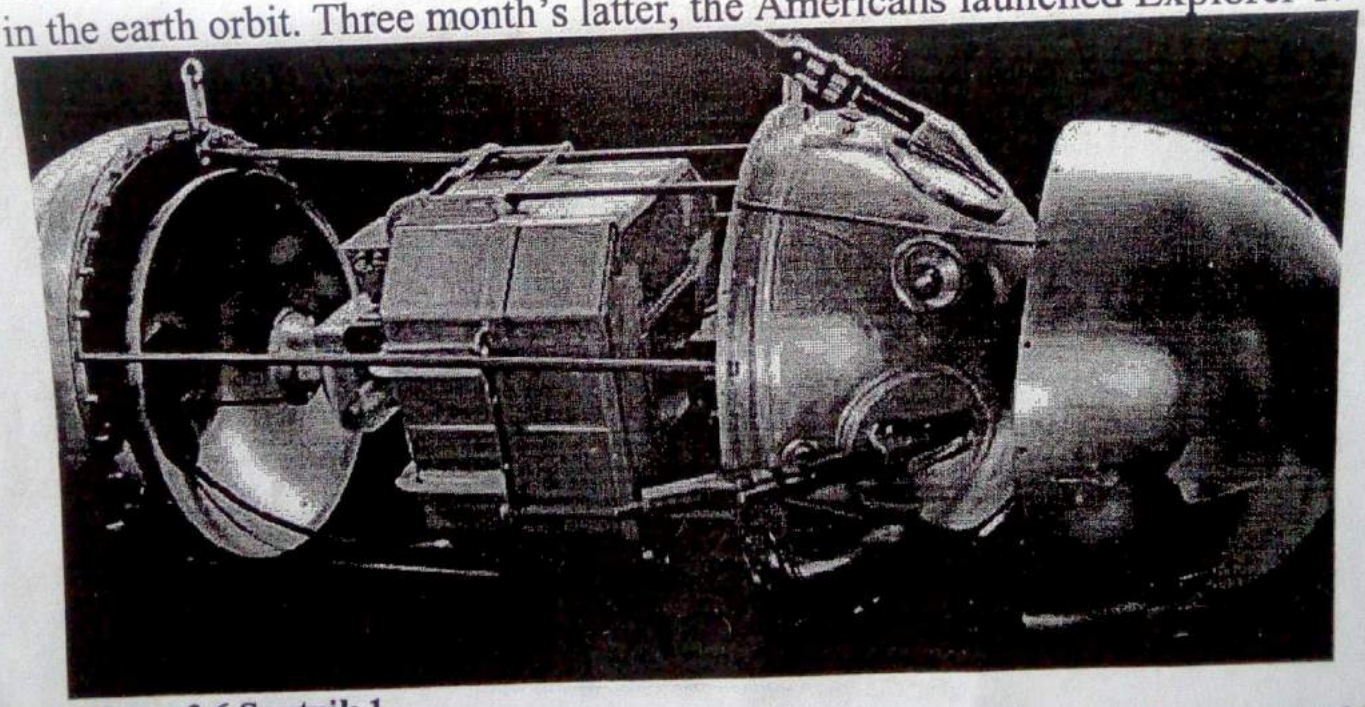

Figure 3.6 Sputnik 1

The Russian Sputnik 1, launched on October 4, 1957, was the first artificial satellite put into orbit around the earth. This historic launch began an era of intensive space programmes by both the Soviet Union and the United States, a surge of interest sometimes called the "space race". In the next three decades, hundreds of probes, satellites, and other missions were to follow Sputnik on the quest to explore both the wonders and the practical potential of space.

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In October 1958 the National Aeronautics and Space Administration (NASA) was created in the United States. Since then, there have been over 3,000 launches of spacecraft of all varieties, mostly into Earth orbit. Twelve men have walked on the Moon's surface and returned to Earth.

In 1961, Soviet Cosmonaut Yury A. Gagarin and American Astronaut Alan B. Shephard Jr. manned the first space vehicle on 12th April and 5th May respectively. On 20th July, 1969, U.S. Astronauts Neil A. Armstrong and Edwin E. Aldrin of the Apollo 11 Lunar Module became the first humans to set foot on the moon. A year later, a moon core soil sample was selected. Furthermore, studies and mission were made to other planetary bodies such as the moon, mars, and mercury to collect materials for study of the possibility of life and a hopeful man's habitation of these bodies. These space explorations has led to the launching of better metereological and communication satellite in our orbit and space leading to improved services particularly in defence and communication. So far leaving matter has been found on earth only.

Atomic energy was utilized militarily during the Second World War when the United States of America in 1945 dropped Atomic bombs on Japanese cities of Nagasaki and Hiroshima, with over 200,000 people killed and thousands maimed, which led to the capitulation of Japan.

Nuclear studies have given birth to alternative nuclear energy with high quantity of energy on nuclear reaction but with harmful by-product used to create nuclear weapons. The disastrous effect of Chernobyl nuclear power plant in the then USSR in 1986, which led to the maiming of many people, exemplified the negative aspect of nuclear energy utilization.

3.7 COMPUTER AND INFORMATION AGE (1950 AND BEYOND)

Computer, the major device for data and information manipulation and transfer was first recognized when sticks and ropes were used as the first analog-computing device. Later about 3000 BC , the ABACUS, the first computing instrument for exclusive general calculation was developed. It was followed by mechanical computing machines, 1623 – 24, invented by a German, Wilhem Schickard, then the slide rule was invented by William Oughtred in the 1930's. The second mechanical calculator, a digital device where numbers are entered by dial wheel and computation by gears was built by French Scientist and Philosopher Blaise Pascal, 1642. English inventor Charles Babbage built the difference engine, 1822, and the first automatic digital computer called digital analytical engine in 1834. Forty-six years later, American statistician, Herman Hollerith built the electronic mechanical machine in 1880.

The mordern computers evolved from the mid twentieth century – 1950's- ranging from the vaccum tube relays, to transistors, to small scale integrated circuits (IC), to the ultra large scale IC's such as Pentium II & III which are know connected to form networks. The networks are interconnected to form Internet. The present information super highway, makes the world link together in a manner never imagined before. Through the interconnected networks, information, product and services of various technologies are shared worldwide with much better efficiency, leading to the present rapid changing technological

digital analytical engine →

Slide rule — William Oughtred (1930's)
mechanical computing machines — Wilhem Schickard (1623-1624)
Calculator → Blaise pascal (1642)
Difference engine → Charles Babbage (1822)

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achievements. The enormous contribution in the software direction is presently apparently being spearheaded by the work of such software giants as the American – Microsoft group and their "windows" products.

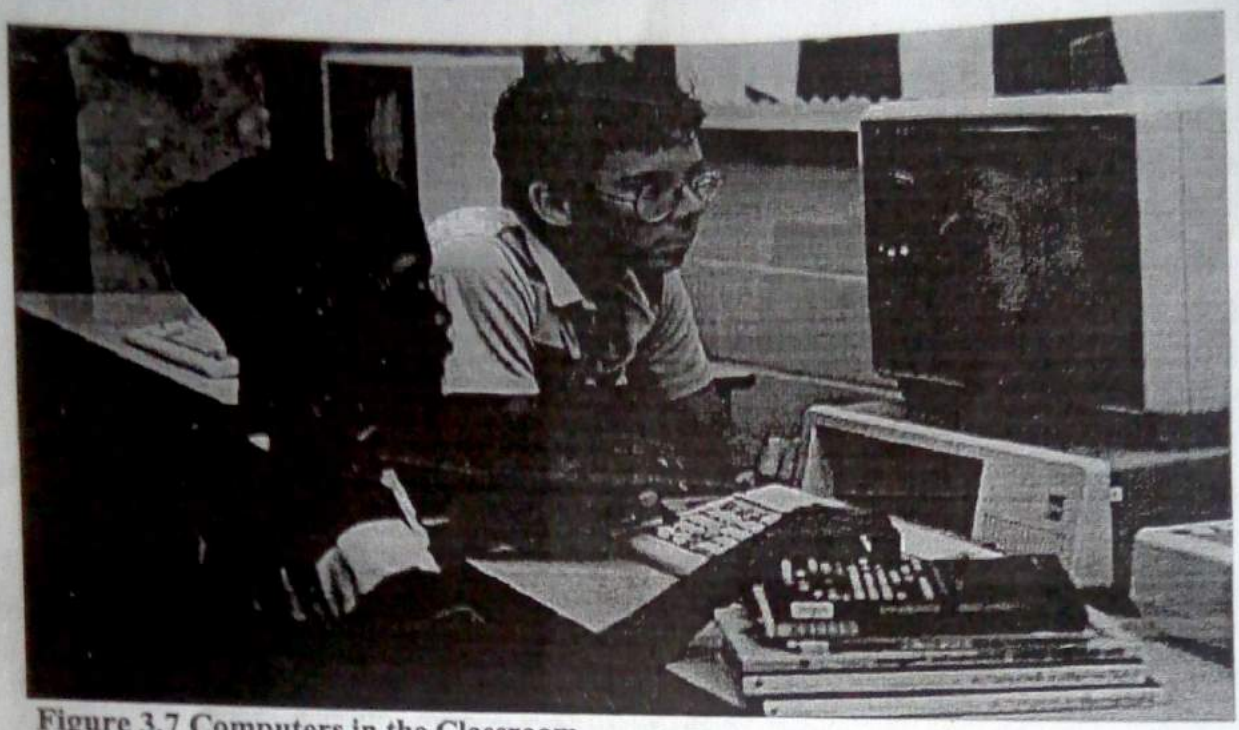

Figure 3.7 Computers in the Classroom

Computers have become increasingly important in school over the past decade. As well as supporting specific IT teaching, they are used in developing basic skills, such as reading and number work, to support data handling in science, explore and research using multimedia reference, and, increasingly, to access the Internet.

3.8 SOME FAMOUS SCIENTISTS

Henry Cavendish **1731-1810**

English scientist, educated at Cambridge University. In 1776 he discovered the properties of hydrogen gas. In 1781 that air was a mixture of gases. In 1784 he discovered that water was made up of hydrogen and oxygen by splitting up water with an electric current. At Cambridge University the famous Cavendish laboratory is named after him.

Sir James Dewar **1842-1923**

Scottish chemist, he invented the vaccum (Thermos) flask. In 1898 he was the first to turn hydrogen gas into a liquid. The next year he was able to make solid hydrogen.

Otto von Guericke **1602-1686**

German physicist, he was the Mayor of Magdeburg in Germany. In 1654 he invented the air-pump. With it he was able to do a very famous experiment to show that air exerted pressure. He attached eight horses to each of two hollow round cups. When he joined the cups together and pumped out the air from inside them, the horses were not able to pull the two halves of the container apart.

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Oliver Heaviside **1850-1925**

English physicist. He discovered in the upper atmosphere a layer of gas that could reflect back radio waves to the earth. He made discoveries also in mathematics and in the way waves behave.

Wilhelm Rontgen **1845-1923**

German scientist, he is famous for his discovery of X-rays.

Sir Enerst Rutherford **1871-1937**

British physicist, born in New Zealand. He was educated at Cambridge University, and worked in the Cavendish Laboratory there. In 1911 he showed that an atom could be split into a nucleus at the centre, with electrons spinning round the nucleus.

Evangelista Torricelli **1608-1647**

Famous Italian physicist. After studying in Rome, he succeeded Galileo, as Professor at Florence University. He is best known for making a mercury barometer by filling a long tube of mercury and then inverting it (turning it upside-down) in a dish of mercury. He also made a microscope to see tiny objects, and a telescope to see the stars and planets.

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4.0 MAN: HIS ORIGIN AND NATURE

Useful Definitions:

Fossil:

- The remains of an animal or plant preserved from an earlier era inside a rock or other geological deposit, often as an impression or in a petrified state.

- The physical evidence of a prehistoric organism, often comprising a shell, bone, or other durable skeletal part, which in the majority of cases belongs to an extinct species. Fossils also include the imprints of organisms that have dissolved or eroded away; preserved footprints and tracks; remarkably unaltered remains preserved in peat bogs, asphalt lakes or tar pits, frozen ground, or amber; and fossilized excrement called coprolites, which may contain remains of eaten animals and plants.

Artefact:

- An object made by a human being, especially one that has archaeological or cultural interest. Most of these are stone tools.
- A man-made object taken as a whole.

Palaeontology:

- The study of fossils, the earth science that studies fossil organisms and related remains
- The study of life in prehistoric times by using fossil evidence

Phylogeny:

- The sequence of events involved in the evolutionary development of a species or taxonomic group of organisms.
- *development of a group*: the evolutionary history of a species, genus, or group, as contrasted with the development of an individual (ontogeny)

Evolution:

- *theory of development from earlier forms*: the theoretical process by which all species develop from earlier forms of life.
  On this theory, natural variation in the genetic material of a population favours reproduction by some individuals more than others, so that over the generations all members of the population come to possess the favourable traits.
- *developmental process*: the natural or artificially induced process by which new and different organisms develop as a result of changes in genetic material
- *gradual development*: the gradual development of something into a more complex or better form

Neanderthals, or Neandertals

- These are Prehistoric Human Skulls, once thought to be primitive ancestors of modern human beings. Serious doubt has now been cast over this theory. They lived in Europe and North Africa between 100,000 and 30,000 BC. They were hunter-gatherers who had brains somewhat larger than those of modern human beings. The German anthropologists Johann Fuhlrott and Hermann

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Schaaffhausen first found Neanderthal fossils in 1856 in the Neander Valley near Düsseldorf, Germany.

Human Evolution

- Biological and cultural development of humans and related species. The main physical evidence of our evolution is a large number of fossil bones and teeth that have been found at various places throughout Africa, Europe, and Asia. Tools of stone, bone, and wood, as well as fire hearths, campsites, and burials, have also been discovered and excavated. As a result of these discoveries in archaeology and anthropology, a picture of human evolution during the past 4 million to 5 million years has emerged.

Hominine
(*plural* **hominines**)

- **Primate with upright stance:** a primate with a two-legged gait, relatively small face and teeth, and large brain. Hominines include human beings and their most direct ancestors.

Geological Timescale

Fossils preserved in rock strata provide scientists with clues to evolutionary history. The stratigraphic column is based on palaeontological evidence, and shows the order in which organisms appeared in the fossil-rich Palaeozoic Era. Each layer represents a *particular time frame* and shows a representative organism which flourished during that time. Although fossils are rarely found in the idealized and localized fashion shown here, they are often in more or less chronological order. Generally, the oldest fossils appear in lower layers, and the most recent fossils at the top, so that placement may be used as an aid in dating the specimens.

EON	ERA		PERIOD	EPOCH	APPROX. TIME BOUNDARY	LIFE FORMS ORIGINATING
PHANEROZOIC	CENOZOIC	QUATERNARY SUB-ERA	PLEISTOGENE	Holocene (Recent)	10,000	
				Pleistocene	1,800,000	Human beings
		TERTIARY SUB-ERA	NEOGENE	Pliocene	5,300,000	Human-like apes
				Miocene	23,800,000	
			PALAEOGENE	Oligocene	33,700,000	True primates
				Eocene	54,800,000	Marine and carnivorous mammals
				Palaeocene	65,000,000	Hoofed mammals
	MESOZOIC		CRETACEOUS		142,000,000	Flowering plants, placental mammals
			JURASSIC		205,700,000	Birds
			TRIASSIC		248,200,000	Small dinosaurs, small mammals
			PERMIAN		290,000,000	Conifers, mammal-like reptiles
	PALAEOZOIC		CARBONIFEROUS		354,500,000	True reptiles, fern forests
			DEVONIAN		417,500,000	Land vertebrates, air-breathing insects
			SILURIAN		443,000,000	Vascular land plants
			ORDOVICIAN		495,000,000	Vertebrates
			CAMBRIAN		545,000,000	Hard-bodied invertebrates
PROTEROZOIC	NEOPROTEROZOIC				1,000,000,000	Soft-bodied invertebrates
	MESOPROTEROZOIC				1,600,000,000	Cells with distinct nuclei
	PALAEOPROTEROZOIC				2,500,000,000	
ARCHAEAN	LATE				3,000,000,000	Primitive unicellular organisms
	MIDDLE				3,500,000,000	
	EARLY				4,000,000,000	
PRISCOAN (HADEAN)					4,650,000,000	

Figure 4.1 **Geological Timescale**
Notes: i) Beginning dates are indicated in the approximate time boundaries column.
ii) The Proterozoic, Archaean, and Priscoan (Hadean) eons are collectively and informally known as the Precambrian era.

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Human Origins

A Confluence of Research

- Paleontology
- Anthropology
- Archaeology
- Genetics
- Paleoclimatology

Conflict, Racism and Uncertainty

- Human origins – commonly at center of the Evolution vs. Creation "debate"
- Evolution and human origins are investigated scientifically – hypotheses are proposed and tested
- Topic is full of uncertainty
  - A) Very young discipline
  - B) Relatively sparse fossil record

A Patchy Fossil Record

- Upland habitat – erosion vs. deposition
- Fossils are not abundant
- Most important sites are in Tanzania, Kenya, Ethiopia (East African Rift System) and Egypt

The Cradle of Humanity

- The East African Rift System
- Earthquakes and formation of rift as Africa splits
- Sinking of rift floor promoted accumulation of sediments
- Early hominids preserved in these sediments
- Recent erosion cuts through sediments to reveal fossils

Famous locations of hominid fossils

- Olduvai Gorge
- **Hadar**
- Laetoli

Australopithecus afarensis – "Lucy"

- Circa 3.8 Ma Pliocene to Pleistocene (?)
- Four feet tall
- Tool user, but not maker
- Coexisted with *A. robustus*
- Upright posture and bipedality arise before enlargement of braincase

The Hominid Time Line

- Accurate dating of fossils is critical
- Direct evolutionary relationships are still unclear
- New fossil discoveries prompt revisions all the time
- The burning questions: Who are we? What is our heritage? Where do we fit in the grand scheme of things?

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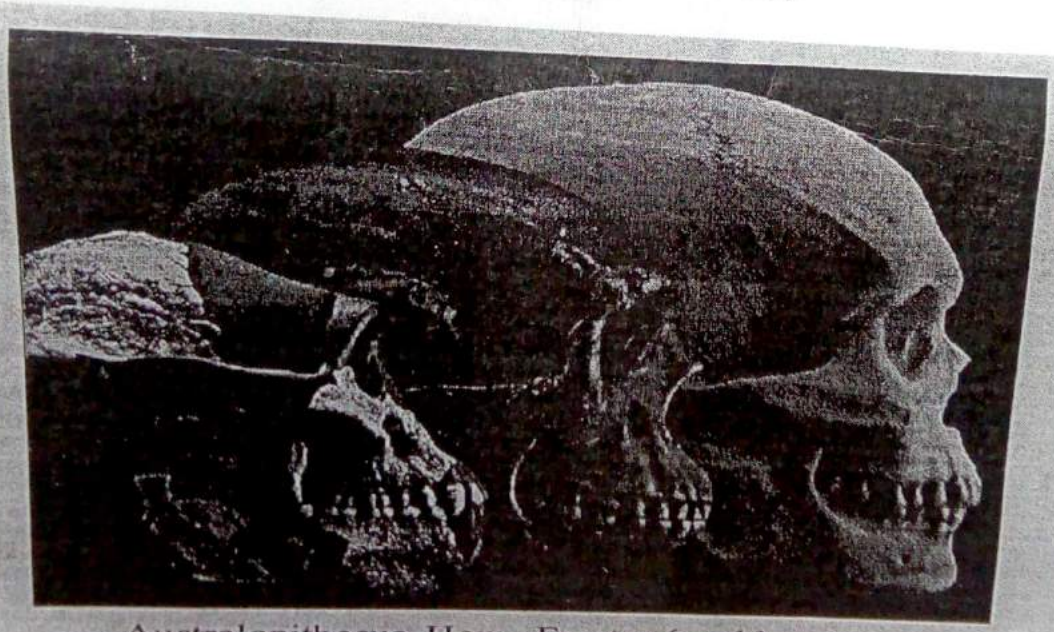
Figure 4.2 Transition to Homo sapiens (Evolution theory)



Australopithecus, Homo Erectus (could plan/scheme but limited speech), Homo Sapiens

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Figure 4.3 Representative Skulls

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Human Evolution

HUMAN PHYSICAL TRAITS

Human beings (members of the genus *Homo*) are classified in the mammalian order Primates; within this order, human beings, along with our extinct close relatives, and our nearest living relatives, the African apes, are sometimes placed together in the family Hominidae because of genetic similarities, although classification systems more commonly still place great apes in a separate family, Pongidae. If the single grouping, Hominidae, is used, the separate human line in the hominid family is distinguished by being placed in a subfamily, Homininae, whose members are then called hominines—the practice that is followed in this article. An examination of the fossil record of the hominines reveals several biological and behavioural trends characteristic of the hominine subfamily.

BIPEDALISM

Two-legged walking, or bipedalism, seems to be one of the earliest of the major hominine characteristics to have evolved. This form of locomotion led to a number of skeletal modifications in the neck, lower spinal column, pelvis, and legs. Because these changes can be documented in fossil bone, bipedalism is usually seen as the defining trait of the subfamily.

BRAIN SIZE AND BODY SIZE

Sophisticated human behaviour, such as our ability to make and to use tools, is related to the large size and complexity of the human brain. Most modern human beings have a braincase volume of between 1,200 and 1,500 cm^3. In the course of human evolution the size of the brain has more than tripled. The increase in brain size may be related to changes in hominine behaviour. Over time, stone tools and other artefacts became increasingly numerous and sophisticated. Archaeological sites, too, show more intense occupation in later phases of human biological history.

In addition, the geographical areas occupied by our ancestors expanded during the course of human evolution. As far as is known, the earliest examples were in north-central, eastern, and southern Africa, and they began to move into the tropical and subtropical areas of Eurasia at least 1.5 million years ago, and into the temperate parts of these continents at least 500,000 years ago. Much later (perhaps 60,000 years ago) human beings were able to cross the water barrier into Australia. Only long after the appearance of modern human beings did people move into the New World, probably less than 30,000 years ago. It is likely that the increase in human brain size took place as part of a complex interrelationship that included increasing social complexity and the elaboration of tool use and toolmaking, as well as other learned skills, which permitted our ancestors to be increasingly able to live in a variety of environments.

Some of the earliest hominine fossils show evidence of large differences in body size, which may reflect a pattern of sexual dimorphism in our early possible ancestors. The bones suggest that females may have been 0.9 to 1.2 m (3 to 4 ft) in height and about 27 to 32 kg (60 to 70 lb) in weight, while males may have been somewhat more than 1.5 m (5 ft) tall, weighing about 68 kg (150 lb). The reasons for this body size difference are disputed, but may be related to specialized patterns of behaviour in

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early hominine social groups. This extreme dimorphism seems to have disappeared gradually in the last million years.

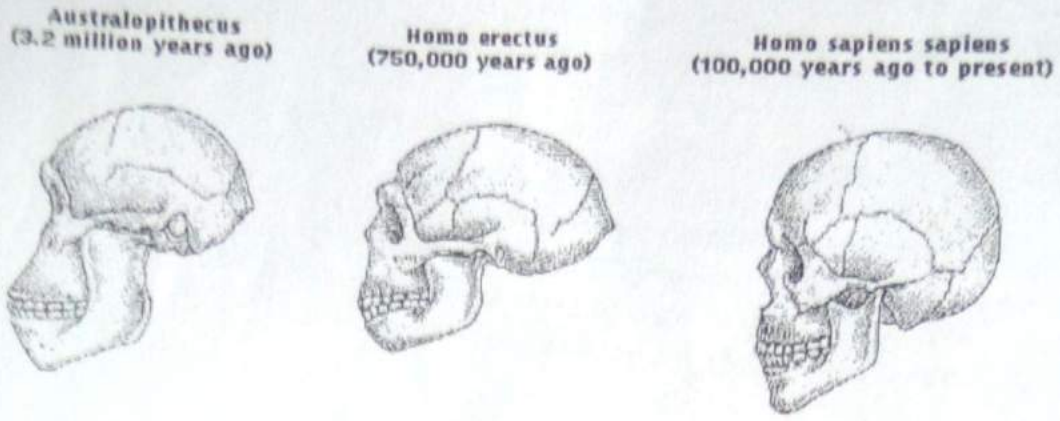

Figure 4.4 Evolution of the Human Skull
The human skull has changed dramatically during the past 3 million years. As the skull evolved from *Australopithecus* to *Homo (sapiens) sapiens,* the capacity of the cranium increased (to accommodate the growth of the brain), the face flattened, the chin receded, and the size of the teeth decreased. Scientists believe that the incredible growth in the size of the brain may be related to the increasing sophistication of hominine behaviour. Anthropologists also theorize that the brain evolved a high capacity for learning and reasoning, and after that cultural, not physical, evolution changed the way human beings live.

THE GENUS HOMO

Although scientists do not agree, some believe that after the evolutionary split that led to the robust australopithecines, *Australopithecus africanus* evolved into the genus *Homo*. Others believe that humans may have briefly shared an ancestry with the early robust australopithecine line. Although fossil evidence is lacking, the evolutionary transition to *Homo* probably occurred between about 2.3 million and 2.7 million years ago. Fossils dating from immediately after this period display a curious mixture of traits. Some possess relatively large brains—several almost 800 cm^3—and large, australopithecine-sized teeth. Others have small, *Homo*-sized teeth but also small, australopithecine-sized brains. A number of fossil skulls and jaws from this period, found in Tanzania, Kenya, Malawi, and Ethiopia, have been placed in the category *Homo habilis*, meaning "Handy Man", because some of the fossils were found associated with early stone tools. *Homo habilis* possessed many traits that link it both with the earlier australopithecines and with later members of the genus *Homo*. However, some experts believe that the variation in *Homo habilis* fossils is so great that at least two separate species are actually represented, the smaller one still called *Homo habilis*, and the larger one *Homo rudolfensis* (after Lake Rudolf, an old name for Lake Turkana in northern Kenya).

The earliest evidence of stone tools comes from sites in Africa dated to about 2.5 million years ago. These tools have not been found in association with a particular hominine species. By 1.5 million to 2 million years ago, sites in various parts of eastern Africa include not only many stone tools, but also animal bones with scratch marks that experiments have shown could only be left by human-like cutting actions. These remains constitute evidence that by this time early hominines were eating meat, but whether this food was obtained by hunting or by scavenging is not known. Also unknown at present is how much of their diet came from gathered vegetable foods and

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insects, and how much came from animal tissue. It is also not clear whether these sites represent activities by members of the line leading to *Homo*, or if the robust australopithecines were also making tools and eating at least some meat.

Fossil evidence of a large-brained, small-toothed form, from northern Kenya and dating from 1.8 million to 1.9 million years ago, has been placed in the species *Homo erectus*, or a more primitive ancestral form, *Homo ergaster* ("Work Man"). The first part of the time span of *Homo ergaster/erectus* was apparently limited to eastern Africa. However, very soon after this, descendent forms of *Homo erectus* are known from the tropical areas of the Old World, and from Georgia in western Asia. A number of archaeological sites dating from the time of *Homo erectus* reveal a greater sophistication in toolmaking than was found at the earlier sites—for example, at the Zhoukoudian ("Peking Man") cave site in northern China, there is possible evidence of the use of fire. Animal fossils found with artefacts thought to have been produced by *Homo erectus* are sometimes of large mammals such as elephants. These data suggest that hominine behaviour was becoming more complex, with a greater range of capabilities, although it is not clear whether *Homo erectus* was mainly a scavenger rather than a hunter.

Through the time of *Homo erectus* certain trends in human evolution continued. The brain sizes of early *Homo erectus* fossils overlap with those of previous hominines, ranging from 600 to 1,000 cm^3. Later *Homo erectus* skulls possess brain sizes in the range of 1,000 to 1,250 cm^3, within the lower end of the size variation of *Homo sapiens*. Recent research suggests that *Homo erectus* may have survived in parts of Asia long after it had become extinct, or evolved into a new species, elsewhere. A number of *Homo erectus* fossils from two sites in Java, Indonesia, were recently dated using associated buffalo teeth to only 30,000 to 50,000 years ago.

MODERN HUMAN ORIGINS

However, this view of the origins of modern human beings (*Homo sapiens*) is still in dispute. Disagreement has focused especially on the place of Neanderthals in the chain of human evolution. The Neanderthals (named from the Neander Valley in Germany, where the first skeleton was recognized) occupied parts of Europe and western Asia from at least 200,000 years ago until about 30,000 to 40,000 years ago, when they began to disappear from the fossil record.

The dispute over the Neanderthals also involves the question of the evolutionary origins of modern human populations, sometimes called races. Although a precise definition of the term "race" is not possible (because modern human beings show continuous variation from one geographical area to another), widely separate human populations are marked by a number of physical differences, dealt with in the classification of races. Some of these differences represent adaptations to local environmental conditions, a process that a few scientists believe began with the spread of *Homo erectus* to non-African parts of the Old World over a million years ago. In their view, human development since *Homo erectus* has been one continuous evolution across the whole inhabited world; that is, local populations have remained, changing in appearance over time. The Neanderthals and equivalent peoples in other areas are seen as descending from *Homo erectus* and ancestral to the various regional forms ("races") of modern human beings.

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Other scientists view racial differentiation as a relatively recent phenomenon. In their opinion, the relatively late dates of the Neanderthals, combined with their distinct features—a low, sloping forehead, large brow ridge, and a long face dominated by a projecting nose—means that they could not have been ancestors of modern human beings, who already existed in Africa and western Asia about 100,000 years ago. They place the Neanderthals and similarly late-surviving primitive peoples in Asia on side-branches of the human evolutionary tree that became extinct. According to this theory, the origins of modern human beings can be found in Africa or the Middle East. Evolving between about 130,000 and 200,000 years ago, these early modern human beings later spread to most parts of the world, supplanting the local archaic populations where these still survived. In addition to various fossil finds from Africa, support for this theory comes from comparisons of DNA in present-day populations. These show that all modern human beings are closely related genetically, suggesting a recent common ancestry, but that non-African peoples (for example, Europeans and Native Americans) are most closely related to each other, suggesting that they descended from an ancestral population that had split from an African one 100,000 years ago or less.

Whatever the outcome of this scientific debate, the evidence shows that both Neanderthal and *Homo sapiens* groups were effective at exploiting the sometimes harsh climates of ice age Europe. Further, for the first time in human evolution, hominines began to bury their dead deliberately, the bodies sometimes being accompanied by stone tools and animal bones.

MODERN HUMAN BEINGS

With the appearance of biologically modern peoples, some important changes in anatomy and behaviour took place. The whole skeleton became more lightly built, the braincase became higher and rounder, the brow-ridges smaller, and the chin more prominent. Tools became more specialized, with the first effective use of difficult materials such as bone, antler, and ivory. Art appeared, especially famous from the walls of caves in France and Spain, produced from 35,000 years ago until the end of the ice age, about 12,000 years ago (*see* Palaeolithic Art). Some anthropologists have also argued that it was only in the last 100,000 years that full human language originated, a development that would have had profound implications for all aspects of human activity. About 12,000 years ago, one of the most important events in human history took place—plants and animals began to be domesticated. This revolution of agriculture and animal husbandry set the stage for the events in human history that led to the development of towns and cities, and a continuing growth in human population numbers.

Modern understanding of human evolution rests on known fossils, archaeology, and the study of living humans and our nearest relatives. The picture is far from complete, however. Future fossil discoveries will enable scientists to fill many of the blanks in the present picture of human evolution. Employing sophisticated technological devices as well as the accumulated knowledge of the patterns of geological deposition, anthropologists are now able to pinpoint the most promising locations for fossil hunting more accurately. In addition, genetic studies, including the extraction of ancient DNA from fossils, will become ever more important in reconstructing the pattern of modern human origins. The history of hundreds of different genes is now being studied from comparisons of the DNA of living people, and DNA has even

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been recovered from several Neanderthal fossils. In general, the evidence supports a recent African origin for modern human beings, and, in the case of the Neanderthals, they are confirmed as a separate lineage from our own, one that began to differentiate from our line of evolution about 500,000 years ago. Such genetic studies hold the promise of an enormous increase in our understanding of human prehistory in the years ahead.

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5.0 MAN AND HIS COSMIC ENVIRONMENT

The planet earth has often been compared to a vast spaceship. The living things aboard this spacecraft produce oxygen, cleanse its air, adjust its gases, transfer energy, and recycle waste products with great efficiency. Yet none of these things would be possible without the non-living environment of the world. Since the science of ecology deals with the non-living environment as well as the living, it is fitting to call this, the greatest of systems of life, the ecosphere.

The earth is composed of the **biosphere**, the totality of its living inhabitants; the **hydrosphere**, its supply of water (both frozen and liquid); its gaseous **atmosphere** (The air around the earth) and its **lithosphere**, that is the rocks and their derivatives, it is also the soil mantle that wraps up the core of the earth.

5.1 THE ATMOSPHERE

This is the, mixture of gases surrounding any celestial object (such as the Earth) that has a gravitational field strong enough to prevent the gases from escaping. The principal constituents of the atmosphere of the Earth are nitrogen (78 per cent) and oxygen (21 per cent). The atmospheric gases in the remaining 1 per cent are argon (0.9 per cent), carbon dioxide (0.03 per cent), varying amounts of water vapour, and trace amounts of hydrogen, ozone, methane, carbon monoxide, helium, neon, krypton, and xenon.

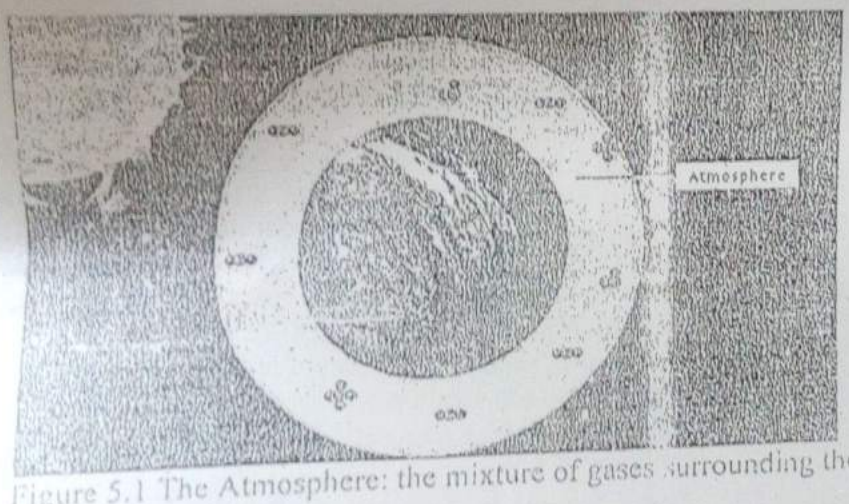

Figure 5.1 The Atmosphere: the mixture of gases surrounding the earth.

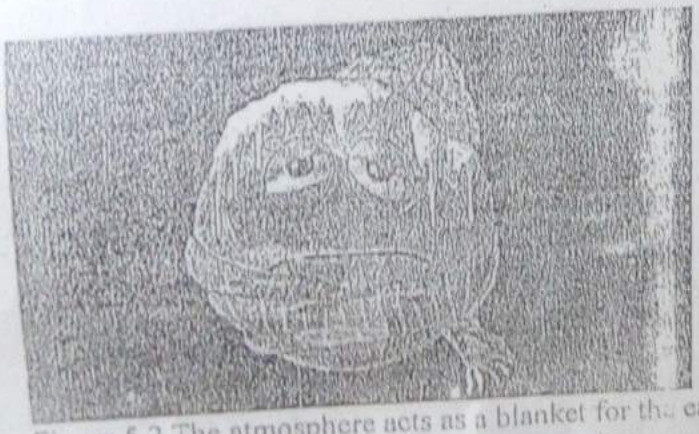

Figure 5.2 The atmosphere acts as a blanket for the earth, without it the earth would be too cold or too hot.

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been recovered from several Neanderthal fossils. In general, the evidence supports a recent African origin for modern human beings, and, in the case of the Neanderthals, they are confirmed as a separate lineage from our own, one that began to differentiate from our line of evolution about 500,000 years ago. Such genetic studies hold the promise of an enormous increase in our understanding of human prehistory in the years ahead.

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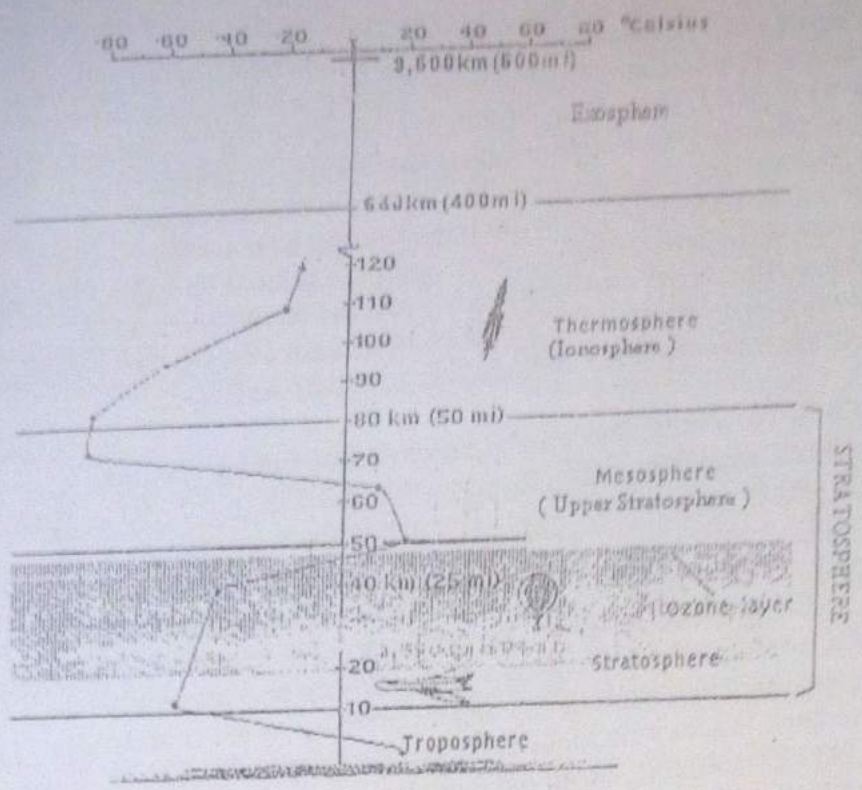

Figure 5.3 Divisions of the Atmosphere

Without our atmosphere, there would be no life on Earth. A relatively thin envelope, the atmosphere consists of layers of gases that support life and provide protection from harmful radiation. The illustration shows the temperature changes associated with the various layers of the atmosphere and their altitude from the Earth's surface.

Similar concerns are posed by the sharp increase in atmospheric methane. Methane levels have risen 11 per cent since 1978. About 80 per cent of the gas is produced by decomposition in rice paddies, swamps, and the intestines of grazing animals, and by tropical termites. Besides adding to the greenhouse effect, methane reduces the volume of atmospheric hydroxyl ions, thereby impairing the atmosphere's ability to cleanse itself of pollutants.

The study of air samples shows that up to at least 88 km (55 mi) above sea level the composition of the atmosphere is substantially the same as at ground level; the continuous stirring produced by atmospheric currents counteracts the tendency of the heavier gases to settle below the lighter ones. In the lower atmosphere, ozone, a form of oxygen with three atoms in each molecule, is normally present in extremely low concentrations. The layer of atmosphere from 19 to 48 km (12 to 30 mi) up contains more ozone, produced by the action of ultraviolet radiation from the Sun. Even in this layer, however, the percentage of ozone is only 0.001 by volume. Atmospheric disturbances and downdrafts carry varying amounts of this ozone to the surface of the Earth. Human activity adds to ozone in the lower atmosphere, where it becomes a pollutant that can cause extensive crop damage.

The ozone layer became a subject of concern in the early 1970s when it was found that chemicals known as chlorofluorocarbons (CFCs), or chlorofluoromethanes, were rising into the atmosphere in large quantities because of their use as refrigerants and as propellants in aerosol dispensers. The concern centred on the possibility that these compounds, through the action of sunlight, could photochemically attack and destroy stratospheric ozone, which protects the Earth's surface from excessive ultraviolet radiation. As a result, industries in industrialized

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The water-vapour content of the air varies considerably, depending on the temperature and relative humidity. With 100 per cent relative humidity the water-vapour content of air varies from 190 parts per million (ppm) at -40° C (-40° F) to 42,000 ppm at 30° C (86° F). Minute quantities of other gases, such as ammonia, hydrogen sulphide, and oxides of sulphur and nitrogen, are temporary constituents of the atmosphere in the vicinity of volcanoes and are washed out of the air by rain or snow. Oxides and other pollutants added to the atmosphere by factories and vehicles have become a major concern, however, because of their damaging effects in the form of acid rain. In addition, the strong possibility exists that the steady increase in atmospheric carbon dioxide, mainly as the result of fossil-fuel combustion over the past century, may affect the Earth's climate through the process known as the greenhouse effect.

The earth's atmosphere may be divided into several layers. In the lowest one, the troposphere, the temperature as a rule decreases upwards at the rate of 5.5° C per 1,000 m (3° F per 1,000 ft). This is the layer in which most clouds occur. The troposphere extends up to about 16 km (10 mi) in tropical regions (to a temperature of about -79° C, or -110° F) and to about 9.7 km (6 mi) in temperate latitudes (to a temperature of about -51° C, or -60° F). Above the troposphere is the stratosphere. In the lower stratosphere the temperature is practically constant or increases slightly with altitude, especially over tropical regions. Within the ozone layer the temperature rises more rapidly, and the temperature at the upper boundary of the stratosphere, almost 50 km (30 mi) above sea level, is about the same as the temperature at the surface of the Earth. The layer from 50 to 80 km (30 to 50 mi), called the mesosphere, is characterized by a marked decrease in temperature as the altitude increases.

Atmosp
strato
troposphere

From investigations of the propagation and reflection of radio waves, it is known that beginning at an altitude of 80 km (50 mi), ultraviolet radiation, X-rays, and showers of electrons from the Sun ionize several layers of the atmosphere, causing them to conduct electricity; these layers reflect radio waves of certain frequencies back to Earth. Because of the relatively high concentration of ions in the air above 80 km (50 mi), this layer, extending to an altitude of 640 km (400 mi), is called the ionosphere. It is also termed the thermosphere, because of the high temperatures in this layer (rising to about 2,200°F, or 1,200°C at about 400 km/250 mi). The region beyond the ionosphere is called the exosphere, which extends to about 9,600 km (6,000 mi), the outer limit of the atmosphere.

The density of dry air at sea level is about 1/800 the density of water; at higher altitudes it decreases rapidly, being proportional to the pressure and inversely proportional to the temperature. Pressure is measured by a barometer and is expressed in torrs, which are related to the height of a column of mercury that the air pressure will support; 1 torr equals 1 mm (0.039 in) of mercury. Normal atmospheric pressure at sea level is 760 torrs, that is, 760 mm (29.92 in) of mercury. At about 5.6 km (3.5 mi) it is 380 torrs (14.96 in); half of all the air in the atmosphere lies below this level. The pressure is again approximately halved for each additional increase of 5.6 km in altitude. At 80 km (50 mi) the pressure is 0.007 torr (0.00027 in). The troposphere and most of the stratosphere can be explored directly by means of sounding balloons equipped with instruments to measure the pressure and temperature of the air and with a radio transmitter to send the data to a receiving station at the ground. Rockets carrying radios that transmit meteorological-instrument readings have explored the atmosphere to altitudes above 400 km (250 mi). Study of the form and spectrum of the aurora gives information to a height possibly as great as 800 km (500 mi).

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countries have replaced chlorofluorocarbons in all [illegible] subsequent atmospheric studies are inconclusive about the actual threat to the ozone layer by human activities.

5.2 ENVIRONMENTAL PROBLEMS

The species Homo sapiens—that is, human beings—appeared late in the Earth's history, but was ultimately able to modify the Earth's environment by its activities. Although human beings apparently first appeared in Africa, they quickly spread throughout the world. Because of their unique mental and physical capabilities, human beings were able to escape the environmental constraints that limited other species and to change the environment to meet their needs.

Although early human beings undoubtedly lived in some harmony with the environment, as did other animals, their retreat from the wilderness began with the first, prehistoric agricultural revolution. The ability to control and use fire allowed them to modify or eliminate natural vegetation, and the domestication and herding of grazing animals eventually resulted in overgrazing and soil erosion. The domestication of plants also led to the destruction of natural vegetation to make room for crops, and the demand for wood for fuel denuded mountains and depleted forests. Wild animals were slaughtered for food and destroyed as pests and predators.

While human populations remained small and human technology modest, their impact on the environment was localized. As populations increased and technology improved and expanded, however, more significant and widespread problems arose. Rapid technological advances after the Middle Ages culminated in the Industrial Revolution, which involved the discovery, use, and exploitation of fossil fuels, as well as the extensive exploitation of the Earth's mineral resources. With the Industrial Revolution, humans began in earnest to change the face of the Earth, the nature of its atmosphere, and the quality of its water. Today, unprecedented demands on the environment from a rapidly expanding human population and from advancing technology are causing a continuing and accelerating decline in the quality of the environment and its ability to sustain life.

A Carbon Dioxide

Hydrocarbon Pollution from Vehicle Exhaust Vehicle exhaust contains a number of airborne pollutants that adversely affect the health of animals and plants and the chemical nature of the atmosphere. Carbon dioxide and hydrocarbon emissions, two of the major components of vehicle exhaust, contribute significantly to global warming and are produced as a by-product of the combustion of petroleum-based fuels. Elevated carbon dioxide and hydrocarbon levels cause sunlight to be reflected and trapped within the atmosphere, which slowly raises the temperature of the atmosphere.

One impact that the burning of fossil fuels has had on the Earth's environment has been the increase of carbon dioxide (CO_2) in the Earth's atmosphere. The amount of atmospheric CO_2 apparently remained stable for millennia, at about 260 ppm (parts per million), but over the past 100 years it has increased to 350 ppm. The significance of this change is its potential for raising the temperature of the Earth through the process known as the greenhouse effect. Carbon dioxide in the atmosphere prevents the escape of outgoing long-wave radiation from the Earth to outer space; as more heat is produced and less escapes, the temperature of the Earth increases.

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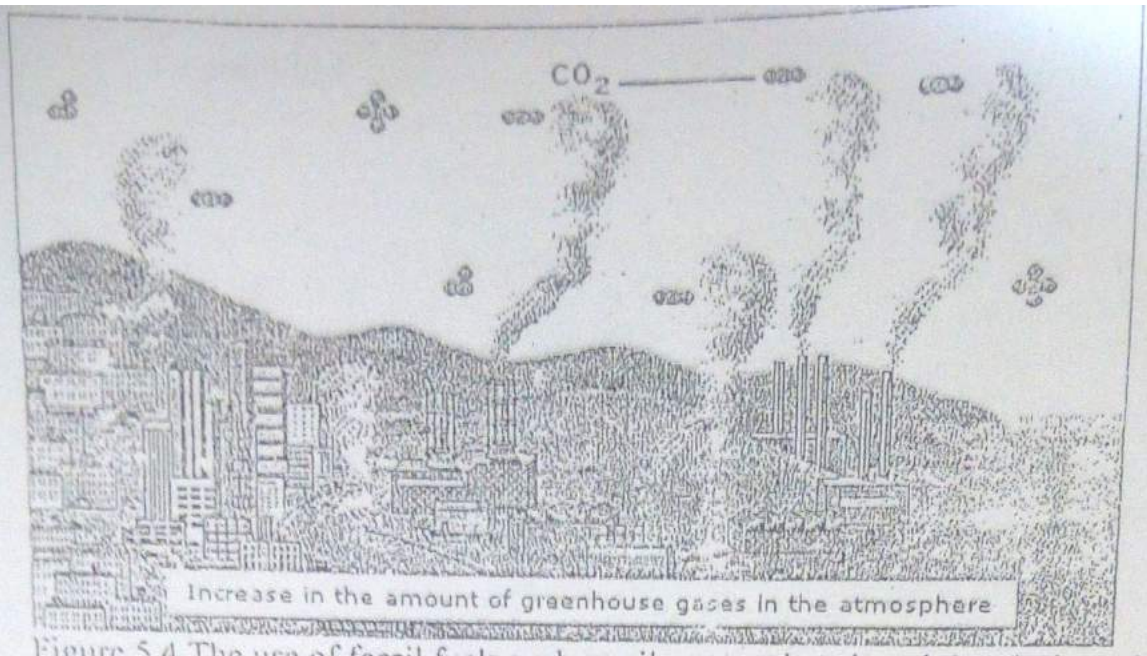

Figure 5.4 The use of fossil fuels such as oil, gas, and coal, and the slash-and-burn clearing of tropical forests have been contributing factors in the carbon cycle.

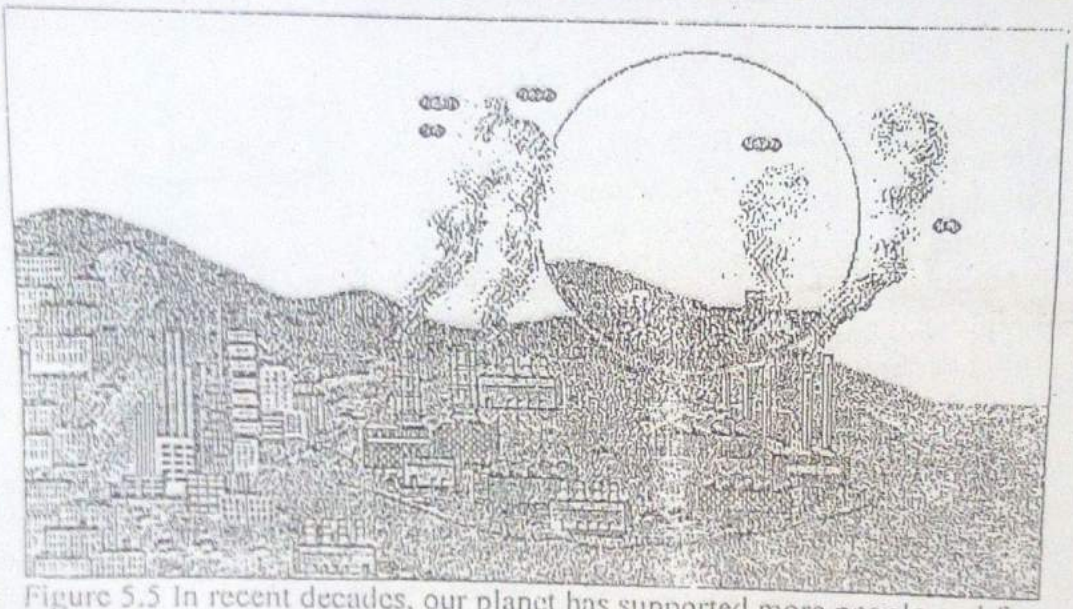

Figure 5.5 In recent decades, our planet has supported more people and fewer trees, leaving an excess of carbon dioxide in the atmosphere.

THE GREENHOUSE EFFECT

The greenhouse effect refers to the way in which gases in the Earth's atmosphere warm the Earth like the glass roof of a greenhouse—by letting sunlight in but keeping the reflected heat energy trapped inside. These naturally occurring gases, notably carbon dioxide and water vapour, are called greenhouse gases.

The greenhouse Effect is the term for the role the atmosphere plays in helping warm the Earth's surface. The atmosphere is largely transparent to incoming short-wave (or ultraviolet) solar radiation, which is absorbed by the Earth's surface. Much of this radiation is then re-emitted as heat energy at long-wave, infrared wavelengths; some of this energy escapes back into space, but much of it is reflected back by gases such as carbon dioxide, methane, nitrous oxide, halocarbons, and ozone in the atmosphere. This heating effect is at the root of the theories concerning global warming.

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Under normal conditions the level of carbon dioxide in the atmosphere remains constant, and trees absorb the same amount of carbon dioxide that people produce. But in recent decades, our planet has supported more people and fewer trees, leaving an excess of carbon dioxide in the atmosphere. The amount of carbon dioxide has been increasing by 0.4 per cent a year; the use of fossil fuels such as oil, gas, and coal, and the slash-and-burn clearing of tropical forests have been contributing factors in the carbon cycle. Other gases that contribute to the greenhouse effect, such as methane and chlorofluorocarbons, are increasing even faster. The net effect of these increases could be a worldwide rise in temperature, estimated at 2° to 6° C (4° to 11° F) over the next 100 years. Warming of this magnitude would alter climates throughout the world, affect crop production, and cause sea levels to rise significantly. If this happened, millions of people would be adversely affected by major flooding.

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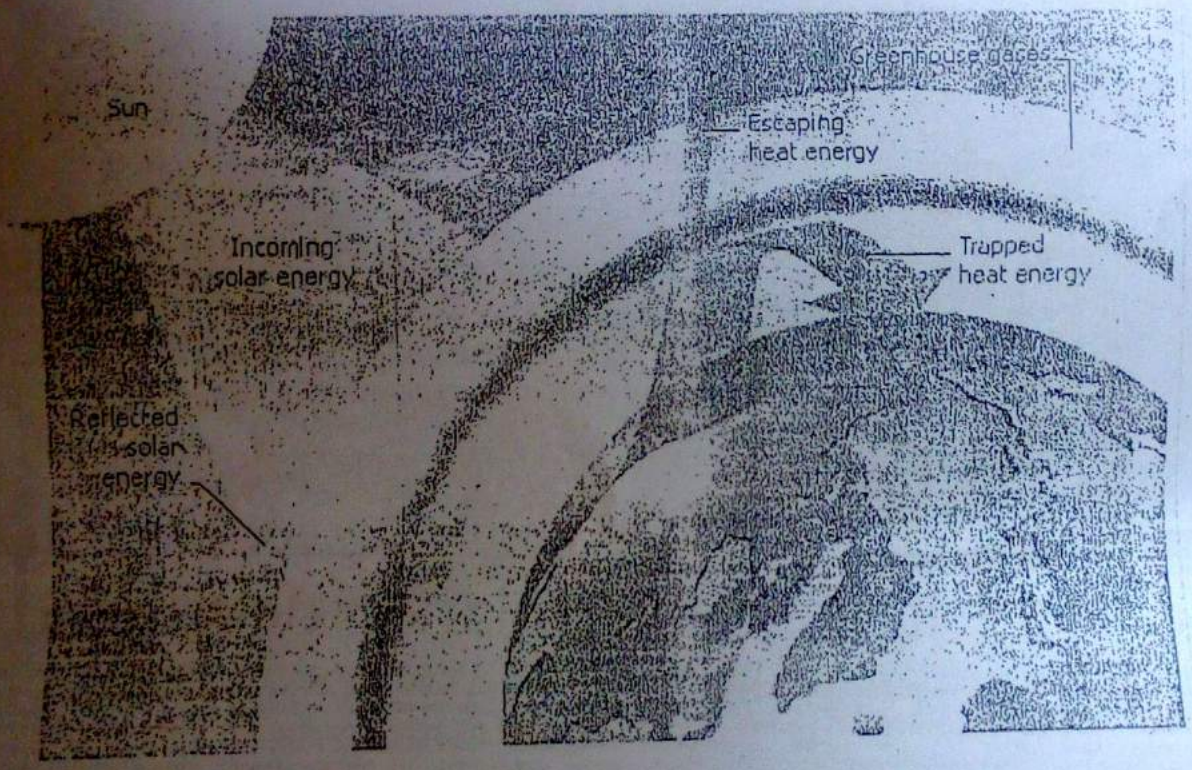

Figure 5.6 Illustration of the Greenhouse Effect (A)

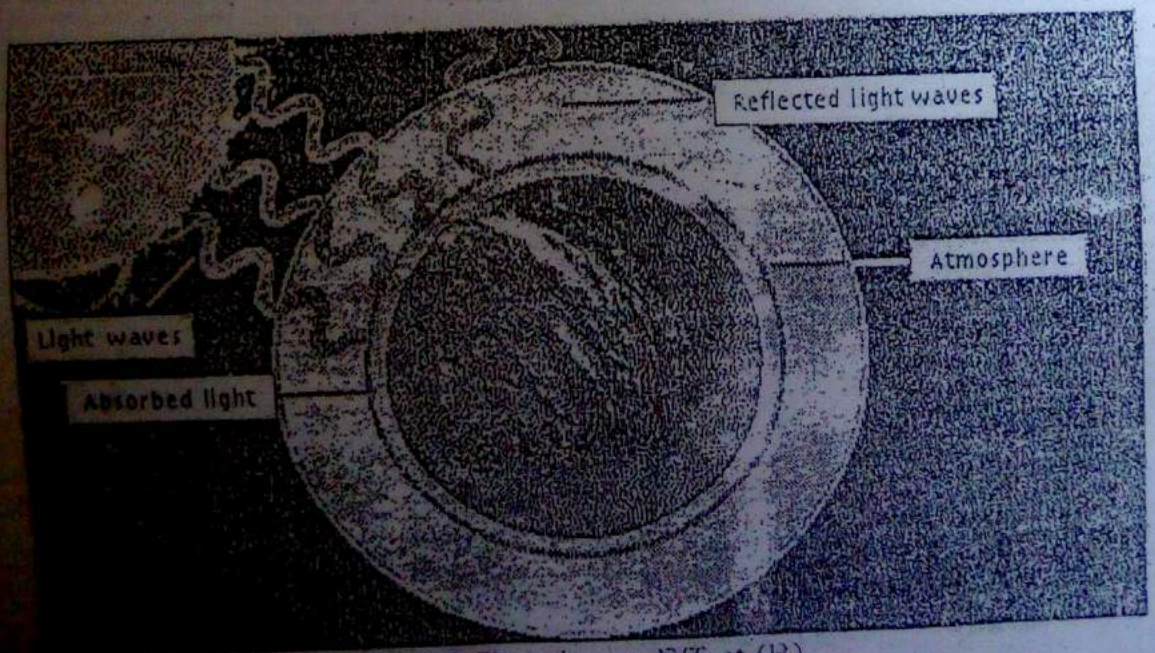

Figure 5.7 Illustration of the Greenhouse Effect (B)

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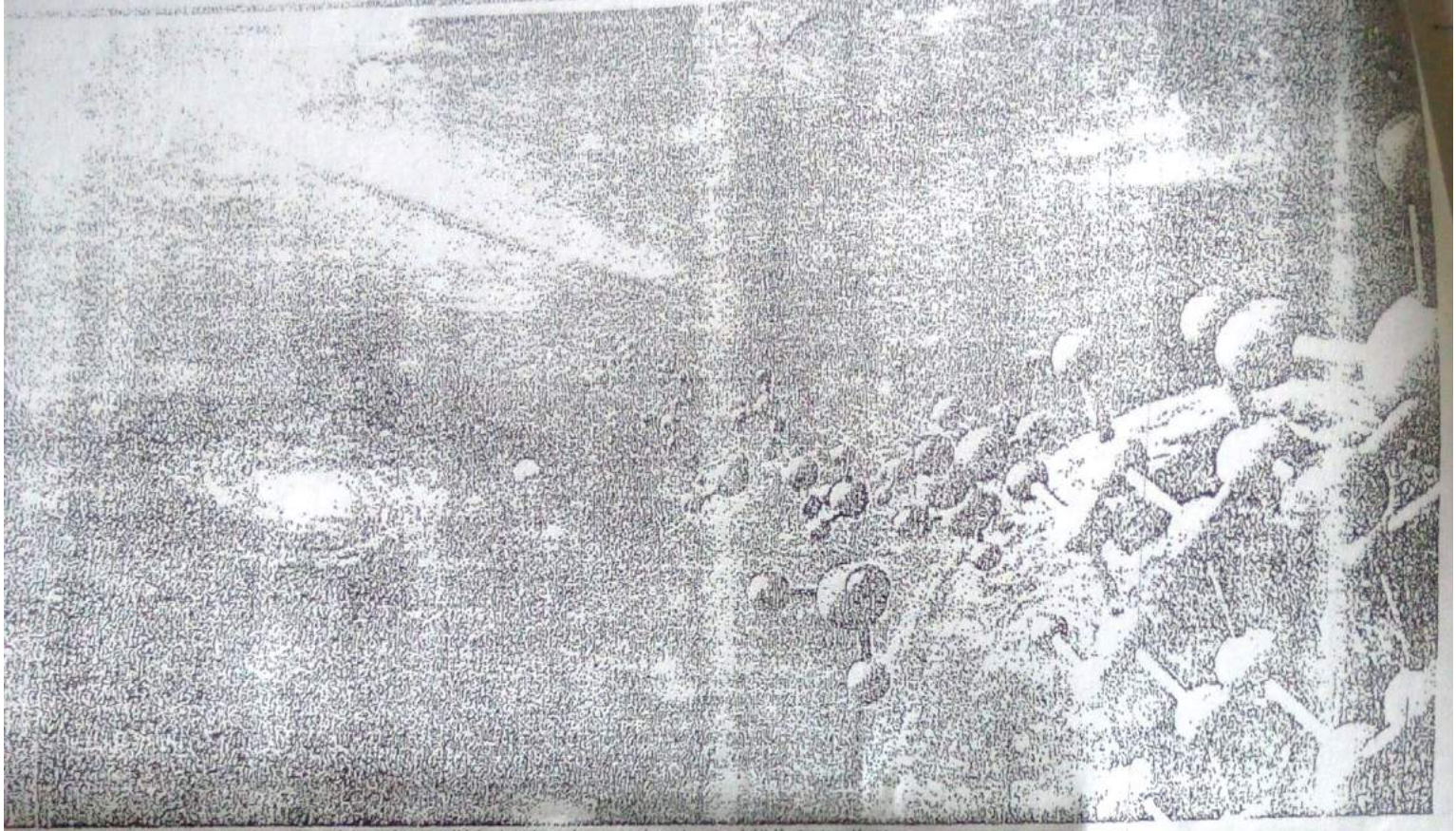
ScienceGuardian



...ites planets... An organic sugar molecule which is directly linked to the origin of life has been detected in a region of our galaxy where habitable planets could exist

First system for assessing habitable planets developed

Within the next few years, the number of planets discovered in orbits around distant stars will likely reach several thousand or more. But even as our list of these newly discovered "exoplanets" grows ever-longer, the search for life beyond our solar system will likely focus much more narrowly on the relatively few of these new worlds, which exhibit the most Earth-like of conditions.

For much of the scientific community, the search for alien life has long been dominated by the notion that our own planet serves as the best model of conditions best suited to the emergence of life on other worlds. And while there's an undeniable logic to seeking life in the same sort of conditions in which you already know it to be successful, there are scientists like Dirk Schulze-Makuch, an astrobiologist with the Washington State University School of Earth and Environmental Sciences and Abel Mendez, a modeling expert from the University of Puerto Rico at Arecibo, who also see such a model as the product of a potentially limiting form of earthling-biased thinking.

To Schulze Makuch and his nine fellow authors — an international working group representing NASA, SETI, the German Aerospace Center, and four universities — the search for life on other worlds is really driven by two questions.

"The first question is whether Earth-like conditions can be found on other worlds, since we know empirically that those conditions could harbour life," Schulze-Makuch said. "The second question is whether conditions exist on exoplanets that suggest the possibility of other forms of life, whether known to us or not."

In a paper to be published in the December issue of the journal *Astrobiology*, Schulze-Makuch and his co-authors propose a new system for classifying exoplanets using two different indices — an Earth Similarity Index (ESI) for categorizing a planet's more earth-like features and a Planetary Habitability Index (PHI) for describing a variety of chemical and physical parameters that are theoretically conducive to life in more extreme, less Earth-like conditions.

Similarity indices provide a powerful tool for categorizing and extracting patterns from large and complex data sets. They are relatively quick and easy to calculate and provide a simple quantitative measure of departure from a reference state, usually on a scale from zero to one. They are used in mathematics, computer imaging, chemistry and many other fields.

The two indices proposed by the group mark the first attempt by scientists to categorize the many exoplanets and exomoons that are expected to be discovered in the near future in accordance with their potential to harbor some form of life.

"As a practical matter, interest in exoplanets is going to focus initially on the search for terrestrial, Earth-like planets," said Schulze-Makuch. "With that in mind, we propose an Earth Similarity Index which provides a quick screening tool with which to detect exoplanets most similar to Earth."

But the authors believe that focusing exclusively on earth-based assumptions about habitability may well be too restrictive an approach for capturing the potential variety of life forms that, at least in principle, may also exist on other worlds.

"Habitability in a wider sense is not necessarily restricted to water as a solvent or to a planet circling a star," the paper's authors write. "For example, the hydrocarbon lakes on Titan could host a different form of life. Analog studies in hydrocarbon environments on Earth, in fact, clearly indicate that these environments are habitable in principle. Orphan planets wandering free of any central star could likewise conceivably feature conditions suitable for some form of life."

The paper's authors concede that attempting to rate the probability that life of some unknown form could exist on any given world is an intrinsically more speculative endeavor. But the alternative, they argue, is to risk overlooking potentially habitable worlds by using overly restrictive assumptions.

"Our proposed PHI is informed by chemical and physical parameters that are conducive to life in general," they write. "It relies on factors that, in principle, could be detected at the distance of exoplanets from Earth, given currently planned future (space) instrumentation."

Nigerian scientists determine gas flow in oil pipelines with acoustic emission

By Chukwuma Muanya

SCIENTISTS led by a Nigerian, Prof. David Mba, have investigated the use of the Acoustic Emission (AE) technology for detecting slugs in two-phase flow in oil and gas pipelines. AE is used to describe the spontaneous elastic energy released by a process in the form of transient elastic waves.

The paper presented an investigation into the use of AE for measuring the concentration of gas, which will offer a non-intrusive and cheaper approach to current technologies used for monitoring gas content within the oil and gas industry.

The study published in the *Journal of Process Mechanical Engineering* concluded "The applicability of the AE technology to measure the Gas Void Fraction (GVF) has been demonstrated. A correlation is developed as a function of the absolute AE energy and slug velocities for the range of liquid and gas velocities.

"In order to validate the applicability of the model for other flow and physical conditions, further experimental investigations are required. The work currently being undertaken investigates the GVF prediction for varying viscosity, pipeline orientation, and surface roughness of the pipe."

The study, entitled *Acoustic emission and gas-phase measurements in two phase flow*, was awarded the 2010 Ludwig Mond Prize by the Process Industries Division of the Institution of Mechanical Engineers (IMechE).

The Institution of Mechanical Engineers (IMechE) is the British engineering society based in central London, representing mechanical engineering. It is licensed by the Engineering Council United Kingdom (ECUK) to assess candidates for inclusion on ECUK's Register of professional Engineers. It was founded in 1847 and received a Royal Charter in 1930.

Ludwig Mond Prize is a prestigious prize awarded for the best contribution made to the progress of mechanical engineering of interest to the chemical industry. It was presented to Prof. David Mba et al. for their paper.

According to the study, the two-phase liquid/gas slug flow regime phenomenon can be encountered over a range of gas and liquid flowrates. The study reads: "Monitoring of slugs and measurement of their characteristics, such as the gas void fraction, are necessary to minimise the disruption of downstream process facilities.

"This article presents experimental results correlating acoustic emission measurements with gas void fraction in a two-phase waterfair flow regime. It is concluded that the gas void fraction can be determined by the measurement of acoustic emission, which hitherto had not been investigated."

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A significant global warming of the atmosphere would have profound environmental effects. It would speed the melting of polar ice caps, raise sea levels, change the climate regionally and globally, alter natural vegetation, and affect crop production. These changes would, in turn, have an enormous impact on human civilization. Since 1850 there has been a mean rise in global temperature of about 1° C ( ). Most scientists have predicted that rising levels of CO2 and other "greenhouse gases" will cause temperatures to continue to increase, with estimates ranging from 2° to 6° C (4° to 11° F) by the mid-21st century. However, some scientists who research climate effects and trends dispute the theories of global warming, and attribute the most recent rise to normal temperature fluctuations.

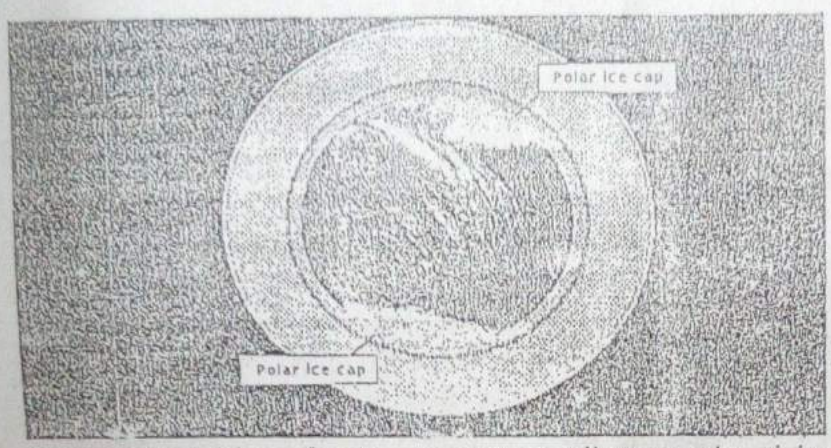

Figure 5.8 Melting of polar ice caps contributes to the, rising sea levels.

Acid rain = Water + SO_2 + Nitro compound.
rain pH = 6.5

B Acid Deposition

Lakes, ponds, and other terrestrial and aquatic environments throughout the world are being severely damaged by the effects of acid rain. Acid rain is caused by the combination of sulphur dioxide and nitrogen compounds with water in the atmosphere to produce rain with a very low pH. Normally, rainwater has a pH of 6.5, making it very slightly acidic. However, with the addition of sulphur and nitrogen compounds, the pH of rainwater may drop to as low as 2.0 or 3.0, similar to the acidity of vinegar. In addition to chemically burning the leaves of plants, acid rain poisons lakewater, which kills most if not all of the aquatic inhabitants.

Also associated with the burning of fossil fuels is acid deposition, which is caused by the emission of sulphur dioxide and nitrous oxides into the air from power plants and motor vehicles. These chemicals interact with sunlight, moisture, and oxidants to produce sulphuric and nitric acids, which are carried with the atmospheric circulation and come to Earth in rainfall and snowfall, commonly referred to as acid rain, and as dry deposits in the form of dry particles and atmospheric gases.

Acid rain is a localized problem. The acidity of some precipitation in northern North America and Europe is equivalent to that of vinegar. Acid rain corrodes metals, weathers stone buildings and monuments, injures and kills vegetation, and acidifies lakes, streams, and soils, especially in the poorly buffered regions of north-eastern North America and northern Europe. In these regions, lake acidification has killed some fish populations. It is also now a problem in the south-eastern and western United States. Acid rain can also slow forest growth, and forest die-back has been major problem. It is associated with forest decline at high elevations in both North America and Europe.

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C Ozone Layer Destruction

During the 1980s, scientists began to find that human activity was having a detrimental effect on the global ozone layer, a region of the atmosphere that shields the Earth from the Sun's harmful ultraviolet rays. Without this gaseous layer, which is found at about 40 km (25 mi) above sea level, no life could survive on the planet. Studies showed the ozone layer was being damaged by the increasing use of industrial chemicals called chlorofluorocarbons (CFCs, compounds of fluorine) that are used in refrigeration, air-conditioning, cleaning solvents, packing materials, and aerosol sprays. Chlorine, a chemical by-product of CFCs, attacks ozone, which consists of three molecules of oxygen, by taking one molecule away to form chlorine monoxide. Chlorine monoxide then reacts with oxygen atoms to form oxygen molecules, releasing chlorine molecules that break up other molecules of ozone.

It was initially thought that the ozone layer was being reduced gradually all over the globe. In 1985, however, further research revealed a growing ozone hole concentrated above Antarctica; 50 per cent or more of the ozone above this area of the Earth was being depleted seasonally (beginning each October). By late 2000 this hole had grown to 28.3 million sq km (11 million sq mi) in area. A thinning of the ozone layer is the key factor in the greenhouse effect, and exposes life on Earth to excessive ultraviolet radiation, which can increase skin cancer and cataracts, reduce immune-system responses, interfere with the photosynthetic process of plants, and affect the growth of oceanic phytoplankton. Because of the growing threat of these dangerous environmental effects, many nations are working towards eliminating the manufacture and use of CFCs. However, CFCs can remain in the atmosphere for more than 100 years, so ozone destruction will continue to pose a threat for decades to come.

D Chlorinated Hydrocarbons

Extensive use of synthetic pesticides derived from chlorinated hydrocarbons in pest control has had disastrous environmental side effects. These organochlorine pesticides are highly persistent and resist biological degradation. Relatively insoluble in water, they cling to plant tissues and accumulate in soils, the bottom mud of streams and ponds, and the atmosphere. Once volatilized, the pesticides are distributed worldwide, contaminating wilderness areas far removed from agricultural regions, and even the Antarctic and Arctic zones.

Although these synthetic chemicals are not found in nature, they nevertheless enter the food chain. The pesticides are either taken in by plant eaters or absorbed directly through the skin by such aquatic organisms as fish and various invertebrates. The pesticide is further concentrated as it passes from herbivores (plant eaters) to carnivores (meat eaters). It becomes highly concentrated in the tissues of animals at the end of the food chain, such as the peregrine falcon, bald eagle, and osprey. Chlorinated hydrocarbons interfere in the calcium metabolism of birds, causing thinning of egg shells and subsequent reproductive failure. As a result, some large predatory and fish-eating birds have been brought close to extinction. Because of the dangers of pesticides to wildlife and to humans, and because insects have acquired resistance to them, the use of halogenated hydrocarbons such as DDT is declining rapidly in the Western world, although large quantities are still used in developing countries. In the early 1980s, the halogenated pesticide EDB, or Ethylene Dibromide, also aroused great concern as a potential carcinogen, and was eventually banned.

Closely related to DDT is another group of compounds: the polychlorinated biphenyls, or PCBs. For years these compounds have been used in industrial production, and eventually they found their way into the environment. Their impact on humans and wildlife has been similar to that of pesticides. Because of their extreme toxicity, the use of PCBs is now restricted to insulators in electrical transformers and capacitors.

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PCDD is the most toxic of another related group of highly toxic compounds, the dioxins, or polychlorinated dibenzo-para-dioxins. The extent of toxicity of these carcinogenic compounds in humans has not yet been proved. PCDD may be found as an impurity in wood and paper preservatives and in herbicides. Agent Orange, a defoliant widely used in jungle warfare, contains minute traces of dioxin.

E Other Toxic Substances

The pollution of rivers and streams with chemical contaminants is one of the world's most critical environmental problems. Chemical pollution entering rivers and streams comes from two major sources: point pollution and non-point pollution. Point pollution involves those pollution sources which can be specifically identified, such as factories, refineries or outfall pipes. Non-point pollution involves pollution from sources that cannot be precisely identified, such as runoff from agricultural or mining operations or seepage from septic tanks or sewage drain fields. It is estimated that each year 10 million people worldwide die from drinking contaminated water.

Toxic substances are chemicals and mixtures of chemicals the manufacturing, processing, distribution, use, and disposal of which present an unreasonable risk to human health and the environment. Most of these toxic substances are synthetic chemicals that enter the environment and persist there for long periods of time. Major concentrations of toxic substances occur in chemical dump sites. If they seep into soil and water, the chemicals can contaminate water supplies, air, crops, and domestic animals, and have been associated with human birth defects, miscarriages, and organic diseases. Despite known dangers, the problem is not lessening. In a recent 15-year period, more than 70,000 new synthetic chemicals were manufactured, and new ones are being created at the rate of 500 to 1,000 each year.

F Radiation

Although atmospheric testing of nuclear weapons has been banned by most countries, eliminating a large source of radioactive fallout, nuclear radiation still remains an environmental problem. Power plants always release some amount of radioactive waste into the air and water, but the main danger is the possibility of nuclear accidents, in which massive amounts of radiation are released into the environment—as happened at Chernobyl, Ukraine, in 1986. In fact, since the break-up of the Union of Soviet Socialist Republics (USSR), the world has learned that contamination of that region from nuclear accidents and nuclear wastes is far more extensive than had been realized. A greater problem facing the nuclear industry is the storage of nuclear wastes, which remain toxic for 700 to 1 million years, depending on the type. Safe storage for geological periods of time is problematic; meanwhile nuclear wastes accumulate, threatening the environment.

G Loss of Wild Lands

The deforestation technique of slash and burn, utilized extensively to clear large areas of forest for agricultural and other purposes, causes an enormous amount of environmental damage. The large amounts of carbon dioxide given off into the atmosphere during burning adds to the greenhouse effect. The removal of all trees and ground cover destroys animal habitats and greatly accelerates erosion, adding to the sediment loads of rivers and making seasonal flooding much more severe.

Increasing numbers of human beings are encroaching on remaining wild lands—even in those areas once considered relatively safe from exploitation, degradation, and pollution. Insatiable

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demands for energy are forcing the development of Arctic regions for oil and gas and threatening the delicate ecological balance of tundra ecosystems and their wildlife. Tropical forests, especially in south-eastern Asia and the Amazon River Basin, are being destroyed at an alarming rate for timber, conversion to crop and grazing lands, pine plantations, and settlements. It was estimated at one point in the 1980s that such forest lands were being cleared or converted at the rate of 20 hectares (nearly 50 acres) a minute; another estimate put the rate at more than 200,000 sq km (78,000 sq mi) a year. In 1993 satellite data provided a rate of about 15,000 sq km (5,800 sq mi) a year in the Amazon Basin area alone. This tropical deforestation has already resulted in the extinction of as many as 750,000 species, and is likely to eliminate millions if allowed to continue unchecked. This would mean the loss of a multiplicity of products: food, fibres, medical drugs, dyes, gums, and resins. In addition, the expansion of croplands and grazing areas for domestic livestock in Africa, and illegal trade in endangered species and wildlife products, could mean the end of Africa's large mammals. In North America, wild areas are being threatened by agricultural expansion and widespread pollution.

H Soil Erosion

Gully formation, a severe form of soil erosion, is a natural geological process that can be greatly accelerated by human activities such as deforestation, overgrazing of cattle, and poor agricultural practices. Erosion attacks the moisture-bearing ability of soils and adds deposits to waterways. These destructive processes continue at an increased rate on every continent, as overpopulation and industrialization tax the remaining soil.

Soil erosion is accelerating on every continent but Antarctica and is degrading one fifth to one third of the cropland of the world, posing a significant threat to the food supply. For example, erosion is undermining the productivity of approximately 35 per cent of all cropland in the United States. In the developing world, increasing needs for food and firewood have resulted in the deforestation and cultivation of steep slopes, causing severe erosion. Adding to the problem is the loss of prime cropland to industry, dams, urban sprawl, and highways. The amount of topsoil lost each year is at least 25 million tonnes, which is enough, in principle, to grow 9 million tonnes of wheat. About half of all erosion is in the United States, the former Soviet Union, India, and China. Soil erosion and the loss of cropland and forests also reduce the moisture-holding capacity of soils and add sediments to streams, lakes, and reservoirs.

I Demands on Water and Air

The erosion problems described above are aggravating a growing world water problem. Expanding human populations need irrigation systems and water for industry; this is so depleting underground aquifers that salt water is intruding into them along coastal areas of the United States, Israel, Syria, and the Arabian Gulf states. In inland areas, porous rocks and sediments are compacting when drained of water, causing surface subsidence problems; this subsidence is already a serious problem in Texas, Florida, and California.

The world is also experiencing a steady decline in water quality and availability. Human beings already use 55 per cent of available freshwater run-off. This level of consumption will be an increasing problem as the population rises. About 75 per cent of the world's rural population and 20 per cent of its urban population have no ready access to uncontaminated water. In many regions, water supplies are contaminated with toxic chemicals and nitrates. Waterborne disease debilitates one third of humanity and kills 10 million people a year.

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MAN AND HIS ENERGY RESOURCES

Energy is the capacity of a physical system to perform work. Matter possesses energy as the result of its motion or its position in relation to forces acting on it. Electromagnetic radiation possesses energy related to its wavelength and frequency. The energy is imparted to matter when the radiation is absorbed, or is carried away from matter when the radiation is emitted. Energy associated with motion is known as kinetic energy, and energy related to position is called potential energy. Thus, a swinging pendulum has maximum gravitational potential energy at the terminal points; at all intermediate positions it has both kinetic and gravitational potential energy in varying proportions. Energy exists in various forms, including mechanical (see Mechanics), thermal (see Thermodynamics), chemical (see Chemical Reaction), electrical (see Electricity), radiant (see Radiation), and atomic (see Nuclear Energy). All forms of energy are interconvertible by appropriate processes. In the process of transformation either kinetic or potential energy may be lost or gained, but the sum total of the two always remains the same.

A weight suspended from a cord has potential energy due to its position. This can be converted into kinetic energy as it falls. An electric battery has potential energy in chemical form. A piece of magnesium also has potential energy stored in chemical form: it is expended in the form of heat and light if the magnesium is ignited. If a gun is fired, the chemical potential energy of the gunpowder is transformed into the kinetic energy of the moving projectile. The kinetic energy of the moving rotor of a dynamo is changed into electrical energy by electromagnetic induction. The electrical energy may be stored as the potential energy of electric charge in a capacitor or battery, or it may be dissipated as heat generated by a current, or expended as work done by an electrical device. All forms of energy tend to be transformed into heat. In mechanical devices energy not expended in useful work is dissipated in frictional heat, and losses in electrical circuits are largely heat losses.

Empirical observation in the 19th century led to the conclusion that although energy can be transformed, it cannot be created or destroyed. This concept, known as the conservation of energy, constitutes one of the basic principles of classical mechanics. The principle, along with the parallel principle of conservation of matter, holds true only for phenomena involving velocities that are small compared with the velocity of light. At velocities that are a significant fraction of that of light, as in nuclear reactions, energy and matter are interconvertible (see Relativity). In modern physics the two concepts, the conservation of energy and of mass, are thus unified.

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Nuclear Power, electrical power produced from energy released by controlled fission or fusion of atomic nuclei in a nuclear reaction. Mass is converted into energy, and the amount of released energy greatly exceeds that from chemical processes such as combustion.

The first experimental nuclear reactor was constructed in 1942 amid tight wartime secrecy in Chicago, Illinois, in the United States. A prototype reactor was demonstrated at Oak Ridge, Tennessee, in 1943, and by 1945 three full-scale reactors were in operation at Hanford, in Washington State. These were dedicated to plutonium production for nuclear weapons; however, the first large-scale commercial reactor generating electrical power was started up in 1956 at Calder Hall, United Kingdom.

Nuclear power is now a well-established source of electricity worldwide. The most common types of reactor are light water reactors, mostly pressurized water reactors (PWRs) together with boiling water reactors (BWRs). Gas-cooled and heavy water reactors make up the rest. Worldwide there are currently about 430 reactors operating in 25 countries providing about 17 per cent of the world's electricity. Nuclear reactors are also used for propulsion of submarines and ships, and there are a number of prototype and experimental reactors around the world. At present, only a few experimental fusion reactors exist, none of which produce usable amounts of electrical power.

Few nuclear power stations are under construction at present, and some have been cancelled when partly built. This is mainly because of long-term resistance from the environmental movement (in particular since the Chernobyl disaster of 1986), but nuclear power stations are also not competitive with natural gas- and coal-fired power stations at present. It is uncertain whether nuclear power generation will increase or decrease worldwide over the next 50 years. However, the very low carbon dioxide emissions from nuclear power stations compared with coal- , gas- , or oil-fired units mean that there is potentially a future expansion in nuclear power driven by the need to control climate change.

More than 40 million kilowatt-hours (kWh) of electricity can generally be produced from one tonne of natural uranium. Over 16,000 tonnes of coal or 80,000 barrels of oil would need to be burned to make the same amount of electricity. Moreover, the amount of carbon dioxide produced in generating one kWh of electricity would be 1 kg for coal, 0.5 kg for gas, and only 10 grams for nuclear power.

Other than economic factors, the main issues limiting expansion of nuclear power are disposal of radioactive waste (including waste left over from decommissioning of old facilities), radioactivity in liquid effluent and gaseous discharges, security concerns over stockpiled plutonium, and the historical connection with nuclear weapons. Availability of nuclear fuel is unlikely to limit nuclear power production in the foreseeable future.

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II THE BASICS OF NUCLEAR POWER

Nuclear Binding Energy The amount of energy required to remove a single proton or neutron from an atomic nucleus varies with the mass of the nucleus. The graph of this relationship is called the binding energy curve.

Nuclear power plants generate electricity from fission, usually of uranium-235 (U-235), the nucleus of which has 92 protons and 143 neutrons. When it absorbs an extra neutron, the nucleus becomes unstable and splits into smaller pieces ("fission products") and more neutrons. The fission products and neutrons have a smaller total mass than the U-235 and the first neutron; the mass difference has been converted into energy, mostly in the form of heat, which produces steam and in turn drives a turbine generator to produce electricity.

In 1932 British physicist James Chadwick discovered the subatomic particle known as the neutron, a major contribution to scientists' understanding of the atom. Chadwick received the 1935 Nobel Prize for Physics for his discovery, which led to the development of nuclear fission and the atomic bomb. At the time this article appeared in the Scientific American journal, in 1932, the atomic nucleus was still being erroneously described as containing combinations of electrons and protons, rather than combinations of neutrons and protons. American usage has been retained.

Natural uranium is a mixture of two isotopes, fissionable U-235 (0.7 per cent) and non-fissionable U-238. However, U-238 can absorb neutrons to form plutonium-239 (P-239), which is fissionable, and up to half the energy produced by a reactor can in fact come from fission of P-239. Some types of reactor require the amount of U-235 to be increased above the natural level, which is called enrichment. Pressurized water reactors (PWRs), the most common type of reactor, require fuel enriched to about 3 per cent U-235.

Reactor fuel is made up of fuel pellets or pins enclosed in a tubular cladding of steel, zircaloy, or aluminium. Several of these fuel rods make up each fuel assembly. The fast neutrons released in the fission reaction need to be slowed down before they will induce further fissions and give a sustained chain reaction. This is done by a moderator, usually water or graphite, which surrounds the fuel in the reactor. However, in "fast reactors" there is no moderator and the fast neutrons sustain the fission reaction

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Classification of Energy Sources

All the sources of energy, currently available for harnessing, can be linked to two fundamental forces in nature- gravitational and nuclear. Nuclear fusion is the source of solar energy - the driving force for much of the energy consumed on earth today.

Renewability or non-renewability of a solar driven process is distinguished based on the energy storage or cycling time involved. Renewable resources have a cycling time less than 100 years, while for non-renewable resources, it is greater than a million years. The depletable resources are fossil fuels, which are non - renewable since the rate of their utilisation far exceeds the rate at which they are formed. Examples of renewable resources are hydro energy, solar energy, wind, biomass, and energy from wastes (such as biogas, agrowastes, etc.).

The renewable solar energy is subdivided into direct and indirect types. Sunlight used directly can produce electricity, heat or derive a chemical reaction. It is used indirectly when it drives other processes, biological - chemical or climatic - mechanical, which in turn are used as sources of energy.

The energy sources can be classified in a number of ways based on the nature of their transaction, as commercial and noncommercial sources of energy. All energy resources, particularly the commercial ones, are natural. Coal, oil and nuclear sources constitute commercial sources, while firewood, biomass and animal dung constitute non- commercial sources.

Also, the energy sources are classified based on animate and inanimate characteristics.

Energy sources could also be classified as exhaustible/ depletable or non - depletable / renewable resources. The distinguishing feature of an exhaustible resource is that, it gets exhausted when used as an input of a production process, and at the same time, its undisturbed role of growth is nil.

That is, the temporal services provided by a given stock of an exhaustible resource are finite.

Further, based on conventionality in deriving energy, energy sources could be classified as conventional (coal, oil, hydro, nuclear, etc.) and non - conventional (solar, wind, tidal, geothermal, biogas, etc.) sources.

They are also classified as primary or secondary types - coal, firewood, etc., being primary sources and electricity, a secondary source. Energy in its primary form can be of different kinds. The main types are Chemical (fossil fuels- coal, oil, natural gas, peat; biomass - wood, agricultural residues, etc.),Potential (water at a certain height),Kinetic (wind, waves), Radiation (sun), Heat (geothermal reservoirs, ocean thermal reservoirs) and Nuclear (uranium). The primary form of energy must generally be converted into secondary or final forms of energy before it can be used. For instance, the potential energy of a waterfall (primary energy) is converted into electricity (secondary energy), which is transmitted and transformed to supply (final) energy to a factory, where it is converted into mechanical energy (useful energy) for productive operations.

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Important types of secondary energy are electricity and mechanical energy. But chemical energy is also important as a secondary energy, for instance, in the form of refined oil products. Final energy is the energy that reaches the consumer. This can be electricity at a suitable voltage, or chemical energy in kerosene or batteries. The consumer, finally, uses certain equipment to convert the final energy he buys, into useful energy for one of his end use activities, e.g., irrigation, transport, cooking, etc.

Most of the energy sources are substitutable to each other due to the fact that some form of energy can be converted to other - such as coal to electricity, use of photo electricity to drive a chemical reaction, wind energy to pump and store water that could be used to produce electricity when required, or solid biomass to produce liquid or gaseous fuels of higher calorific value. All forms are ultimately converted into heat. This gives rise to the inter-fuel substitution process with which an economy can substitute its abundantly available resources to the scarcely endowed one.

RENEWABLE AND NON RENEWABLE ENERGY

Renewable Energy, energy present in the natural flows of wind, water, and sunlight in the environment and that is continually replenished as quickly as it is extracted and used up. Renewable energy will, therefore, never run out.

II THE IMPORTANCE OF RENEWABLE ENERGY

Most of the energy sources on Earth originate from the Sun, with the exceptions of the energy in the tides, caused by the gravitational pull of the Moon and Sun, and geothermal energy, which results from the heat escaping from hot rocks 2 km (1.2 mi) below the Earth's surface and from the effects of radioactive decay. The Sun's radiation is equivalent to 1.4 kW/sq mi in space before any attenuation due to travelling through the Earth's atmosphere. This solar radiation is converted naturally into various energy streams. Wave energy results from the interaction between the convection-driven winds and the surface of the sea; hydro-energy is produced by the hydrological cycle; and biological energy (biomass energy) is that which is stored in living organisms by the process of photosynthesis. All these forms of energy are available as renewable resources because of the continual replacement of the energy on a daily, or even hourly, basis.

By way of contrast, fossil fuels such as coal, oil, and gas, although originally laid down effectively as biomass, take millions of years to form and need to be regarded as finite, non-renewable resources.

Interest in renewable energy came to the fore during the worldwide energy crises of the 1970s, when high oil prices highlighted the world's dependence on fossil fuels. Secure and affordable energy provision is vital for nations' development, as all industrialization, manufacturing, and building programmes consume vast amounts of energy. Since the oil crises of the 1970s, and largely as a result of the increased exploration and exploitation of fossil fuel reserves, the

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abundant supply of oil and coal across the world has enabled market forces to drive down the price of fuel, and consequently electricity, to a very low level. However, estimates suggest that approximately half of the world's oil reserves, and a smaller fraction of coal reserves, have been used in little over 200 years. Oil will never completely run out but, as demand outpaces supply, renewables can play a major role in bridging the gap.

Units of Energy

Energy is widely denominated in joules (1 joule = 0.239 calorie), gigajoules (1 GJ = 10^9 joules), or exajoules (1 EJ = 10^{18} joules). In what follows, all forms of energy are expressed in gigatonnes (Gtoe) or million tonnes (Mtoe) oil equivalent:

1 tonne oil equivalent (1 toe) = 42 GJ = 10.034×10^9 calories

1 gigatonne oil equivalent = 42 EJ = 10.034×10^{18} calories

It should be noted that:

1 tonne coal equivalent (1 tce) = 29.3 GJ = 7×10^9 calories

1 tonne natural gas liquids (1 t NGL) = 46 GJ = 11×10^9 calories

III RESOURCES

Estimating energy supplies requires geological knowledge, economic calculation, and technological know-how. All three contain varying degrees of uncertainty. In recent years the convention has emerged of representing increasing geological uncertainty of occurrence and increasing economic costs as two dimensions of a matrix. Where resources have been identified as technically and economically recoverable with current technologies and at current prices, they are called "proved reserves"

Confusion arises because these are usually the figures for reserves quoted by energy companies, which are exploring and investing with a time-"horizon" of up to 20 or 30 years to meet customers' expected demands. It is sometimes assumed that these are the only resources that exist. This is not usually the case, nor is it usually the view of energy companies that these are the only resources in existence.

World Commercial Energy Consumption by Region Commercial energy is energy produced for sale rather than for direct use. Much of it comes from non-renewable resources, such as oil, coal, and natural gas. Although these resources are distributed over a large geographical region, consumption of energy centres in industrialized nations. This table shows the per cent of the

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world's total energy supply used by each region. Oil is not the only resource involved in the comparison; oil equivalents are provided to give perspective to percentages.© Microsoft Corporation. All Rights Reserved.

Other resources that have uncertain geological and economic characteristics also form part of the resource base. In the case of fossil fuels these additional resources are usually classified as ultimately recoverable resources (Table 2). They include coal and lignite; conventional oil and the unconventional oils (heavy crude, natural bitumen, and shale oil); and natural gas (in Devonian shales, tight sand formations, geopressured aquifers, and coal seams). Where there may be additional quantities but the amounts are uncertain and their economic recovery highly uncertain, they are called occurrences. In the case of methane hydrates trapped in permafrost, or natural uranium (and its hydrates) in sea water, the quantities in existence are very large, despite all the other uncertainties surrounding them. Improved geological understanding, technological advance, and higher energy prices can be expected to improve our understanding and raise our estimates of the resource base.

These resource figures can therefore be built up as in Table 1. Estimates of the ratios of the reserves to current annual production levels are given. They imply that there are nearly 200 years of coal at current production levels (nearer 240 years if lignite is included), 65 years of natural gas, and over 40 years of oil. However, as already indicated, the proved reserves figure is likely to rise. More important, the demand for fossil fuels and for primary energy more generally is expected to rise (by 60 to 100 per cent over the next 30 years).

If the technology existed, and the economic criteria were satisfactory, these additional occurrences might provide some 2,500 years of fossil fuels at the world's present annual rate of consumption. Neither the technological nor economic criteria are ever likely to be more than partly met, and in the event of CO2 and other greenhouse gas emissions becoming inadmissible on this scale (or their recapture and reabsorption infeasible), then these occurrences will remain largely of theoretical interest.

It is also worth noting that fossil fuel resources are not evenly distributed around the world. Nearly 70 per cent of the world's proved recoverable oil reserves are in the Middle East; 36 per cent of the proved recoverable natural gas reserves are in the Commonwealth of Independent States (CIS), and 40 per cent in the Middle East. Two thirds of the world's proved recoverable hard coal reserves are in North America and the CIS, and a further 10 per cent in China.

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NB: Nuclear energy does not generate Greenhouse effect.

Turning to more speculative ultimately recoverable resources, some 75 per cent of the hard coal is in the CIS and China, and a further 10 per cent in North America. Most of the world's tar sands and bitumen are in North and Central America, the latter also having most of the world's heavy oil. Shale oil is more evenly spread, but North America and China account for some 45 per cent of the world total. Natural gas is also fairly widespread, though again the Americas and the CIS account for over 75 per cent of the speculative hydrates estimate.

To the extent that fossil fuel resources are concentrated in a relatively few regions of the world, issues arise such as import dependency, proneness to supply disruptions and price fluctuations, and pressures to diversify sources to improve security of supply.

A potentially important additional source of energy, and one that creates virtually no greenhouse gas emissions, is nuclear energy. There are some 430 commercial nuclear power plants in operation in the world, with a total generating capacity of about 340 GW (1 GW, or gigawatt, is 1 billion watts). More than 30 countries have nuclear power plants in operation or under construction. They provide about 18 per cent of the electricity generated throughout the world, but this figure varies from zero in many countries to over 75 per cent in France.

Most of the reactors in operation or under construction are light-water reactors. Nuclear plant construction continues in the Asian Pacific nations and in a few countries elsewhere. Some developed countries have begun, or plan to, phase out nuclear power despite only modest advances in their new renewable energy use. In general, therefore, nuclear power development has stalled in the face of public concerns with operational safety, waste disposal, and proliferation of nuclear weapons.

waste disposal

These three issues pose major problems for the nuclear industry, and for the time being have put a ceiling on development that is far below the technical potential.

There is no basic shortage of uranium or thorium—an alternative being actively explored—for nuclear power generation. At the present rate of use (under 60,000 tonnes per year), with reactors currently utilizing only about 0.65 per cent of their potential, it is estimated that 64 years of uranium exist in recoverable quantities at under US$130/kg. Reprocessing and recycling uranium and plutonium would increase the number of years for which fuel would be available at current

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requirements by 50 per cent. The use of breeder reactors (development of which has also stalled in recent years) would greatly extend availability.

Placing nuclear power resources on a similar basis to fossil fuel resources, we get the results shown in Table 4. These figures suggest that nuclear energy resources with the use of fast breeder reactors are some 60 per cent greater than the total of proved plus ultimately recoverable fossil fuel resources. They are more than double the largest single fossil fuel resource, coal.

The other major energy resource comes from the various renewable forms of energy. The Sun is the major ultimate source for solar energy and biomass energy as it originally was for the fossil fuels. The total solar energy resource is over 10,000 times the world's current annual primary energy use. The energy in the sunlight falling on Saudi Arabia alone represents several times the world's annual energy supply. In less than 40 minutes the United States receives more energy in the form of sunlight than it does from all the fossil fuels it consumes in a year. The key question is: how much of this energy, and of the other potentially usable renewable forms of energy, is being realized now and will be realized in the coming decades?

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Evolution is the change in the inherited characteristics of biological populations over successive generations. Evolutionary processes give rise to diversity at every level of biological organisation, including species, individual organisms and molecules such as DNA and proteins.[1]

Life on Earth originated and then evolved from a universal common ancestor approximately 3.8 billion years ago. Repeated speciation and the divergence of life can be inferred from shared sets of biochemical and morphological traits, or by shared DNA sequences.[2] These homologous traits and sequences are more similar among species that share a more recent common ancestor, and can be used to reconstruct evolutionary histories, using both existing species and the fossil record. Existing patterns of biodiversity have been shaped both by speciation and by extinction.[3]

Charles Darwin and Alfred Wallace were the first to formulate a scientific argument for the theory of evolution by means of natural selection. Evolution by natural selection is a process that is inferred from three facts about populations: 1) more offspring are produced than can possibly survive, 2) traits vary among individuals, leading to different rates of survival and reproduction, and 3) trait differences are heritable. Thus, when members of a population die they are replaced by the progeny of parents that were better adapted to survive and reproduce in the environment in which natural selection took place. This process creates and preserves traits that are seemingly fitted for the functional roles they perform. Natural selection is the only known cause of adaptation, but not the only known cause of evolution

The proposal that one type of animal could descend from an animal of another type goes back to some of the first pre-Socratic Greek philosophers, such as Anaximander and Empedocles . In contrast to these materialistic views, Aristotle understood all natural things, not only living things, as being imperfect actualisations of different fixed natural possibilities, known as "forms", "ideas", or (in Latin translations) "species. This was part of his teleological understanding of nature in which all things have an intended role to play in a divine cosmic order.

THE PRECAMBRIAN ERA

The Precambrian Era. The name means: "before the Cambrian period." This old, but still common term was originally used to refer to the whole period of earth's history before the formation of the oldest rocks with recognizable fossils in them. In the last few decades, however, geologists have found that there are some hard-to-discern fossils in some Precambrian rocks, so this period is now also known as the Cryptozoic or "obscure life" Eon (from the words "crypt" = "hidden," and "zoon" = "life").

The Precambrian covers almost 90% of the entire history of the Earth. It has been divided into three eras: the Hadean, the Archean and the Proterozoic.

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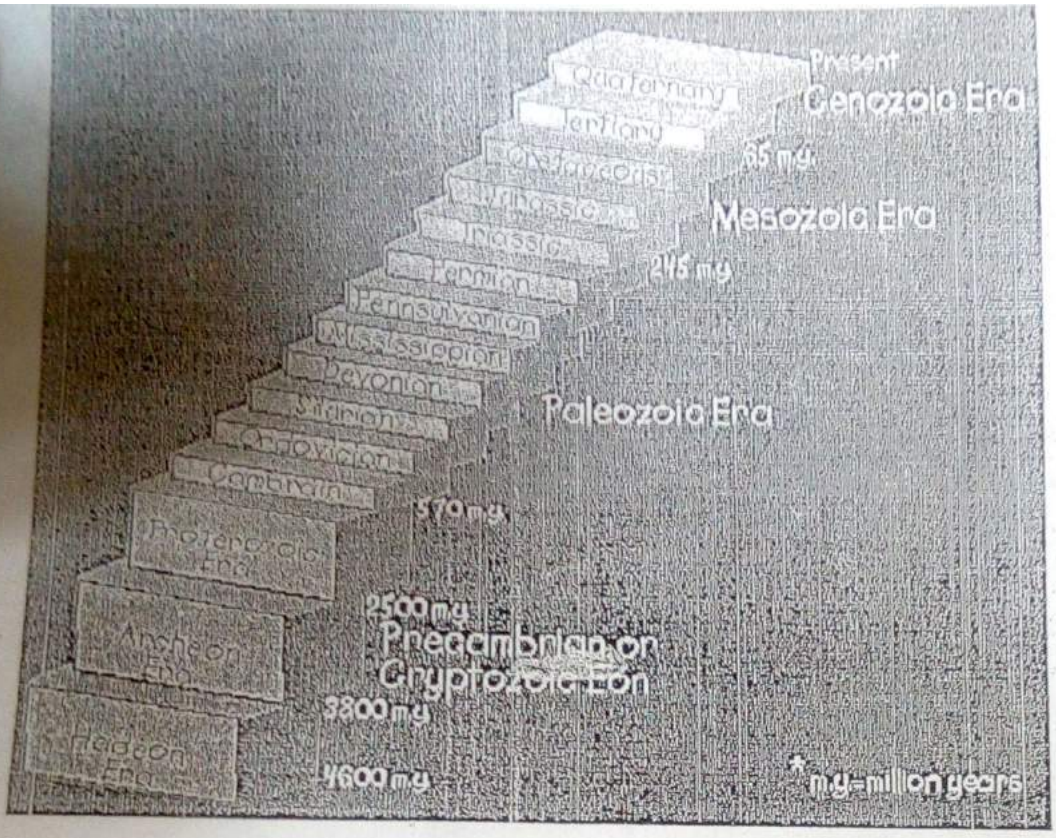

The Precambrian Era comprises all of geologic time prior to 600 million years ago. The Precambrian was originally defined as the era that predated the emergence of life in the Cambrian Period. It is now known, however, that life on Earth began by the early Archean and that fossilized organisms became more and more abundant throughout Precambrian time.

The two major subdivisions of the last part of the Precambrian are the Archean (oldest) and the Proterozoic. Rocks younger than 600 Ma are considered part of the Phanerozoic.

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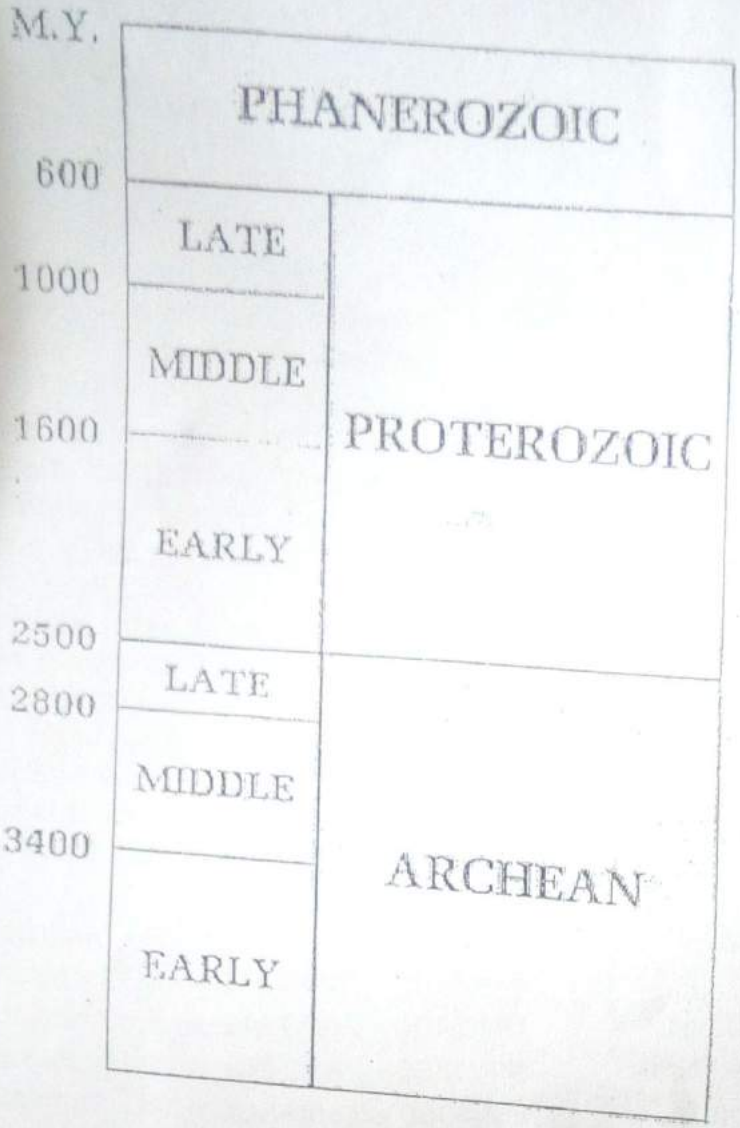
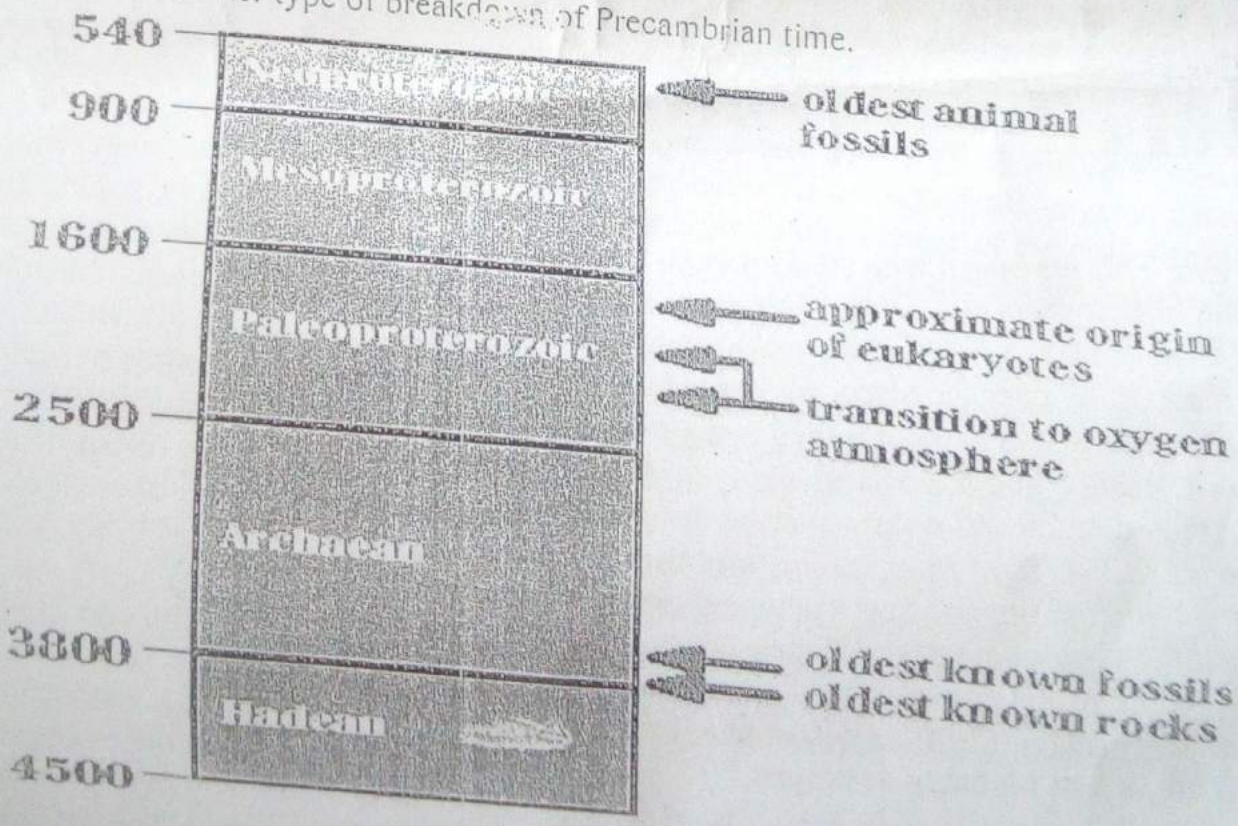


Below is another type of breakdown of Precambrian time.



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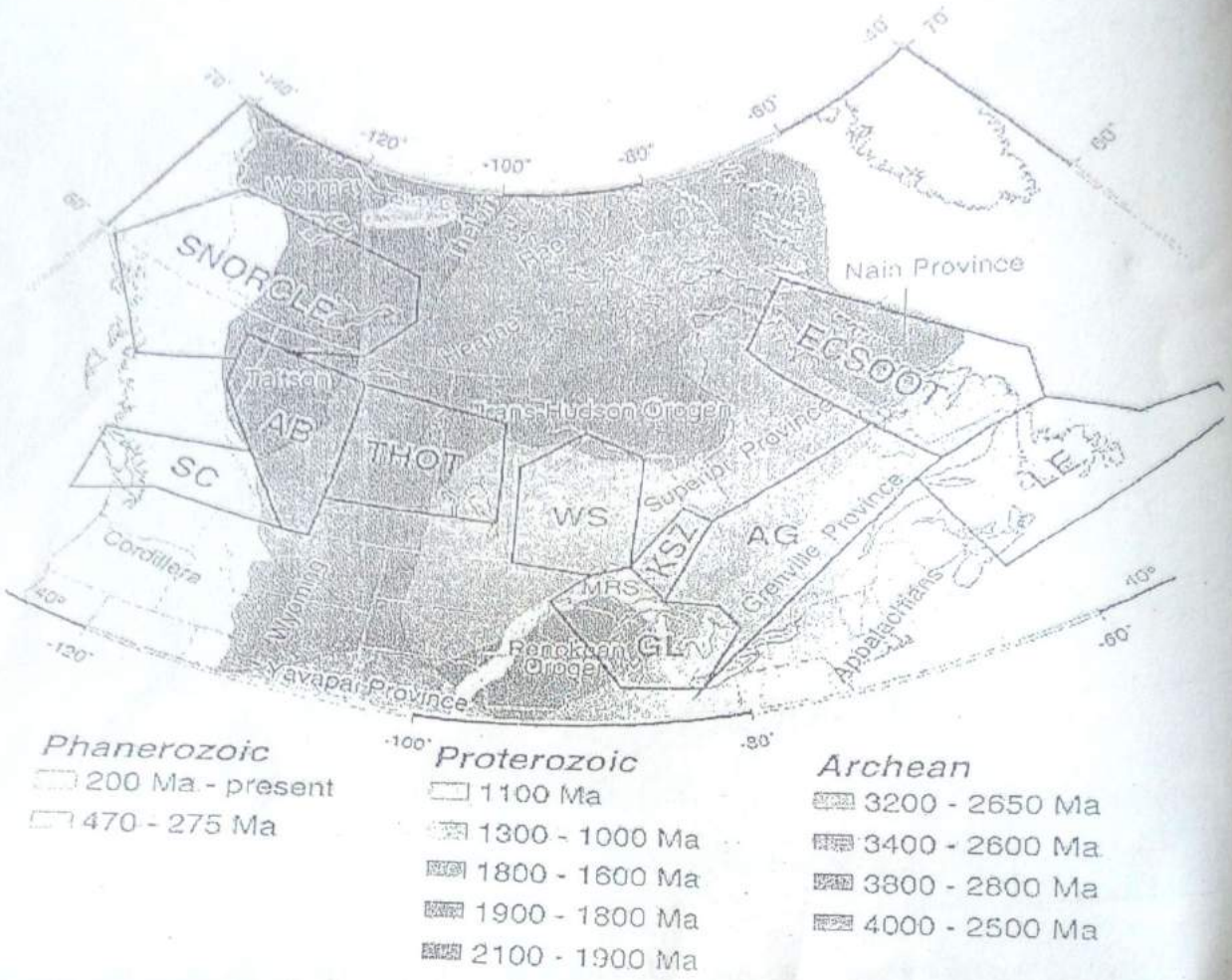

Source: Unknown

Hadean

Hadean ("Hades-like") Era. This era began with the formation of the earth from dust and gas orbiting the Sun about 4.6 billion years ago. During this era the surface of the Earth was like popular visions about Hades: oceans of liquid rock, boiling sulfur, and impact craters everywhere! Volcanoes blast off all over the place, and the rain of rocks and asteroids from space never ends. It's hard to take a step without falling in a pool of lava or getting hit by a meteor! The air is hot, thick, steamy, and full of dust and crud. But you can't breathe it anyway: it's made of nothing but carbon dioxide and water vapor, with traces of nitrogen and smelly sulfur compounds! Any rocks that do form from cooling lavas are quickly buried under new lava flows or blasted to bits by yet another impact. Some people think that an asteroid as large as the planet Mars hit the Earth near the beginning of the Hadean era, completely smashing and melting the Earth and forming the Moon as part of the "splash!" Wow! No one has found any rocks on earth from this era. Only meteorites from space and moon rocks are this old. If any life formed on earth during this era, it was probably destroyed.

HADEAN EARTH

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Archean ("Ancient" or "Primitive") Era. This era begins about a billion years after the formation of the earth, and things have changed a lot! Mostly everything has cooled down. Most of the water vapor that was in the air has cooled and condensed to form a global ocean. Even most of the carbon dioxide is gone, having been chemically changed into limestone and deposited at the bottom of the ocean. The air is now mostly nitrogen, and the sky is filled with normal clouds and rain. The lava is also mostly cooled to form the ocean floor. The interior of the earth is still quite hot and active, as shown by the many erupting volcanoes. The volcanoes form lots of small islands in long chains. The islands are the only land surface. The continents have not formed yet. The islands are carried over the surface of the earth by the movement of rock deep in the earth's interior. (This movement results from the loss of heat from the deep interior and is called *plate tectonics*.) Occasionally the small islands collide with each other to form larger islands. Eventually these larger islands will collide to form the cores of the continents we know today. Thank goodness those pesky asteroids and meteorites are now mostly gone, so impact craters form only occasionally. What about life? If you look closely, you will see evidence of blue-green algae (actually simple bacteria) floating in the ocean. That's all there is! Just single-celled bacteria in the ocean. There is as yet no life on land. Life began in the ocean near the beginning of this era. The oldest known fossils - the remains of different types of bacteria - are in archean rocks about 3.5 billion years old.

Proterozoic

Proterozoic ("Early Life") Era. Well, here we are about 700 million years ago, near the end of the longest time period in geologic history. It began about two billion years after the formation of the earth and lasted about another two billion years! So what has happened in all that time? Hmmmmm. There is a lot more land to be seen. In fact, there are two supercontinents, one visible across the equator on this side of the earth and another one on the other side. These huge masses of land formed by collisions of the many, many islands made by volcanoes during the Archean and most of the Proterozoic eras. The earth's interior has cooled some more, and there are fewer volcanoes than in the Archean. Even though the movements of the earth's surface we call Plate Tectonics are still very fast and continental collisions are frequent (every few hundred million years or so!), the centers or cores of the continents are now quite large and stable. In fact, geologists date the beginning of the Proterozoic Era by the age of the oldest continental rocks that have not been reheated or chemically altered. Life has not changed much during the last two billion years, but the few changes are significant. Life is still found only in the ocean, but somewhere around 1.7 billion years ago, single-celled creatures appeared that had a real nucleus. Another important change is about to happen: true multi-celled life is about to appear, some 30 million years before the end of the Proterozoic. These multi-celled creatures will have no hard parts like shells or teeth in their bodies, so their fossils will be hard to find. The atmosphere is about the same, mostly nitrogen, with a little water vapor and carbon dioxide. But what's this? Free oxygen released by the algae floating in the oceans is beginning to collect in the air. These single-celled plants have been producing oxygen for about two billion years, but up until now the oxygen has been combining chemically with iron and other elements to form great mineral deposits around the world. Paradoxically, this oxygen, which we must have to live, is poisonous to most of the life forms living on the Earth during the Proterozoic, so another great change in the types of life is about to occur.

The earth at this time is also very cold, with huge, bluish glacial ice sheets visible across the supercontinent, even in the normally warm equatorial regions! In fact, glaciers invaded Michigan at this time; this glaciation is referred to as the Gowganda glaciation.

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Paleontology is a rich field, imbued with a long and interesting past and an even more intriguing and hopeful future. Many people think paleontology is the study of fossils. In fact, paleontology is much more.

Paleontology is traditionally divided into various subdisciplines:

Micropaleontology: Study of generally microscopic fossils, regardless of the group to which they belong.

Paleobotany: Study of fossil plants; traditionally includes the study of fossil algae and fungi in addition to land plants.

Palynology: Study of pollen and spores, both living and fossil, produced by land plants and protists.

Invertebrate Paleontology: Study of invertebrate animal fossils, such as mollusks, echinoderms, and others.

Vertebrate Paleontology: Study of vertebrate fossils, from primitive fishes to mammals.

Human Paleontology (Paleoanthropology): The study of prehistoric human and proto-human fossils.

Taphonomy: Study of the processes of decay, preservation, and the formation of fossils in general.

Ichnology: Study of fossil tracks, trails, and footprints.

Paleoecology: Study of the ecology and climate of the past, as revealed both by fossils and by other methods.

In short, paleontology is the study of what fossils tell us about the ecologies of the past, about evolution, and about our place, as humans, in the world. Paleontology incorporates knowledge from biology, geology, ecology, anthropology, archaeology, and even computer science to understand the processes that have led to the origination and eventual destruction of the different types of organisms since life arose. The exhibits that we have set up here are created by paleontogists. More than just an overview of the diversity that has existed through time on this planet, the exhibits also highlight some of the research that paleontologists are conducting at the Museum of Paleontology.

Anthropology is the "science of humanity. It has origins in the humanities, the natural sciences, and the social sciences. The term "anthropology" is from the Greek *anthrōpos* , "man", understood to mean humankind or humanity, and *-logia* "discourse" or "study." The essence of anthropology has been, since its tradition, cross-cultural comparison, and cultural relativism has become the canon of anthropological inquiry.

Anthropologists study topics including the origin and evolution of *Homo sapiens*, the organization of human social and cultural relations, human physical traits, human behavior, the variations among different groups of humans, how the evolutionary past of *Homo sapiens* has influenced its social organization and culture, and so forth.

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Archaeology studies human history from the development of the first stone tools in eastern Africa 3.4 million years ago up until recent decade (Archaeology does not include the discipline of paleontology.) It is of most importance for learning about prehistoric societies, when there are no written records for historians to study, making up over 99% of total human history, from the Palaeolithic until the advent of literacy in any given society. Archaeology has various goals, which range from studying human evolution to cultural evolution and understanding culture history.

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What is science?

Science is the concerted human effort to understand, or to understand better, the history of the natural world and how the natural world works, with observable physical evidence as the basis of that understanding. It is done through observation of natural phenomena, and/or through experimentation that tries to simulate natural processes under controlled conditions.

Science is a systematic and logical approach to discovering how things in the universe work. It is derived from the Latin word "scientia," which translates to knowledge. Unlike the arts, science aims for measurable results through testing and analysis. Science is based on fact, not opinion or preferences. The process of science is designed to challenge ideas through research. It is not meant to prove theories, but rule out alternative explanations until a likely conclusion is reached.

When conducting research, scientists observe the scientific method to collect measurable, empirical evidence in an experiment related to a hypothesis (often in the form of an if/then statement), the results aiming to support or contradict a theory.

The steps of the scientific method are:

- Make an observation or observations.
- Ask questions about the observations and gather information.
- Form a hypothesis — a tentative description of what's been observed, and make predictions based on that hypothesis.
- Test the hypothesis and predictions in an experiment that can be reproduced.
- Analyze the data and draw conclusions; accept or reject the hypothesis or modify the hypothesis if necessary.

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- Reproduce the experiment until there are no discrepancies between observations and theory.

Some key underpinnings to the scientific method:

- The hypothesis must be testable and falsifiable.
- Research must involve deductive reasoning, not inductive reasoning. Deductive reasoning is the process of using true premises to reach a logical true conclusion.
- An experiment should include a dependent variable (which does not change) and an independent variable (which does change).
- An experiment should include an experimental group and a control group. The control group is what the experimental group is compared against.

Scientific theories and laws

The scientific method and science in general can be frustrating. A theory is almost never proven. A few theories do become scientific laws (such as the law of gravity) and laws are generally considered to be without exception — though in fact even some laws have been modified over time after further testing found discrepancies.

This does not mean theories are not meaningful. For a hypothesis to become a theory, rigorous testing must occur, typically across multiple disciplines by separate groups of scientists. Saying something is "just a theory" is a lay person's term that has no relationship to science, because in science, a theory is something that is very well supported by observation and experimentation.

A brief history of science

The earliest evidence of science can be found in prehistoric times, from the discovery of fire, invention of the wheel and development of writing. Early tablets contain numerals and information about the solar system.

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Science became decidedly more scientific over time, however.

1200s: Robert Grosseteste develops the framework for the proper methods of modern scientific experimentation, including the principle that an inquiry must be based on measurable evidence that is confirmed through testing.

1400s: Leonardo da Vinci begins his notebooks in pursuit of evidence that the human body is microcosmic. The artist, scientist and mathematician also gathers information about optics and hydrodynamics, but none of his scientific works are ever published.

1500s: Nicolaus Copernicus advances the understanding of the solar system with his discovery of heliocentrism, the model in which the Earth and planets revolve around the sun, which is the center of the solar system.

1600s: Johannes Kepler builds upon these observations with his laws of planetary motion. Galileo improves on a new invention, the telescope, and uses it to study the sun and planets. The 1600s also saw advancements in the study of physics as Isaac Newton developed his laws of motion.

1700s: Benjamin Franklin discovers that lightning is electrical. He also contributes to the study of oceanography and meteorology. The understanding of chemistry also evolves during this century as Antoine Lavoisier, dubbed the father of modern chemistry, develops the law of conservation of mass.

1800s: Milestones include Alessandro Volta's discoveries regarding electrochemical series, which leads to the invention of the battery. John Dalton also introduces atomic theory, which states that all matter is composed of atoms that combine to form molecules. The basis of modern study of genetics advances as Gregor Mendel unveils his Mendel's laws of inheritance. Later in the century, Wilhelm Conrad Röntgen discovers X-rays. George Ohm's Ohm's law provides the basis for understanding how to harness electrical charges.

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1900s: The discoveries of Albert Einstein, who is best known for his theory of relativity, dominate the beginning of the 20th century. Einstein's theory of relativity is actually two separate theories. His special theory of relativity, which he outlined in a 1905 paper, "The Electrodynamics of Moving Bodies," concludes that time must change according to the speed of a moving object *relative* to the frame of reference of an observer. His second theory of general relativity, which he published as "The Foundation of the General Theory of Relativity" in 1916, advances the idea that matter causes space to curve.

Medicine forever changes with the development of the polio vaccine in 1952 by Jonas Salk. The following year, James D. Watson and Francis Crick discovered the structure of DNA.

2000s: The 21st century sees the first draft of the human genome completed, leading to a greater understanding of DNA and advancing the study of genetics and its role in human biology and as a predictor of diseases and other disorders.

What Is Technology? Technology is a body of knowledge devoted to creating tools, processing actions and extracting of materials. The term "**Technology**" is wide and everyone has their own way of understanding the meaning of technology. We **use technology** to accomplish various tasks in our daily lives, in brief; we can describe technology as products, processes or organizations. We use technology to extend our abilities, and that makes people as the most important part of any technological system.

Technology is also an application of science to solve a problem. But what you have to know is that technology and science are different subjects which work hand-in-hand to accomplish a specific task or solve a particular problem.

We apply technology in almost everything we do in our lives, we use technology at work, we use it to , extract materials , we use technology for **communication**, transportation, learning, manufacturing, creating artifacts, securing data, **scaling businesses** and so much more. Technology is human knowledge which involves tools, materials and systems. The

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application of technology results in artifacts or products. If technology is well applied, it can benefit humans, but if it is wrongly applied, it can cause harm to human beings.

Many businesses are using technology to stay competitive, they create new products and services using technology, and they also use technology to deliver those products and services to their customers on time. A good example is, mobile phones companies like Apple & Samsung, these two electronics companies, use high end technology to create new smartphones and other electronic devices to stay competitive. This competitive edge is gained through employing advanced technology.

ADVANCING TECHNOLOGY:

Technology is dynamic; it keeps on improving because even our needs and demands for technology keep on changing. We have moved from the industrial age (**industrial revolution**) to an information age. During the industrial age, companies with large sums of capital had the potential of employing expensive technological tools to gain competitive advantage; small businesses had less potential because they could not afford expensive manufacturing or processing technological tools. But, the advancement in technology has created a new economic environment which depends on information and that is what I call "INFORMATION AGE", the information age provides a different work environment and this has helped small businesses gain position in highly competitive markets.

TYPES AND EXAMPLES OF TECHNOLOGY:

We use technology to accomplish various tasks, so technology comes in different types, below I have listed some of the different types of technology we use on a daily basis and on each type of technology I have included an example of that particular technology.

- **Communication Technology:** This is a system that uses technical means to transmit information or data from one place to another or from one person to another. Communication is used for many purposes; it is used to convey ideas, exchange information

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and express emotions. Humans use communication technology tools like phones, computers, emails, fax, text messaging tools to stay in touch with friends and family , then, businesses use communication technology tools to facilitate the flow if information in a workplace, to help in decision making , to serve customers needs and requests, to promote new products or services to targeted consumers and so much more.

Construction Technology: This is the study of advanced methods and equipments which can be used to build structures. Construction builds two types of structures. These include buildings and heavy engineering structures. Construction uses various technological actions to erect a structure on the site where it will be. The use of construction technological tools like heavy tractors to prepare land where the construction will be, computer design software to create designs for structures on computers and in 3D format, using various construction technologies to enclose structures and install utilities has helped in advancing both residential buildings and commercial buildings today.

Assistive Technology: This is the type of technology which is used by people with disabilities to accomplish specific tasks which seem to be difficult or impossible to perform. The term "Assistive" means helping or providing an extra hand. Assistive technology is being used in schools to help students with Autism to learn better, it is used to help people with disabled bodies' move, speech recognition application help people who can't type with a keyboard to use a computer and so much more. Due to advancement in technology, we have a variety of assistive technologies which can assist you accomplish anything which might seem difficult.

Medical Technology: This is the type of technology which is used to extend and improve human life. Medical technology reduces patient's pain, and injury. Developed countries have benefited from the use of medical technology in their health care systems and this explains the reason why people in developed countries leave longer than people in developing

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countries. Medical technology is used to diagnose infections, treat diseases and to make research on diseases affecting humans.

Information Technology: Information Technology is a set of hardware and software tools used to store information. Information technology tools help in providing the right people with the right information at the right time. Knowledge workers in organization use information technology to complete various tasks and these can include; transferring of information which facilitates decision making with in an organization, improve customer service, and so much more. In this information age, it is very important to manage information systems to ensure accuracy and efficiency. Management information systems (MIS) involves planning for, development, management, and use of information technology tools to help knowledge workers and people perform all tasks related to information processing and management. Big financial institutions like "BANKS" use information technology to operate their entire businesses as well as serve their customers.

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Energy Sources Classification

Criterion	Categories	Examples
1) Origin	Solar	Solar radiation, Wind energy, Hydro Power, Biomass, fossil fuels
	Non solar	nuclear energy, Geothermal energy
2) DURABILITY	Non-renewable	fossil fuells, nuclear fuels.
	renewable	Solar radiation, wind energy, hydro power, bio mass, Geothermal energy
3) Participation in world Consumption	Convectional	fossil, fuels, hydro power, nuclear fuels
	Un Convectional	Solar radiation, Wind energy, Bio mass, Geothermal energy
4)	Commercial	Coal, gas
	non commercial	vegetal and cattle waste
4) The mobility of energy Corner	Transportable	fossil fuels, Nuclear fuels, Biomass
	Non Transportable	Solar radiation, wind energy, Hydro power, Geothermal energy

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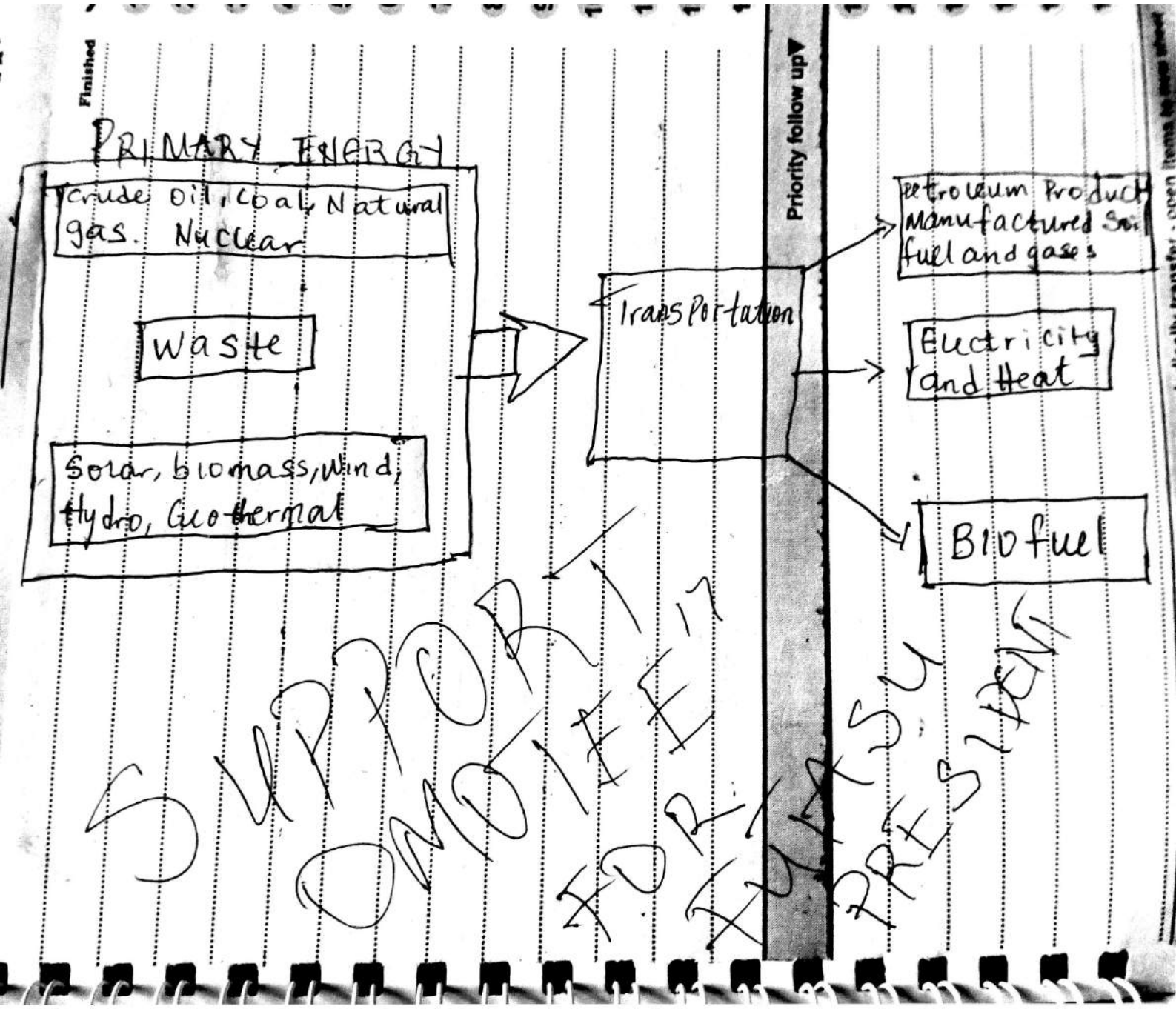

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