NATIONAL UNIVERSITIES COMMISSION

HISTORY AND PHILOSOPHY OF SCIENCE

for Distance Learners in the Nigerian University System

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Contents

Study Guide for GST 203: History and Philosophy of Science:

General Information:

Students taking this course should read this study guide carefully so as to understand the requirements and content of this course. The essence of the course is for students to understand the brief history of the sciences, their philosophy and epistemological foundations. The course is analytical, and it critically examines the contexts, personalities, objects and thoughts that inspire scientific activities.

Course code and Name:	GST 203: History and Philosophy of Science
Credit points:	2 units
Year:	200 Level
Semester:	First
Total hours:	28 hours @ two hours per week of study. Note: some weeks, students shall have taken two modules, while in others only one is to be taken.

About the course:

History and Philosophy of Science is an effort to explain the nature of scientific enquiry and assess how reasonable or justified science is or should be from various philosophical viewpoints. The course examines the history of various branches of natural sciences, their contributions to human development, problems being encountered as a result of scientific progress and the way out. This course helps you to understand? and appreciate? the evolution of science, its classification and its contradictions. The course also helps you to understand? the context in which scientific discoveries are made, the people behind them and their applications. The course also helps you to identify and define key scientific concepts and classifications.

Lecturer Information:

Course Lecturer:

Email: (address):

Contact: The course lecturer will be online every Thursday, 4-6pm (from the beginning of the semester up to a week to the examination) on mobile phone, facebook and blog for consultation and questions.

Symbols and Acronyms:

AD anno domino (Latin word for year of the lord, signifying the birth of Jesus Christ and the start of the Gregorian calendar)

BC before Christ (the years before the start of the Gregorian calendar)

BCE same as BC

√2 Square root of two

λ = h/mv (where λ pronounced Lambda is the wavelength associated with a particle of mass m, moving with velocity v; h is the Planck's constant

E = hf Energy is equals to (h) Plank's constant and (f) frequency of waves

E= mc^2 Energy mass equation

EMF Electromagnetic force

DNA deoxyribonucleic acid

RNA Ribonucleic acid,

SUV sport utility vehicle

Terms you need to know?

- Science
- History
- Philosophy
- Ancient
- Theory
- Epistemology
- Experiment
- Modern
- Technology
- Pure science
- Applied science

Taking GST 203: History and Philosophy of Science

To take GST 203, you need to (after completing your registration) read the study guide for the course. After reading and understanding the study guide for the course, you should do the following:

1. Study one unit every week for two hours (some weeks, two units) making a total of 20 units for the semester for the course, excluding examination.
2. Review the power point presentation on the unit and the blog

3. Access the link provided in the course material and the recommended texts

4. Review all the materials related to the unit

5. Take the self assessment question(s) in the unit or tutor-marked assignment as provided

6. Write and submit the tutor-marked assignments online via email. Late submission shall be penalized with deduction of marks accordingly

7. For any queries or questions, contact the course lecturer on the blog, email or facebook. 10 marks of the continuous assessment shall be awarded for any student with not less than six online contacts on these media.

8. On completion of the above steps, a student is qualified to take examination

How to Prepare for GST 203 Examination

To prepare for the examination, you should read and understand the study material given to you on CD-ROM. Other materials you shall need to prepare for the examination include:

- ✓ the various power points presentations provided on the blog
- ✓ the various links provided at the end of the units
- ✓ The sample questions at the end of every section
- ✓ The recommended reading texts

Prerequisites

All students taking this course should be 200 level students or above and must be computer literate.

Assessments

A. The continuous assessment for GST 203 is 30%, consisting of 10% contact and consultation and 20% for two Tutor-Marked Assignments.

B. The examination shall make up 70% of the total marks.

C. Feedback and advice is a component of the continuous assessment.

D. The examination shall be conducted at the DL Centre. Students are to come to the centre on the examination date with their I.D. cards and pens only. The examination is computer-based.

E. Plagiarism, indecent and improper use of online resources shall be penalized by marks deduction, failure in the course and referral to the Students Disciplinary Committee.

Module One: Science and the Scientific Method

Unit 1.1: History of Science

Unit 1.2: Philosophy of Science

Unit 1.1: History of Science

Introduction

To understand history and philosophy of science, there is the need to get well acquainted with brief history of science itself. Science is easily recognizable to people largely because of the numerous technological objects which are used all over. Apart from its place in technological development, science is often thought to be the ultimate form of objective and rational inquiry, and scientists are widely regarded as being able to gather and interpret evidence and use it to arrive at conclusions that are 'scientifically proven.' For example, courts do routinely rely to a large extent on the evidence of an expert witness who is a scientist of some sort to convict or acquit someone of a crime. Just like in this example, in almost all areas of modern life (health, weather, agriculture, etc), people are likely to seek or rely indirectly upon the scientific evidence and the opinions of scientists before making important decisions. This is one reason why understanding and thinking about science is important.

1.1.1 Learning Outcomes for Unit 1.1

By the end of this unit, you should be able to:

i. define and explain the meaning of Science.

ii. explain brief history of Science.

iii. differentiate between various types of Science.

iv. explain the contribution of early civilizations to the growth and development of Science.

v. list and explain the process through which scientific knowledge was accumulated.

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1.1.2 What is Science?

The answer to this question is of great importance, and many philosophers have sought to provide an answer so that it can be used to assess whether beliefs that are claimed to be scientific really are. **Science** can be defined simply as

> a system of accumulating knowledge that uses observation and experimentation to describe natural phenomena. It is an accumulated body of knowledge that humanity has gained over the years using that system. In short, science refers to any systematic field of study or the knowledge gained from it.

This definition means that the *purpose* of science is to develop general laws that explain how the world around us works and why things happen the way they do. How do we accomplish such a feat? That's where the "accumulation and classification of observable facts" comes in. The *practice* of science involves experimentation and observation. Scientists observe the world around them and collect facts. They also design experiments that alter the circumstances they are observing, which in turn leads to the collection of more facts. These facts might eventually allow scientists to learn enough about the world around them so they can develop ideas that help us understand how the natural world works.

The problem of saying what is scientific and what is not is called the **demarcation problem**. Some people have claimed scientific status for beliefs and practices, such as those of astrology and creationism (the doctrine that God created the Earth a few thousand years ago). If there is anything of which science consists, it is a method or set of methods. Therefore, the study of scientific method (known as **methodology** of science) is at the centre of the philosophy of science.

It is usual to divide the sciences into **two types,** namely **the natural sciences and the social sciences. Natural sciences** have as their object of study the natural world and include physics, chemistry, astronomy, geology and biology; while **social sciences** study specifically human or social world and include psychology, sociology, anthropology and economics. The philosophical questions they raise are often quite different from those raised by the natural sciences. For the purposes of this course, the philosophy of science is the philosophy of natural science.

1.1.3 The Scientific Method

What distinguishes science from other forms of knowledge is its method. In science the mode of generating knowledge is referred to as the scientific method, and it is the logical and rational order of steps by which scientists come to conclusions about the world around them is referred to as the scientific method. The scientific method helps to organize thoughts and procedures so that scientists can be confident in the conclusions they reach. In this section, the focus will be to discuss the nature of the scientific method beginning with the origins of modern science in the search for a new method of inquiry to replace reliance on the authority of the Church and the pronouncements of the ancients. Our goal will be to determine whether we should believe in what science tells us or be sceptic about them.

The scientific method has four main stages. These are

1. Observation
2. Turn that observation into hypothesis,
3. Test that hypothesis with experiment,
4. Draw a conclusion from that experiment about the hypothesis.

Stage one

The first step is by **observation**. This is the only acceptable method of learning about a natural law and it is achieved by taking **measurements** (that is, gathering data). Continuous observation leads to the formulation of hypothesis.

Stage two

This is the stage whereby **hypothesis** is formed for explanation of phenomenon. A scientific hypothesis is an idea or proposition that can be tested by observations or experiments, about the natural world. In order to be considered scientific, hypotheses are subject to scientific evaluation and must be falsifiable, which means that they are worded in such a way that they can be proven to be incorrect.

Stage three

In this stage, several experiments or tests by various groups of independent researchers to prove or disprove the predictions of the hypothesis. In scientific research, it is important to know that we do not set out to 'prove' a hypothesis, we only test it. Not only is this more intellectually honest, but it is essential in deciding whether it is correct or not.

Stage four

Once the hypothesis has been tested, the next stage is to draw a conclusion (prediction) from that experiment about the hypothesis. The two common methods that are usually used for predictions are **induction** and **deduction** which are good logic tools of reasoning. Scientific method uses inductive reasoning. It is a principle of reasoning that sanctions inference from the observation of particular instances to a generalization that embraces them all and more. There is **induction by enumeration** which is where we simply observe that some large number of instances of some phenomenon has some characteristic, and then infer that the phenomenon always has that property. There is also **induction by elimination** whereby competitors are eliminated or falsified. Generally, inductive methods have no conclusive verification. Deductive reasoning derives conclusion from a set of pre-existing premises. Deduction formulates hypothesis by falsification.

1.1.4 Scientific Theory

When a hypothesis or groups of hypotheses have been proved by various independent groups of researchers at various times, the hypothesis is accepted as a **scientific theory.** To scientists, a theory is a coherent explanation for a large number of facts and observations about the natural world. A theory is:

- internally consistent and compatible with the evidence
- firmly grounded in and based upon evidence
- tested against a wide range of phenomena
- demonstrably effective in problem-solving

In popular use, a theory is often assumed to imply mere speculation, but in science, something is not called a theory until it has been confirmed over many independent experiments. Theories are more certain than hypotheses, but less certain than laws. It is often said that theories can never be proved, but can only be disproved. This is because there is always the possibility that a new observation or experiment will be in conflict with long-standing theories. This conflict often leads to what is called **paradigm shift**.

1.1.5 Scientific Law

When overwhelming evidence is obtained over a period of time to support scientific theory, the theory becomes a **scientific law**. A scientific law is a description of a natural phenomenon or principle that invariably holds true under specific conditions and will occur under certain circumstances.

1.1.6 The Scientific Revolution

The period called *the Scientific revolution* also embraces *the Copernican revolution*, which is the name given to the period during which the theory of the solar system and the wider cosmos, which had the Earth at the centre of everything (geocentrism), was replaced by the theory that the Earth revolved around the Sun (heliocentrism). From the philosophical point of view, the most important development during the scientific revolution was the increasingly widespread break with the theories of Aristotle (384–322 BC).

1.1.7 History of Science

The term “science” is a Latin word for ‘knowledge’: *scientia*. What we today refer to as science was until the 1840s called *natural philosophy or pre-modern science*. For a true understanding of where we are in science today, one needs to look at what happened in the past. The history of science can teach us many lessons about how science should and should not be practiced. It can also help us understand the direction in which science is heading today. Without a historical perspective, however, you will not fully appreciate what science is. The presentation of the history will be presented based on different periods.

1.1.8 Emergence of Science (600 B.C. to 500 A.D)

According to history, the first true scientists were ancient Greeks between 600 B.C. and 500 AD. However, before them many cultures like the ancient Egyptians, Mesopotamians and

Chinese had collected observations and facts, but had not tried to use those facts to develop explanations of the world around them. **Thales**, **Anaximander**, and **Anaximenes** stood out among these Greek scientists.

Thales studied the heavens and made effort to give an explanation for the movement of the heavenly bodies (the planets and stars). He was able to correctly predict "short-term disappearance of the sun." which of course was a **solar eclipse**, an event in which the moon moves between the earth and the sun, mostly blocking the sun from view.

Anaximander was the first scientist who tried to explain the origin of the human race without reference to a creator. He explained that all life began in the sea, and at one time, humans were actually some sort of fish. Charles Darwin later restarted the idea, and it is today called evolution.

Anaximenes believed that air was the most basic substance in nature. In fact, his belief was that all things were constructed of air. His thinking is that when air is thinned out, it grows warm and becomes fire, and that when it thickened, it condenses into liquid and solid matter. These ideas were found to be wrong; nevertheless, his attempts to explain all things in nature as being made of a single substance led to the concept of **atoms.**

Leucippus was another Greek scientist who built on the concept of **Anaximenes** and proposed that all matter is composed of little units called "atoms." He is known as the father of atomic theory.

Three other notable scientists from Greek during this period are **Aristotle**, **Archimedes** and **Ptolemy.**

Aristotle's greatest work was in the study of living things. He was the first to make a large-scale attempt at the **classification** of animals and plants. Although Aristotle was known for a great number of wonderful advances in the sciences, he was also responsible for a great deal of nonsense that hampered science for many, many years. For example, he believed that certain living organisms spontaneously formed from non-living substances. This idea was called **spontaneous generation,** and the idea is that living organisms can be spontaneously formed from nonliving substances.

Archimedes is best known for his work with fluids when he showed how one could predict whether or not an object would float in a liquid.

Ptolemy studied the heavens and assumed that the earth was at the center of the universe, and that the planets and stars orbited about the earth in a series of circles. This system is called **Geocentric system**. In this system, the earth sits at the center of the universe and does not move. This system was considered the correct explanation for the arrangement of planets and stars in space until about the 1700s.

1.1.9 Dark Ages (500 A.D. to 1000 A.D.)

The development of science during this period was impeded because of the influence of Roman Empire which was the super power of the period but did not believe there is so much use for trying to explain the world around us. Despite this, there were scientists, including **Alchemy** who still experimented and made observations.

Alchemists mostly wanted to find a means by which lead (or some other inexpensive substances) could be transformed into gold (or some other precious substances). It is also worth noting that during this period a lot of people made observations and inventions. For example, both the Arabs and Chinese were making careful studies of the heavens. Their observations were much more detailed and precise than those of the Greek scientists before them. However, there were only few attempts to explain what the data meant, at least the data were being collected and were used later by scientists to draw significant conclusions about the world around us.

1.1.10 Beginning of Modern Science (1000 A.D. to 1500 A.D.)

Some important figures in this time period were **Robert Grosseteste**, **Roger Bacon**, **Thomas Bradwardine** and **Nicholas of Cusa.**

Grosseteste was of the opinion that the secrets of the natural world could be learned by discovering the laws that God had set in motion. He pointed out that the purpose of inquiry was to learn the *reasons* behind the facts. In other words, he wanted to explain *why* things happened the way they did. That is the essence of science. He explained that a scientist should make observations and then come up with a tentative explanation for *why* the observed events happened. The scientist should then make more observations to test his explanation. If the new observations confirmed the explanation, the explanation might be considered reliable. If the new observations contradicted the explanation, the explanation was probably wrong. This is essentially the method we use in modern science, and thus he is often called the father of the scientific method. Grosseteste applied his scientific method to the problem of explaining the rainbow.

Roger Bacon was a strong advocator of the use of Grosseteste's method. He used science to break the shackles of superstition. In his days, there was a belief that a diamond could be broken only by the application of goat's blood. Bacon proposed experiments that, when performed, showed that goat's blood had no effect whatsoever on diamonds. He was also of a strong belief that science could be used to support the reality of Christianity.

Thomas Bradwardine examined many of Aristotle's ideas critically and found most of them lacking. He concentrated on motion, and using mathematics and experiments, he was able to show that most of what Aristotle said about motion was wrong.

Nicholas of Cusa was interested in knowing more about the idea that God was infinite. He studied the planets and the stars, thinking they were probably the largest (and thus closest to infinite) things that he could study. He observed that the earth spins while it travels around the sun. This was in direct disagreement with Ptolemy's ideas. It was confirmed later that his idea is the correct one.

1.1.11 The Renaissance: The "Golden Age" of Science (1500 A.D. to 1660 A.D.)

Science in this period was very exciting. The excitement came from the scientific works of many authors, including **Nicolaus Copernicus**, **Andreas Vesalius, Johannes Kepler, Galileo Galilei.**

Nicolaus Copernicus, like Nicholas of Cusa, based on his study of earth, sun, planets, and stars, also believed that Ptolemy's view of the universe was wrong. Copernicus placed the sun at the center and assumed that the planets (including the earth) traveled around the sun. This system was called the **heliocentric system**. It is sometimes called the **Copernican system**, in honor of Copernicus.

Andreas Vesalius was a medical doctor and tried to show all the details of the human body. He was able to give accurate illustrations of the organs, muscles and skeleton of the human body.

Johannes Kepler made detailed observations of the planets. He went to the extent of deducing the basic orbits the planets use to travel around the sun. These orbits, he also describes using mathematical equations which today are known as “Kepler’s Laws,” and they became one of the most powerful arguments for the heliocentric system. His data showed that the planets do not really travel around the sun in circles. They actually travel around the sun following an oval pattern, which mathematicians call an **ellipse**.

Galileo Galilei provided another set of evidence that supported heliocentric system. He did detailed experiments about motion, confirming the work of Bradwardine and showing the flaws in Aristotle’s thinking. Galileo worked with telescopes and collected volumes of data about the planets and the stars. With the data, he was able to show that the planets do not shine on their own, but that they appear as lights in the night sky simply because they reflect the light of the sun. In addition, he showed that the light coming from Venus went through phases, just like the moon. Facts like these made it clear that the heliocentric view was superior to the geocentric view.

1.1.12 The Era of Newton (1660 A.D. to 1735 A. D.)

This period also witnessed a lot of exciting discoveries in science. **Isaac Newton** was a major player in this era. Other scientists included **Robert Boyle, Antoni van Leeuwenhoek**

Isaac Newton’s achievements during the period included the formulation of the three laws of motions. In formulating the law, he made a direct link between mathematics and science, and consequently proposed that a scientific law was useless if it could not be used to develop a mathematical equation that would describe some aspects of nature. In addition to the laws of motion, he also added many details to the understanding of the motion of fluids and laid down his universal law of gravitation. Newton used detailed experiments and observations to show that the reason an object falls when dropped was due to gravity.

Robert Boyle did many experiments with gases, formulating laws that are still used today in chemistry. **Antoni van Leeuwenhoek,** also during this period, built the first **microscope,** and that enabled him to see a world that had been invisible up to the period, which enabled him to discover many tiny (microscopic) life forms, including bacteria. The existence of these life forms helped scientists explain many things that had been, up to this point, complete mysteries.

1.1.13 Industrial Revolution (1735 A.D. to 1820 A.D.)

During this period, **Antoine-Laurent Lavoisier** was busy studying chemical reactions. He analyzed chemical reactions in a systematic way and realized that matter cannot be created or destroyed – it can only change forms. This is known as the **Law of Mass Conservation**. He was also the first to properly explain **combustion**.

John Dalton, another scientist, carried out many experiments with gases and proposed many new ideas that helped guide science in the future . His most important work during the period was his **atomic theory**. Building on the works of Democritus and others, Dalton proposed a detailed theory about atoms. Although a few of his ideas were wrong, most of them were right.

In this age, scientific knowledge grew; many inventors were able to use this knowledge to invent machines that made work faster and more productive. The use of the machines turned hours of manual labor into just a few minutes of work. This changed forever the way things were made, and so this period in history is also called the **Industrial Revolution**.

1.1.14 The Remaining Part of 19th Century (1820 A.D. to 1900 A.D.)

This period is probably best known for the work of **Charles R. Darwin**. He proposed a theory that attempted to explain the diversity of life that exists on earth. This theory, now known as the theory of evolution, made no reference to God. This proposition has advanced biology enormously. Up until the time of Darwin's work, most scientists thought living creatures stayed the same throughout history. In other words, scientists thought that every type of creature that exists today has existed throughout history. This idea was called the **immutability of the species**, and Darwin masterfully showed that this just wasn't true. He showed that living organisms can adapt to changes in their surroundings through a process he called **natural selection**. Over time, this can lead to new organisms that are radically different from their ancestors.

In this time period, **Louis Pasteur** was able to finally destroy the idea of spontaneous generation, once and for all, and made great advances in the study of bacteria and other living organisms. He developed a process called **pasteurization**, which he originally used to keep wine from souring. Louis Pasteur is also known for his brilliant work with vaccines. His work laid the foundation for most of today's vaccines.

Gregor Mendel also during this period devoted much of his life to the study of reproduction. The entire field of modern **genetics**, which studies how traits are passed on from parent to offspring, is based on his work.

During this period in history, science developed a much better understanding of electricity and magnetism. **Michael Faraday**'s experiments and ideas about electricity were also during this period. Many of the terms used in the study of electricity today are terms that were first used by Faraday. He believed that electricity and magnetism were actually the result of a single process. In other words, he believed that whatever made electricity run through wires also made magnets stick to certain metals.

James Clerk Maxwell worked with Faraday and was intrigued by Faraday's work. Faraday could not offer evidence for the idea that whatever made electricity run through wires also made magnets stick to certain metals, It was Maxwell who was able to develop mathematical equations that showed Faraday was right, that electricity and magnetism are both different aspects of the same phenomenon, now called **electromagnetism**.

Another very important scientist of this period was **James Joule**. He determined that, like matter, energy cannot be created or destroyed. It can only change forms. This is now known as the **First Law of Thermodynamics**, and it is the guiding principle in the study of energy.

1.1.15 Modern Science (1900 A.D. to the Present)

By this time, the thought of many was that all that could be discovered about nature had all been discovered. This changed when **Max Planck** produced a revolutionary idea. He explained certain experiments that could not be explained in terms of Newton's laws. To offer explanation, he proposed that much like matter exists in tiny packets called atoms, energy exists in tiny packets, which he called **quanta.** Planck produced a lot of evidence for his idea, and after a long while, it became accepted by the scientific community. Eventually, an entirely new way of looking at energy and matter, called **quantum mechanics**, was formed as a result of Planck's idea.

One of the most famous scientists in quantum mechanics was **Albert Einstein**. He used Planck's idea of energy quanta to explain "photoelectric effect" which could not be explained by Newton's laws of motion.

There were later many works that confirmed Planck's idea. One of the pivotal cases was made by **Niels Bohr**. Bohr developed a picture of the atom, which we call the **Bohr Model**. This picture of the atom required the assumption that energy comes in small packets. Using the Bohr Model, many of the mysteries of the atom were revealed. In the end, the weight of the evidence overwhelmed the scientific community's devotion to Newton's laws, and quantum mechanics became the new guiding principle in science.

1.1.16 Conclusion

We can see that science, as we know it today, has a long history. The history of science is also related to many civilizations (Greek, Arabs, Babylonians, etc.). There is no way by which one could cover everything about the history of science in just one course. Nevertheless, this is a reasonable overview.

Unit 1.2: Philosophy of Science

In this unit the following will be focused on

- Meaning of philosophy of science
- Identify scholars behind the development of philosophy of science

Objectives

At the end of this unit, you are expected to:

i. explain the importance of philosophy of science;

ii. narrate its history and evolution;

iii. identify the major scholars that shaped its development.

Introduction

As the name implies, philosophy of science is a combination of philosophical and scientific thinking. Even though science, as we defined it in unit1.1, is methodical and objective, because it is practiced by human beings. It is subject to human understanding of things they see and observe. These understanding and thinking about science affect what scientists do and how they do it. The scientific method is the foundation of what is today known as philosophy of science. The scientific method is thousands of years old and is still developing. Many scientists and philosophers have contributed to the philosophy of science, but the most outstanding ones are William of Ockham, Edward Sapir and Benjamin Whorf, W.V. Quine, Karl Popper, Thomas Bayes and E.T. Jaynes, etc. Philosophy of science is an important and fast-evolving discipline in its own right. Major contributions to the discipline come from both scientists and philosophers alike.

1.2.1 Definition of Philosophy of Science

Philosophy of science is defined as a branch of philosophy that studies the philosophical assumptions, foundations and implications of science. These include the natural sciences, such as physics, chemistry and biology; the social sciences, such as psychology, history and sociology, and currently the formal sciences such as logic, mathematics, set theory and proof theory. Debate is robust within the discipline and much remains inconclusive, because for nearly every assertion advanced, a philosopher can be found who will disagree with it. Can you define philosophy of science in your own words? Write your own definition of philosophy of science for group discussion.

1.2.2 The Various Theories in Philosophy of Science

There are many schools of thought within the field of philosophy of science which explain various scientific views. The following are the major ones:

Ockham's Razor:

The scientific method is the first real step on the road to what is today known as philosophy of science. Many scholars have made contributions to the philosophy of science, but it was William Ockham (c. 1295 – 1349) that came up with what is today known as Ockham's razor. Though it has been phrased in many ways, its most popular variant says: "entities should not be multiplied beyond necessity". The world renowned physicist Albert Einstein rephrased it as "make everything as simple as possible, but not simpler". Hundreds of years later, Ockham 's razor has been reformulated in a quantitative and mathematical manner.

Whorfianism:

The observation that different languages have different words for different objects, and that the particular language we use biases the observations we make and the conclusions we reach was made by Edward Sapir and Benjamin Whorf in the 1930s. The import of this observation was not realized until the 1970s when it became obvious that ***Whorfianism*** or the Sapir-Whorf hypothesis could be extended to all areas of the scientific process – as human beings, our brains work a certain way, and every aspect of it has the potential to slightly bias our observations. That very much like there are optical illusions that prey upon our imperfect perceptual systems to produce errors in judgment, there are cognitive illusions that testably produce beliefs that contradict fundamental laws in probability theory. That is, they are like medicated eye glasses which show objects in unreal ways and is used to judge the object which obviously will result to biased judgments.

Theory of Falsifiability:

W.V. Quine, the mid 20th century philosopher, asserted that for any given set of empirical facts, many theories can be generated to explain them. He insisted that we can never know what theory is "correct" until we get more data. It took Karl Popper (see Fig. 1), another philosopher of science, to reject this and replace it with the ***theory of falsifiability*** which argues that for something to be science, it must have the potential to be refuted by further experimentation. This is one of the most frequently cited contributions to the philosophy of science.

Bayesianism:

Another significant contribution to the philosophy of science was made by Reverend Thomas Bayes, an 18th century evangelist and his intellectual heir, E.T. Jaynes (1922 - 1998). Adding to a result in probability theory called Bayes' rule, Jayne's formalised the process of hypothesis construction based on precise mathematical foundations. Bayes' rule accepts subjectivism; that we can never know anything 100%, but only with varying degrees of confidence, which can be precisely updated based on incoming evidence and prior probabilities. This is the school currently known as ***Bayesianism*** which is very popular and growing in the physical and computer sciences.

Philosophy of science is still growing and transforming with the contributions of scientists and philosophers of different disciplines and schools of thought.

1.2.3 Summary

In this unit, philosophy of science, as a subject, is defined. The definition states that philosophy of science is a branch of philosophy that studies the assumptions, implication and foundation of science. The unit also discusses four major theories of philosophy of science.

1.2.4 Conclusion

We can observe from going through this unit that science as methodical and objective as it is, is carried out with human perceptions and assumptions which can be subjective. Philosophers of science have been trying to provide understanding of how such human or social behaviour affect the work of scientists whether in a laboratory, on the field or in thinking. That tells us that science as human endeavour is not completely objective but mixed human subjectivities. Despite these subjectivities, however, science has able to make meaningful contributions to our lives.

Self Assessment Questions No. 1

Answer the following questions by filling in the correct answers in the blank spaces.

1. ____________ Theory argues that for something to be science, it must have the potential to be refuted for further experiment.
2. Philosophy of science is defined as ______________
3. ______________ Theory of philosophy of science is linked to language use.
4. Philosophy of science is a branch of ___________________
5. __________ Theory argues that things should be made simple as possible but not beyond that.

Tutor Marked Assignment No. 1

1. What are the distinctions between early science and modern science?
2. List and explain two theories of philosophy of science.

Module Two: The Origin of the Universe

Unit 2.1: Origins of the Universe

In this unit, the following will be focused upon:

- The rationale for discussing the origins of the universe.
- The scientific basis for explanation of the origins of the universe.
- The ancient Greek civilization and how it encouraged the study of the living.
- How Thales, one of the earlier Greek philosophers, provoked interest on the origins of the universe.
- The various ancient Greek scholars/philosophers' explanation of the origins of the universe.
- The basis for the review of the earlier theories of the origins of the universe.
- The Big Bang and Quantum Cosmological theories on the origins of the universe.

Objectives

At the end of this unit, you should be able to:

i. Explain the theory of everything and its connection with the origin of the universe.
ii. Explain the basis for the explanation of the origins of the universe.
iii. Explain the influence of Greek civilization on the origin of the universe.
iv. Discuss how Thales provoked the discussion on the origins of the universe.
v. List and explain the seven bases for the explanation of the origins of the universe by ancient Greek scholars.
vi. Explain the basis for the review of earlier ancient theories of the origin of the universe.
vii. Explain the Big Bang and Quantum Cosmological theories on the origins of the universe.

Introduction

Since time immemorial, numerous people have been searching for the origin of the universe. The universe, as constituted, has remained an enduring mystery and a tall challenge to successive generations dating back to the distant past. Opinions had varied about the origin of the universe. The curiosity of contemporary man to unravel the mystery of the origin of the universe is not unprecedented. From the time immemorial, the mystery about the origin of the universe had attracted the attention of man. In this unit, you're introduced to the scientific theories or explanation of how the world or universe started. It should be seen that theories on the origins of the universe are as old as science. The theories of the origins of the universe are as follows:

2.1.1 Theories of the Origin of the Universe by Ancient Greeks

It must be placed on record that the Ancient Greeks had distinguished themselves as pace-setters in the bid to explain the origin of the universe. The Greek civilization was unique and could be distinguished from other centers of civilization in the past. Whereas centres of civilization, such as Egypt, Assyria, China, India, Aztec and a host of others, devoted their resources, energies and time to the glorification of the dead, by building monuments or pyramids, to venerate them, the Greek civilization was about the celebration and sanctity of human life. The Greek had proclaimed that man is the most wonderful creature on earth. Therefore, the Greeks deployed their resources to make life worth living for their citizens.

In the 6th Century BC, the Greeks in the Mediterranean island of Miletus asked a fundamental question about the genesis of the universe. This was to become an important question whose validity and ramifications had outlived generations, times, locations and ages. The first person to ask the question was **Thales**, a philosopher, who asked what was the world made of. Such question or enquiry was thought unnecessary because the issue of the creation of the universe was not only thought to be conclusive but belongs to the realm of the spiritual world, which was not opened to ordinary person. Thales refused to go to the priest to seek an answer to his question. Instead, he proclaimed that his question was scientific in nature and deserved scientific answer. That would have amounted to declaration of rebellion against the status-quo-which could not have taken such an affront lightly. At the risk of his life, Thales pronounced that Water was the ultimate explanation for the origin of the universe.

The significance of his position could be seen in the courage he had, to make a declaration of that nature in a society where issues could only be handled through the intervention of spirits. In other words, it was not the neatness of his argument or his answer that mattered but what mattered was that it opened the floodgate for subsequent scholars who had been provoked by his question and answer.

Subsequently, other philosophers were to follow his footsteps and provided answers to his question, albeit in different ways and context. In addition to the explanation of the origins of the universe by Thales, below is the chronology of other scholars who attempted to answer the question on the origin of the physical world:

Anaximene:

had also asserted that the world was made from a lump of matter that was shapeless and motionless. He could not account for the origin of the matter itself.

Anaximander:

had claimed that the universe was made from pure air.

Heraclitus:

was of the opinion that the universe was made from an enduring impact of everlasting fire. He was reputed to have said that the world is in the state of flux that nothing appears to be steady. Hence, he summed up that "You cannot step into the same river".

Aristotle:

had attributed the origin of the universe to First Order unmovable mover. He had asserted that the creator of the universe has the power to move everything around it, but it remains unmoved.

Plato:

in his theory of Forms went beyond mere explanation about the origin of the universe but equally alluded to the fact that what is knowable is what is permanent. He contended that the physical world as constructed is subject to frequent changes; hence our desire to explain it is dwarfed. He claimed that the only world that is knowable is the super-sensible one where things are permanent and therefore would be explained. Therefore, Plato's theory was to provide a fascinating dimension to the quest by humanity to unravel the mysteries of the physical world.

Pythagoras:

who was a mathematician and magician had claimed that NUMBER is the first substance, hence accounts for the origin of the universe. He had substantiated his claim by saying that since everything in the world is related to one another in terms of numbers, inevitably it becomes the sole explanation for the origin of the universe.

There are also other scholars who had attempted to explain the origin of the universe. Note that theories by ancient Greeks are many in number but was started by Thales.

2.1.2 The Big Bang Theory

The Big Bang theory is the cosmological model of the universe that is best supported by lives scientific evidence and observation. As used by scientists, the term Big Bang generally refers to the idea that the universe had expanded from primordial hot and dense initial condition at some finite time in the past and continues to expand to this day. George Lemaintres proposed what became known as the Big Bang theory of the origin of the universe. However, he called it with another name, "hypothesis of the primeval atom". The framework for the model relies on Albert Einstein's general relativity theory as formulated by Alexander Friedmann.

The Big bang theory was developed from observation of the structure of the universe and from theoretical consideration. In 1912, Vesto Slipher measured the first Doppler shift of a "Spiral nebula", which is an obsolete term for spiral galaxies and discovered that almost all such galaxies were receding or going away from Earth. He did not understand the cosmological implication of this fact. Ten years later, Friedmann showed that the universe might be expanding in contrast to static universe model advocated by Einstein.

In 1924, Edwin Hubbles confirmed that the spiral nebulae were indeed other galaxies. Independently, in 1927, Georges Lemmatizes, Belgian physicist predicted that the recession of the nebulae was due to the expansion of the universe. In 1931, Georges Lemmatizes suggested that there was evidence that the universe had contracted backward in time. This suggestion was to provide the basis for the development of the Big Bang theory.

The Big Bang theory is relevant from the above background of the universe. The exponent of the theory had argued that if in 20th century, the galaxies were expanding, by an inversion argument at a time the galaxies that were expanding had compressed. Robert Penrose, who proposed the theory, alluded to the processes of winding and rewinding of the galaxies as having accounted for the origin of the universe. The exponent of the theory contented that the universe had emerged from high level of monumental explosion triggered off by high density created by the compression of the galaxies. It was claimed that there was pre-existing void, which facilitated the processes that led to emergence of the universe. The universe was said to have been created about 15 billion years ago.

As we shall see later, the inadequacy of the above model, notwithstanding, it could be considered a major breakthrough in the bid to explain the origin of the universe. However, there is no doubt that the theory appeared to have raised more dust than it had sought to settle. Several unanswered questions have arisen from the model.

This is, more so, as the exponents of the Big Bang Theory had laid claims to science as the springboard for the theory- thereby exposing it to further questioning. Perhaps, if they had not claimed that they were scientists, their opinions would have been tolerable. However, that was not to be; hence, the shortcomings associated with the big bang Theory.

The unanswered questions associated with the theory include the following:

(a) The theory was unable to explain how the creation of the universe could have taken place without the singularity of time, space and matter tied together. Whereas they alluded to pre-existing void, they were unable to account for time and space, hence raising a fundamental question about the scientification of this science model.

(b) The model could not account for the origin of the pre-existing void said to have facilitated its emergence; neither could they explain origin of galaxies themselves.

(c) Is it feasible to argue that time and space spontaneously came into being at the same time?

(d) Besides, if the galaxies wind and rewind as claimed by the exponents, are we likely to experience another contraction in future that could trigger another explosion? If yes, what would be the implication of that development to mankind?

(e) It is equally contradicting that galaxies that were said to be part of the universe could be used to account for the origin of the universe.

2.1.3 Quantum Cosmological Theory

Hitherto, the great edifice of physics that was built up in the 17^{th} century through the work of such pioneers as Galilieo Galilei and Isaac Newton was commonly referred to as classical mechanics. The great triumph of Newton was to demonstrate that his law of motion correctly describes the shapes and periods of the planetary orbits. In time, it was assumed that if every particle of matter is subject to Newton's law, with its motion's determined by initial conditions and forces acting upon it, then everything that happens in the universe is fixed in every detail. The universe is clock. Everything that ever happened is happening now or will happen in the future which has been unalterably determined from the first instance of time. The future is fixed. This was the sweeping implication of Newtonian machines.

However, Davies Paul (1988) asserted that if the future is determined by the present, then the future is in a way already contained in the present. The present state of the universe contains the information for the past too. All of existence is thus frozen in a single moment of time. Past and future have no real meaning. Things are happening. Time flows. What this means is that it seems the universe has never ceased to be creative, fashioning ever, newer and more novel structure and relationship in the wondrous transition from the stardust to thinking humans.

The above standpoint, notwithstanding, it would seem that the scientific search for the ultimate explanation about the origin of the universe remains an issue of concern. Such concerns and frustration among scientific community were echoed by Emil Wiechert when he said: “so far as modern science is concerned, we have to abandon completely the idea that by going into the realm of the same, we shall reach the ultimate foundation of the universe. I believe we can abandon this idea without any regret. The universe is infinite in all directions, not only above up in the large but also below as in the small. If we start from our human scale of existence and explore the context of the universe further and further, we finally arrive both in the large and in the small, at misty distances where first our senses and then even our concepts fails us.”

It is against the above background that the Quantum Cosmologists evolved and positioned their theory. The exponents of the Quantum, cosmological theory had viewed the Big Bang Theory with serious misgiving, given its deficiencies and infertility as scientific platform for the explanation of the origin of the universe. In the light of the above, the exponents of Quantum Cosmological theory assert that for the creation of the universe to take place in the manner presented by the Big Bang Theory, the singularity of time, space and matter would have been present. They further, argue that in the absence of the above scenario, it would amount to contempt of scientific reasoning to uphold the Big Bang Theory as a dependable framework to explain the origin of the universe. They were of the view that the universe as presently constituted is a dynamic force of self creation.

However, like the Big Bang Theory, the Quantum Cosmologists equally have their shortcomings. Firstly, they fail to explain the origin of the universe itself and the process of its self-creation. Besides, they are unable to explain the transformation of the universe from its infancy to date. Perhaps, an agitating question could be the size of the universe at the beginning. Besides were there universes or one universe?

From the foregoing, it could be argued that even in the face of the pervasive "Theory of everything" the nature of true and our bid to understand the origin of the universe seems to be that it ever recedes from our grasp. Or could it be a case of "the more we look the less we see".

Self Assessment Questions, No.3

1. Discuss the contribution of Ancient Greek Scholars to the understanding of the origin of the universe.

2. Thales argued that the universe originated from water. Can you explain three other arguments by ancient Greek philosophers?

3. In your own words, discuss how the Big Bang theory came about.

3. Do you think that the Quantum Cosmological model is a better explanation for the origin of the universe? Explain your answer in detail.

Further Reading

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Module Three: Introduction to the Sciences

Unit 3.1: Physics

Unit 3.2: Mathematics

Unit 3.3 Chemistry

Unit 3.4: Biology

Unit 3.1: Physics

In this unit, the following will be focused upon:

- The history of physics
- The contribution of physics to societal development
- The major personalities behind the development of Physics

Objectives

It is envisaged that after going through this unit, you should be able to:-

i) Explain the evolution of physics as a course of study

ii) Appreciate the contribution of physics to societal development.

Introduction

In this unit, the definition, brief history and major classifications of physics as a discipline are discussed. Also discussed are the major personalities behind the discoveries in the discipline. Under the history of physics, the various stages in the history of physics are explained.

3.1.1 Definition and Origins of Physics

Physics is a branch of Science which deals with the study of matter and energy. In Physics, content of the universe, the forces they exert on one another and the results produced by these forces are studied.

Physics has a wide scope, often closely related to the other natural sciences and, in a sense, encompasses them. Chemistry, for example, deals with the interactions of atoms to form molecules; much of modern geology is largely a study of the physics of the earth and is known as geophysics; and astronomy deals with the physics of stars and the outer space.

Even living systems are made up of fundamental particles and, as studied in biophysics and biochemistry, they follow the same types of laws as the simpler particles traditionally studied by physicists.

Physics emerged as a separate field of endeavour only in the early 19th century. Prior to that, virtually anybody who could dabble into physics so much so that a physicist was often also a mathematician, philosopher, chemist, biologist, engineer, or even a political leader or an artist. Today, the field has grown so wide that physicists have to specialize in one or two branches of the science.

3.1.2 Stages in the History of Physics

Antiquity:

The history of physics dates back to antiquity, when the Babylonians, Egyptians and early Mesoamericans observed the motions of the planets and succeeded in predicting eclipses, but failed to find an underlying system governing planetary motion. Further contributions came from the Greeks notable among whom are Archimedes, who designed various practical mechanical devices such as levers and screws, and measured the density of solid bodies by submerging them in a liquid, and the mathematician and geographer Ptolemy, who proposed the of planetary motion (Ptolemaic system), in which the earth was the centre and sun, moon and stars moved around it in circular orbits.

Middle Ages:

The middle ages brought little progress with the notable exception of the advocacy of the experimental method as the true foundation of scientific knowledge by, especially, the English scholastic philosopher and scientist, Roger Bacon.

Renaissance:

By the 16th and 17th centuries, following the renaissance, a highly successful attempt was launched to interpret the behaviour of heavenly bodies. The push was initiated by the Polish philosopher Nicolaus Copernicus who propounded the heliocentric system that the planets move around the sun, and was reinforced by the German astronomer Johannes Kepler who provided precise astronomical measurements which provided data to overthrow the Ptolemaic system, and further led to the enunciation of three laws, known as Kepler's laws, that conformed with a heliocentric theory. Galileo then constructed his telescope, and beginning in 1609, was able to confirm the heliocentric system, in addition to laying down the foundation of mechanics (by making observations on falling bodies) which reached its pinnacle during the time of Isaac Newton.

Modern:

(see notes below).

The following gives a brief account of the historical developments in various important areas in physics:

Mechanics

By about 1665, Isaac Newton enunciated the principles of mechanics (Newton's laws of motion), formulated the law of universal gravitation, separated white light into colours, proposed a theory for the propagation of light and invented differential and integral calculus. Newton's contributions covered an enormous range of natural phenomena. He was thus able to show that not only Kepler's laws of planetary motion but also Galileo's discoveries of falling bodies follow a combination of his own second law of motion and the law of gravitation, and to predict the appearance of comets, explain the effect of the moon in producing the tides, and explain the precession of the equinoxes. Subsequent development of physics owes much to Newton's laws of motion, especially the second law, which states that the force needed to accelerate an object will be proportional to its mass times the acceleration. His contribution to the description of forces led to the elucidation of the force of gravity- one of only four known fundamental forces in the universe, the others being: electromagnetic force, nuclear force and, the weak forces accounting for the phenomenon of radioactivity.

Electricity and Magnetism

Although electrostatics was known to the ancient Greeks, and the Chinese have used magnets as far back as 2700 BC, a clear understanding of electricity magnetism did not occur until the end of the 18^{th} century. In 1785, the French physicist Charles Augustine de Coulomb first confirmed experimentally that electric charges attract or repel one another according to an inverse square law, similar to that of gravitation. A powerful theory to calculate the effect of any number of static electric charges arbitrarily distributed was subsequently developed by the French mathematician Simeon Denis Poisson and the German mathematician Carl Friedrich Gauss. The development of a chemical battery by Alessandro Volta in 1800, provided the ability to maintain an electromotive force (EMF) required to drive electrically charged particles – electricity. Soon afterwards, the German physicist Georg Simon Ohm discovered the existence of a simple proportionality constant between the current flowing and the electromotive force supplied by the battery, known as the resistance of the circuit.

Historical concepts of magnetism started in the 17th century. The first connection between magnetism and electricity came about as a result of the works of the Danish physicist Hans Christian Oersted and the French scientist Andre Marie Ampere, both in 1819. By 1831, Michael Faraday had put forward his findings on electromagnetic induction. These qualitative findings were finally summarized into a precise mathematical concept by James Clerk Maxwell in a set of partial differential equations bearing his name. An unexpected result arising from the solution of the Maxwell equations is the prediction of electromagnetic waves. In 1887, the German physicist Heinrich Rudolph Hertz succeeded in generating such waves by electrical means, thereby laying the foundation for radio, radar, television, and other forms of telecommunications.

Light

The apparent linear propagation of light was known since antiquity, and the ancient Greeks believed that light consisted of corpuscles; a view held by Newton. The English scientist Robert Hooke and Dutch astronomer, mathematician and physicist Christian Huygens proposed a wave theory of light, which was confirmed by the demonstration of interference in the early 19th century by the British physicist Thomas Young. However, the particle nature of light had to be assumed by Max Planck in 1900 (he called it quanta) to explain the blackbody radiation and by Albert Einstein to explain photoelectric effect in 1905 (photons).

The speed of light was first measured by the Danish astronomer Olaus Roemer in 1676. His measurement was in fair agreement with the improved 19th – century observations of Armand Fizeau, and with the work of the American Albert Abraham Michelson and co-workers, which extended into the 20th century. Maxwell showed that light is electromagnetic in nature, and his work predicted the existence of non-visible light. Today, electromagnetic waves are known to cover from gamma rays, through x-rays, visible light, microwaves and radio waves.

Maxwell's work, however, could not provide insight into the mysterious medium called ether, a hypothetical substance that was thought to transmit electromagnetic radiation, including light, and was thought to permeate all space. In 1887, the Michelson- Morley experiment, named after the American physicist Albert Michelson and the American chemist Edward Williams Morley, was performed, to measure the motion of the earth through the ether. The result of the experiment was unexpected and inexplicable. It was not until the arrival of the theory of relativity in 1905 that an explanation was obtained.

Thermodynamics

Thermodynamics assumed major stature during the 19th century, and helped to disentangle the confusion in the concepts of heat and temperature by arriving at meaningful definitions and relating them to concepts of work and energy. The first true connections between heat and other forms of energy (ability to do work) was observed in 1798 by Benjamin Thompson who noted that the heat produced in the boring of cannon was roughly proportional to the amount of work done (product of a force and the distance moved by a body during its application). The equivalence of heat and work was explained by Ferdinand von Helmholtz and Lord Kelvin in the middle of the 19 century, and numerically determined by James Prescott Joule in several experiments between 1840 and 1849. These led to the formulations of the **first law of thermodynamics,** a statement of the conservation of energy (*energy can neither be created nor destroyed, but can be converted to one form or the other*).

In 1824 the French physicist Nicolas Sadi Carnot pointed out that a heat engine (a device that can produce work continuously while only exchanging heat with its surroundings) requires both a hot body as a source of heat and a cold body to absorb heat that must be discharged. When the engine performs work, heat must be transferred from the hotter to the colder body. These ideas were eventually formulated rigorously as the **second law of thermodynamics** by the German physicist Rudolph Julius Clausius and by Lord Kelvin in various alternate but equivalent forms. One such formulation is that *heat cannot flow from a colder to a hotter body without the expenditure of work*. Contemporaneous with the developments in thermodynamics, kinetic theory and statistical mechanics was being developed by scientists like Maxwell, Ludwig Boltzmann and a host of other physicists. Kinetic theory applied the laws of mechanics and probability to the behaviour of individual molecules, and drew statistical inferences about the properties of a gas. One of the achievements of kinetic theory was to show that temperature, the macroscopic thermodynamic property describing the system as a whole, was directly related to the average kinetic of the molecules.

Early Atomic and Molecular Theories

The results obtained from utilizing spectroscopy to gain insight into the interior of the atom, combined with the discovery of subatomic particles, contrived to overthrow the classical theories of physics.

In 1823, the British astronomer and chemist Sir John Frederick Herschel suggested that a chemical substance might be identified by examining its spectrum – the discrete wavelength pattern in which light from a gaseous substance is emitted. As a result, the spectra of many substances have been catalogued. Discrete line spectra originate from gaseous substances, while a heated solid has a continuous spectrum over the full visible range and into the infrared and ultraviolet regions. Attempts to explain these radiation characteristics using the tools of theoretical physics available at the end of the 19^{th} century led to a wrong conclusion.

3.1.3 The Breakdown of Classical Physics

By 1880, most phenomena could be explained by Newtonian mechanics, Maxwell's electromagnetic theory, thermodynamics, and Boltzmann's statistical mechanics. A few problems, such as the determination of the properties of the ether and the explanation of the radiation spectra from solids and gases, appeared unresolved. These unexplained phenomena sowed the seeds of a revolution, which, augmented by a series of remarkable discoveries, changed the understanding of physics as it is known today. The remarkable discoveries which came within the last decade of the 19^{th} century include the discovery of x-rays by Wilhelm Conrad Roentgen of Germany in 1895; the electron by Sir Joseph John Thomson of Britain in 1895; of radioactivity by Antoine Henri Becquerel of France in 1896; and of the photoelectric effect by Hertz, Wilhelm Hallwachs, and Philipp Eduard Anton Lenard of Germany during the period 1887 and 1899. Coupled with the observations of Michelson-Morley and the discovery of cathode rays, experimental evidence in physics outstripped all available theories to explain it.

3.1.4 Modern Physics

Two major new developments during the first third of the 20^{th} century, the quantum theory and the theory of relativity, explained these findings, yielded new discoveries, and radically changed the understanding of physics as it is known today.

Relativity

By the early part of the 20^{th} century, a German-American scientist called Albert Einstein developed a theory which originally attempted to account for certain anomalies in the concept of **relative motion,** but which in its ramifications, developed into one of the most important basic concepts in physics. The theory of relativity is the basis of the essential unity of matter and energy (matter and energy equivalence through the equation, $E = mc^2$, where E refers to energy, m to the mass of matter and c is the speed of light, numerically equal to 3×10^8m/s), of space and time, and of the forces of gravity and acceleration.

Quantum Theory

Quantum theory is concerned with explaining how particles of a matter or the tiniest part of a thing like wood, stone, water, etc can interact within themselves and with energy. Unlike classical physics which is concerned with describing the behaviour of objects in larger scale, quantum theory is concerned with describing the behaviour of the universe in a smaller scale. Quantum theory describes all fundamental forces - except gravity - that physicists have found in nature. In another words, the theory was developed to account for sub-atomic behaviour called quantum mechanics or wave mechanics. It started in 1923 with the postulate of de Broglie, that all particles have both wave and particle properties nature. This is referred to as the wave – particle duality. Simply put, all particles behave just like light (which a form of waves) and as particles.

Related to the above principle of quantum theory is another one called intrinsic angular momentum or spin discovered by Wolfang Pauli in 1925. Simply put, tiny particles of matter do not stay fixed in one position but move and spin round at the same time. Imagine a ball that is thrown from one distance to another. As it is moving, it is also rolling round itself; this is how particles behave, and that is why the principle is called spin or intrinsic angular momentum. Additional important concepts have been incorporated into quantum mechanics. These include the discovery of uncertainty principle by Heisenberg in 1927. The principle asserts the existence of a natural limit to the precision with which certain pairs of physical quantities can be known. Simply put, one cannot exactly specify the location of particles as they keep moving constantly. The uncertainty principle states that it is impossible to specify simultaneously the position and momentum of a particle, such as an electron, with precision. The principle, also referred to as the indeterminacy principle, further states that a more accurate determination of one quantity will result in a less precise measurement of the other. The implication of this is that in Quantum Mechanics, calculations are probabilistic, instead of the being deterministic as in Classical mechanics. Can you recall the three concepts in quantum theory we just discussed? The box below highlights them

Wave particle duality means that particles behave in two ways; as waves and as particles

Intrinsic angular momentum or spin means that particles move from one place to another while turning round and round at the same time as they move

Uncertainty principle means that one cannot exactly specify the location of particles as they keep moving constantly

Thus, a different and statistical approach developed in modern physics as a result knowledge in quantum theory. The fully deterministic cause-effect relations produced by Newtonian mechanics were supplanted by predictions of future events in terms of statistical probability only.

3.1.5 Nuclear Physics

As mentioned earlier, Henri Becquerel discovered radioactivity (the spontaneous disintegration of nuclei of certain materials accompanied by the emission of radiation) in Uranium ore in 1896. Within a few years, radioactive radiation was shown to consist of three types of emission: alpha rays, which are doubly ionized helium atoms; beta rays, which are very fast electrons; and gamma rays, identified as highly energetic electromagnetic radiations. By 1903, it was realized that radioactivity leads to the transmutation of the emitting element into a different one, and that radioactivity occurs only from the nuclei of heavy elements.

In experiments conducted by Fermi and many collaborators in which uranium was bombarded with neutrons, a series of new elements, known as transmutation elements, were made. An important discovery in the course of conducting the experiments was that some uranium nuclei broke into two parts, a phenomenon called nuclear fission. The process of nuclear fission leads to the release of huge amounts of energy, in addition to some neutrons (and also, usually, other particles which may be radioactive, and hence, dangerous). These results were exploited by Fermi and his group, leading to the operation of the first nuclear reactor in 1942. It was also the same result that was utilized in the production and subsequent deployment of the atomic bomb in 1945, under the direction of the American Physicist Robert Oppenheimer, and the first nuclear power reactor for the production of electricity in England in 1956.

Further developments were based on the energy production of the type found in stars, that is, nuclear fusion. This is a process whereby four hydrogen nuclei are converted into a helium nucleus under high pressure and very hot conditions, with two positrons and huge amounts of energy formed as by-products. This is the principle of the hydrogen bomb- a much more powerful bomb than the atomic bomb- first detonated in 1952.

Much current research is devoted to the generation of useful energy from nuclear fusion which fortunately does not produce greenhouse gases and therefore does not contribute to climate change. However, despite the advantage, nuclear physics provides the ability to produce nuclear bomb which can destroy lives in large numbers as was used in Hiroshima and Nagasaki, Japan during the Second World War. Also, accidents at nuclear reactors can lead to sicknesses and loss of lives as it happened in Chernobyl, Ukraine, in 1986 and Fukushima in 2011.

What is your opinion on the use of nuclear for generating, defense, health in your country? Discuss with the class.

3.1.6 Conclusion

We can from history observe that physics as a discipline has a long history from ancient, middle age, to renaissance eras. The discipline is also viewed from both classical to modern form with each form making vital contributions to human life. Like other sciences, we have to note here that physics can promote by making a lot of thing easily possible and can be deployed in such a way as to destroy like (e.g. nuclear bomb).

Self Assessment Questions No.3

1. Explain the contributions of Isaac Newton to the development of Physics.

2. Discuss the difference between classical physics and modern physics.

3. Describe the three concepts in Quantum Theory.

FURTHER READING/LINKS

1. You can access these links for additional information on philosophy of physics:
2. www.qsmithwmu.com/philosophy_of_physics_papers_quentin_smith.html
3. www.absoluteastronomy.com/topics/philosophy_of_physics

Unit 3.2: Mathematics

In this unit, the following will be focused upon:

- The history of Mathematics
- The contribution of Mathematics to scientific development.
- The major ideas and personalities behind the development of mathematics

Objectives

At the end of this module, you should be able to:

i. Discuss the evolution of Mathematics as discipline

ii. Mention and discuss the contribution of Mathematics to science and human development.

3.2.1 History of Mathematics

"Mathematics is the language with which God wrote the universe" is one of the most outstanding sayings of Galileo Galilei. To delve into the history of this "queen of science" will amount to digging into the foundations of humanity as with philosophy. Mathematics has advanced way beyond simple calculations, counting, arithmetic, shapes study and measurements to a complex calculations, geometry, infinite series, calculus, programming and so on.

The oldest known mathematical object is the Lebombo bone, discovered in the Lebombo mountains of Swaziland and dated to approximately 35,000 BC. Other prehistoric artifacts discovered in Africa and France dated 35,000 and 20,000 years old, and they suggest early attempts to quantify time. Notable are the Ishango bones found near the headwaters of the Nile river (north-eastern Congo) and are said to be as much as 20,000 years old.

In an attempt to trace the origin of mathematics, we take a look first at prehistoric mathematics which dates back to as far as the origin of mankind. The first man definitely would have been able to distinguish between a single animal and that more than a unit. Keeping track of natural events such as the phases of the moon, rising and setting of the sun, as well as seasonal changes are examples of the early practice of mathematics made more evident by the discovery of notched bones dated back to 35000 to 20000 years ago.

Conflicting arguments on whether the Egyptian or Babylonian mathematics came first are yet to be agreed upon. However, the earliest written mathematics is engraved on the stone head of ceremonial mace of Egyptian King Menes. Most were written on papyrus that indicated the Egyptians were using mathematics as early as 2000 years Before the Common era (2000BC).

According to Aristotle (350BC), “Egypt was the cradle of mathematics”. The advancement of mathematics has been attributed to various conditions necessitating such developments. For instance, Egyptian mathematics was driven as a result of the flooding of the Nile (according to the Greek Historian, Herodotus) forcing them to reset boundary markers of their fields engaging the assistance of surveyors to perform practical arithmetic and geometric computations. It is therefore believed that the Egyptians were the earliest mathematicians who, however, drew conclusions instinctively rather than with proofs. They might have introduced the earliest fully-developed base-10 numeration system at about 2700BC. Written numbers used several materials to represent units, tens, hundreds and thousands. For instance, a stroke was used for units and a lotus plant for thousands. The concept of place value was not in existence then and so made working with larger numbers cumbersome. A clear demonstration into their methods of multiplication and divisions carried out then was revealed in the Rhind papyrus dated around 1650BC. The pyramids are themselves indicators of the advancement of Egyptian mathematics pointing towards the possibility of the Egyptians knowing the formula for a volume of a pyramid and also with the use of ropes for construction purposes forming angles to show that they had an insight into what will later become Pythagoras’s theorem.

Babylonian mathematics has over the past centuries been given immense reference. As a nation at the centre of the Sumerian civilization which flourished before 3500BC, Babylon was characterised with building of cities, land numeration and geometry which became the driving force behind the development of Babylonian mathematics leading to the introduction of symbols written on wet clay tablets which were then baked in the hot sun discovered in this age. Around 2300BC, the Akkadians invaded the region for a period of time during which the elementary model of the abacus was invented.

The Babylonians had an advanced number system, perhaps more advanced that what we use today. They used the sexgesimal numeric system or base-60 (that is a system of numbering where repletion of numbers can be done after sixty different numbers) as opposed to the base-

10 used in today's mathematics. The present numbering system used repeats itself after tenth number (0, 1, 2,3,4,5,6,7,8, & 9). So if you write 10, you are repeating 0 & 1 from the first ten. The Babylonians divided the day into 24 hours with each hour, 60 minutes and each minute 60 seconds which has survived over 4000 years and is still used today though to base-10 as opposed to the base-60 used then. They are believed to have recorded advances in mathematics involving multiplication, reciprocal tables, squares roots, geometric problems, and so on.

Greek mathematics and astronomy owes a lot of its advances to Egyptian mathematics. Thales (546BC), the founder of Greek mathematics along with Pythagoras who coined the term "mathematics" from the ancient Greek *μάθημα* (*mathema*), meaning "subject of instruction" (500BC), were one of the earliest and greatest Greek mathematicians but reported to have travelled to Egypt and must have learned a lot of their mathematics from there. Eudoxus, the teacher of Aristotle studied in Egypt too before teaching in Greece.

Greek mathematics unlike that of the Egyptians made attempts to prove mathematical statements repeatedly especially in geometry. The importance of proving mathematical statements before drawing conclusions was established in 550BC by Pythagoras, popularly known for the "Pythagoras's theorem" and also for saying that; "Numbers rule the universe". For example, the Pythagoras's theorem,$a^2 + b^2 = c^2$, has over 50 proofs, the highest for any one mathematical theorem.

The Alexandrian or Hellenistic period from about 300BC to 300AD was the dawn of a new mathematical era. The centre of mathematics moved from Athens to Alexandria in Egypt built by Alexander the Great after conquering the entire region. Quite a number of Greek mathematicians studied and taught in Alexandria. Notable among them were Euclid (Euclidean geometry), Archimedes (first system of latitude and longitude) and Diophantus (first to recognise fractions as numbers). A lot of original mathematical manuscripts contained in the library were lost when it was engulfed by fire.

In 80 BC, the Romans took control of Alexandria, and it became part of the Roman province of Egypt. The Romans had no use for pure mathematics only for its practical application though; the province produced great mathematicians of the Roman Era. During this period, notable discovery was the quantification of geometry through the invention of trigonometry by astronomer Hipparchus of Rhodes generally considered its father. He imported the sexgesimal numeric system into Greek geometric models.

The Roman numerals, still in use today, were the number system used for transactions and administration. It was based on the Roman alphabets, I, V, X, L, C, D and M, combining to form various values. It, however, did not include a concept for zero, thus, making it inefficient for mathematical and arithmetical purposes. This resulted in calculations being performed using an abacus.

The Classic Maya civilization (250 BC to 900 AD) handled huge sums of numbers ranging to millions, independently developed the concept of zero far back as 36BC and used it as a place holder in vigesimal number system (base-20) and in some cases base-5 numeration system. Astronomy played a central role in their religion, and this motivated them to develop mathematics. Maya calendar was more accurate than the European at the time the Spanish landed in the Yukatan peninsula.

The trade of the Chinese Empire was the force behind mathematical development in the Chinese dynasty. The Chinese did not have a real concept for zero but rather made use of zero and developed small rods made from bamboo plants to perform calculations. The position to which the rods were placed gave a decimal place-value system. It is believed that the use of the abacus was originally the idea of the Chinese due to the "Suanpan" that dates to about 200BC. They gave attention to practical mathematics and had the Zhou Bi as the earliest extant mathematics textbooks. The civil service, construction sector and engineering all made use of the Jiuzhang Suanshu of "Nine Chapters on the Mathematical Art" as the important tool for education.

There were in the 13th century over 32 mathematical schools around the empire making that period the Golden Age of Chinese mathematics. The most notable Chinese mathematician was Qin Jiushao, an ambitious and callous military officer who is believed to have explored solutions to quadratic and even cubic equations using a method of repeated approximations similar to that much later put together by Sir Isaac Newton. Qin wrote an important equation known as the Chinese remainder theorem and wrote his only book on mathematics called "Mathematics Writings in Nine Sections" in 1247. Contained in it was the method for solving simultaneous linear congruences and had the earliest description of algorithm later developed in Europe. Qin also used his method of repeated approximations to solve equations involving numbers raised to the power of ten which even as of then was an audacious task.

The contribution of Indians to the development of mathematics is believed to date back way longer than stipulated. It was driven basically by religion for which they had to build altars.

The role of their contributions could be traced to their geographical location as a meeting point for people of diverse cultures and nations with evident visits by Pythagoras.

Today's mathematics is indebted to Indian mathematics specifically in expressing every possible number with a set of 10 symbols, that is, each symbol with a place value and an absolute value as well. The study of mathematical astronomy in India dates back to at least 3000BC introducing the Indian numerals which were later developed to form the Hindu-Arabic numerals used in present day mathematics. They also made use of the base-10 instead of the base-60.

Worthy of mention in Indian mathematics are the Sulbasutras which were in a real sense "construction manuals" for geometric shapes, such as rectangles and circles and rules of constructing altars with resemblance to what later became Pythagoras's theorem. Further advancement was experienced during the Jaina period (about 150BC). Areas such as theory of numbers, operations with fractions and more surprising was the theory of the infinite containing some notions of logarithms to base 2.

Madhava from Southern India is sometimes referred to as the greatest Indian mathematician and astronomer. Though most of his work has been lost, according to Kerala mathematicians, his is the source of several infinite series expansion. He linked infinite series with geometry and trigonometry and obtained up to 13 decimal places accurate values of π.

Islamic or Arabic mathematics laid the foundation for what is today present mathematics. After conquering most part of the Middle East and North Africa, the Islamic Empire was established. Islamic mathematicians then imported mathematical advancements from India and Greece and translated them into Arabic; for instance,. the Euclid's Elements. As it is forbidden to depict humans in drawings by Islam, the growth of mathematics became significant with the use of complex geometric patterns for decorations of buildings. The House of Wisdom, established in 810AD after the expulsion of Alexandria (700AD), was responsible for translating Greek and Indian mathematical and astronomical works to Arabic.

The most significant contribution of Arab mathematics (with major Indian contribution) is the Hindu numerical systems: 1,2,3,4,5,6,7,8,9 and 0. This contribution is erroneously attributed to Muhammad Al-Khwarizmi who introduced the theory of algebraic calculus and used mathematical induction to prove the binomial theorem:

$$(a+b)^2 = a^n + na^{n-1}b^1 + \frac{n(n-1)}{2}a^{n-2}\,b^2 + \cdots + \ b^n$$

Other notable Muslim mathematicians include: Abul Hasan al-Uqlidisi who wrote the earliest extant of texts showing the use of decimals instead of fractions; Ibrahim ibn Sinan who continued Archimedes investigations of areas, volumes and tangent of a circle; the discovery of all the modern trigonometric functions besides the sine; al-Kindi's introduction of cryptanalysis and frequency analysis; development of analytic geometry by Ibn al-Haytham; the beginning of algebraic geometry by Omar Khayyam; introduction of non-Euclidean geometry by Sadr al-Din and the development of an algebraic notation by al-Qalasādī.

As opposed to the development of mathematics in other regions of the world, Europe was from 500AD to mid 1400s in its Dark Ages characterised by a halt in the development of science and mathematics.

At about the 4th to 12th centuries, trade calculations were based on Roman numeral system and the Greek and Roman models of abacus. The European period of mathematics emerged as trade began with the East, thus enhancing the need for practical mathematics. Translation of Islamic and Greek mathematics was seriously practiced; for example, Robert of Chester translated the work of Al-Khwarizmi and Gerard of Cremona that of the Euclid Elements.

Leonardo of Pisa an Italian mathematician, popularly known as Fibonacci, contributed immensely to European mathematics. He spread the use of the Hindu-Arabic numeral system through the region. The European era evolved mathematics to a high scientific level. John Napier, in Scotland, investigated natural logarithms in 1614. This is also the time when Fermat proposed his famous "Last Theorem" which has only just been proved by Andrew Wiles in the 1990's. As with the quest to find a general solution for the fifth degree (quintic) polynomial equation, the challenge presented by Fermat occupied great minds over a period of centuries and produced enormously rich benefits, but there was no solution until recently. Fermat's main contribution to mathematics was, however, the founding of number theory -- that branch of mathematics which deals with the arithmetic properties of the natural numbers. Copernicus and Galileo revolutionised the applications of mathematics to the study of the universe. Kepler formulated mathematical laws of planetary motion. Analytic geometry of René Descartes (1596–1650), a French mathematician and philosopher, allowed those orbits to be plotted on a graph, in Cartesian coordinates. Simon Stevin (1585) is the father of modern decimal notation that allows the present representation of all numbers, whether rational or irrational. Sir Isaac Newton, an Englishman, discovered the three popular fundamental laws in physics, explaining Kepler's Laws. He introduced the concept of infinitesimal calculus. Independently, Gottfried Wilhelm Leibniz, in Germany, developed calculus and much of the calculus notation still in use today. Pascal and Fermat set the groundwork for probability theory and the corresponding rules of combinatorics. Pascal name is commemorated in Pascal's Triangle as well as the Pascal programming language. Leibniz's influence on the various members of the Bernoulli family was important in seeing the calculus grow in power and variety of application. Leonhard Euler may be argued to be the most influential European mathematician of the 1700s. His contributions range from founding the study of graph theory with the Seven Bridges of Königsberg problem to standardizing many modern mathematical terms and notations. He named the square root of minus 1 with the symbol *i*, and popularized the use of the Greek letter π to stand for the ratio of a circle's circumference to its diameter. He contributed a lot to the study of topology, calculus, combinatorics, and complex analysis. Toward the end of the 18th Century, Lagrange began a rigorous theory of functions and of mechanics. The period around the turn of the century saw Laplace's great work on celestial mechanics as well as major progress in synthetic geometry by Monge and Carnot. By 19th century, mathematics became very abstract. Many landmark achievements were made in abstract algebra and geometry. Carl Friedrich Gauss (1777–1855) did revolutionary work on complex variables, geometry and on the convergence of series. Karl Pearson (1857-1936) founded statistics as we know it today. Notable in this era is the introduction of Boolean algebra by George Boole which is the beginning of mathematical logic and the foundation of computer science.

Born in Nigeria, unlike the 18th century Ghanaian Anto Amo, who worked and lived in Europe, Muhammad ibn Muhammad al-Fullani al-Kishnawi spent his life career in the Middle East. He was a Fulani from northern Nigeria. He travelled to Egypt, and in 1732, he wrote a manuscript (in Arabic) of procedures for constructing magic squares up to order 11. Muhammad died in Cairo in 1741.

The 20th century saw mathematics become a major profession. Every year, thousands of new Ph.Ds in mathematics are awarded, and jobs are available in both teaching and industry. In earlier centuries, there were few creative mathematicians in the world at any one time. One of the more colourful figures in 20th century mathematics was Srinivasa Aiyangar Ramanujan (1887–1920), an Indian who conjectured and proved over 3000 theorems.

There are many observable trends in mathematics, the most notable being that the subject is growing ever larger; computers are ever more important and powerful, the application of mathematics to bioinformatics is rapidly expanding, the volume of data to be analyzed being produced by science and industry, facilitated by computers, is explosively expanding.

Mathematics is the Empress of the Sciences. Without her, there would be no physics, nor chemistry, nor cosmology. Any field of study depending on statistics, geometry, or any kind of calculation would simply cease to be. And then, there are the practical applications: without mathematics, there is no architecture, no commerce, no accurate maps, or time-keeping: therefore, no navigation nor aviation nor astronomy.

She is all-powerful:, and she rules ruthlessly. Imperious and unyielding, mathematics brooks no dissent and tolerates no error. In an age of uncertainty, mathematics is the only discipline that generates knowledge that is immutably, incontestably and eternally true.

Further Reading

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Self Assessment Exercises

1. Explain how significant mathematics is to the other sciences and technology.

2. Why is mathematics called the empress of the sciences?

Unit 3.3: Chemistry

In this unit, the following will be focused upon:

- The history of chemistry
- The contribution of chemistry to societal development.
- The disciplinary classification of chemistry

Objectives

It is envisaged that after going through this unit, you should be able to:-

i. Explain the evolution of chemistry as course of study
ii. List and explain the contribution of chemistry to societal development
iii. List and describe the disciplinary classification of chemistry

Introduction

Chemistry as scientific discipline has been in existence for a long time. The discipline has made numerous contributions to the development of human life in various areas. In this unit, the history, classification and contribution of the science of chemistry to human development shall be examined. Also, some of the major personalities who made fundamental contributions to the development of chemistry will be mentioned. First, we start by asking what chemistry is all about.

3.3.1 What is chemistry?

Before we enter into a discussion on the history, we should define just what is chemistry? The dictionary definition states that chemistry is the science of composition, structure, properties and reactions of matter, especially of atomic and molecular systems. The central theme of chemistry is that all matter consists of molecules that are comprised of atoms.

For thousands of years, people have studied the transformation of materials into new products with potential properties that they desired. This was the basis of the well-known field known as alchemy which was popular from around 1900 BC to about 1700. Some well-known goals of alchemy work were to convert metals into gold or to convert materials into the Elixir of Life which was thought to cure all diseases. These experiments were in essence attempts to perform chemical reactions, but their basis was not scientific. However, the practice of experimentation and recording of results set the stage for modern chemistry.

Eventually, people became skeptical of alchemy and frustrated with the language used to report results. Modern chemistry essentially grew out of the skepticism and the need to have a more systematic explanation of the phenomena that was being observed.

3.3.2 Stages in the History of Chemistry

Chemistry, as a branch of science, has been around for a long time. In fact, chemistry is known to date back to as far as the prehistoric times. Due to the amount of time chemistry takes up on the timeline, the science is split into four general chronological categories. The four categories are: prehistoric times - beginning of the Christian era (black magic), beginning of the Christian era - end of 17th century (alchemy), end of 17th century – mid-19th century (traditional chemistry) and mid 19th century - present (modern chemistry). This is explained in details below:

Black Magic and Alchemy Era:

Chemistry as we know it today originated from early studies of alchemy and magic. Similar to modern day chemists, alchemists tried to change a certain substance into another; in this case, it is gold. Alchemists also searched for secrets to eternal life. Alchemy slowly started to reach its peak in the late 1400's when people started to question and doubt the thoughts and theories of alchemy. Slowly, these scientists grew away from ideas of magic and became more dependent on what were facts, not theories based on superstitions. These scientists began recording and organizing their discoveries in books, which later would become the basis of chemistry.

The alchemists were the first to study chemistry. They had two quests: to change lead into gold or to find the Philosopher's Stone, and to find the Elixir of Life, a concoction that would lead to a long life and to cure illnesses. The alchemists discovered many processes, elements, and chemical compounds in the Middle Ages, even though alchemy was a mixture of science, medicine, magic, and religion. They discovered the elements hydrogen and phosphorous, alcohol and gun powder, and the processes of filtration, evaporation, and distillation.

Traditional Chemistry:

Chemistry started to lift off once a British chemist known as Robert Boyle published his book *The Sceptical Chymist* in 1661. In this book, Boyle put down rules for a careful scientific investigation, and he slowly proved how alchemy was just a myth. He provided clear and vivid details on how a pure element cannot be split to form simpler substances. He also described how the four elements alchemists believed in could not explain the behavior of many substances on Earth. Slowly, alchemy started to die, and people realized the reality of chemistry. They put aside their beliefs of magic and alchemic methods to focus more on purifying substances and investigating their many properties. Chemists started to become fascinated with chemical reactions and the composition of matter.

Modern Chemistry:

Today, there are 92 natural elements and 23 synthetic elements throughout the world. Elements are either metals or non-metals, and they have many other descriptions to classify them further in the periodic table. Each element has one or two letter symbol which helps chemists from all over the world to classify them without misinterpretations of different languages. Every element has its own atomic number which symbolizes how many protons and neutrons are in the element's nucleus.

Chemists also focus heavily on chemical reactions. Chemical reactions change the chemical make-up of different substances to break down substances into smaller simpler parts, or even create more advanced and complex substances. In a chemical reaction, the substances that are present before the reaction starts are reactants. When the chemical reaction process is over, the final result of the mixing of the substances are the products. Chemical reactions may be very fast or even extremely slow; for example, rusting. Catalysts are substances that speed up the process of chemical reactions. They can help manufacture many items, including margarine and vegetable oils. John Dalton is considered the father of chemistry. John Dalton proposed the modern atomic theory in 1808. Investigators learned that atoms were composed of subatomic particles called electrons, protons, and neutrons in 1850.

Marie and Pierre Curie discovered radioactivity in 1912 which led to the development of nuclear reactors to produce electricity and the nuclear arsenal in the 1940s. The discovery of radioactivity along with x-rays in 1895 resulted in the formation of nuclear medicine which is used for diagnosis and treatment of cancer.

Polymer chemistry and the invention of synthetic fibers began in the 1920s. Naturally, occurring polymers include cotton, cellulose, rubber, proteins, and nucleic acids. Synthetic polymers include Bakelite, acrylic, nylon, rayon, Dacron, polyester, primaloft, Lucite, Plexiglas, polystyrene, vinyl, and Teflon.

Watson and Crick deduced the double helix structure of DNA ushering in molecular biology and biochemistry in 1953. Eventually, this led to determining the genetic code for multiple species and the ability to identify a crime suspect through forensic DNA tests.

Synthetic hormones to treat thyroid disease and insulin-dependent diabetes were produced in the 1970s and 1980s. Superconductors and nanotechnology were discovered in 1986. Superconductors will reduce the need for oil and coal in future. Superconductors will be used to provide self-propelled rail cars and ships and to power electric vehicles traveling on electrified roads.

The bridge between alchemy and modern chemistry may have started with Islamic alchemists. Around the year 815, Islamic alchemists such as Jabir ibn Hayyan (also known as Gerber) introduced experimentation and methods of experimental chemistry used today such as crystallization, distillation and filtration. He introduced a systematic and experimental approach to scientific research based in the laboratory, in contrast to traditional alchemists whose works lacked scientific reasoning.

The development of the scientific method led to some pivotal work in the early 1600s, notably the publication of a book by Robert Boyle. Robert Boyle is credited as one of the fathers of modern chemistry after he published his book *The Sceptical Chemist* in the early 17th century which outlines some of the original ideas of atoms, molecules and chemical reactions. This work provides a clear distinction between alchemy and chemistry and formed the basis for the modern theory of chemistry. Boyle's research which included the famous Boyle's Law (describes the relationship between pressure and volume for gases) stimulated a flurry of research particularly on gases for the next 100 years.

3.3.3 Classification of Chemistry

The traditional classification of chemistry is placed originality in the areas of organic, inorganic and physical chemistry. But chemistry as a central science has many other areas, such as medicinal chemistry, biochemistry, colloid chemistry, environmental chemistry, nuclear chemistry, food chemistry, pharmaceutical chemistry, industrial chemistry, agrochemistry, forensic chemistry, astrochemistry, electrochemistry, quantum chemistry, etc. These areas can be used to easily understand how chemists could study different elements, matters and the chemical changes that are performed under different conditions to produce new compounds. However, our discussion will be restricted to the following branches:

Organic Chemistry

In early 19th century, chemists usually considered that compounds acquired from living microorganisms were very much complicated to be acquired synthetically. They called these substances "organic". Through the initial half of the 19th century, experts pointed out those organic compounds could be synthesized inside the laboratory.

An **organic compound** is any member of a large class of gaseous, liquid or solid chemical compounds whose molecules contain carbon. Thus, an organic compound is any member of a large class of chemical compounds whose molecules contain carbon; for historical reasons, a few types of compounds such as carbonates, carbon oxides and cyanides, as well as elemental carbon are considered inorganic.

Examples of organic compounds: CH_4 – methane; C_2H_6 – ethane; C_2H_4 – ethane; C_3H_8 – propane; C_3H_6 – propene; C_4H_{10} – butane; C_6H_6 – benzene; C_7H_8 – toluene; C_6H_6O - phenol

Organic chemistry is definitely one of a typical most significant in chemistry. It as well covers an immense strain of molecules, including those of industrial chemical compounds, such as plastics, rubber, dyestuffs, narcotics and solvents.

Organic chemistry is actually a sub-discipline in chemistry relating to the study of the properties, structure, reactions, composition, as well as preparation (by functionality or perhaps by some other means) of carbon-based substances, hydrocarbons, as well as their derivatives. These substances may contain a variety of other components, which include oxygen, hydrogen, the halogens, nitrogen and phosphorus, sulfur and silicon. Organic compounds tend to be structurally different. There are varied applications associated with organic compounds: They either make up the foundation of, or are essential constituents of, numerous products which include drugs, plastics, food, petrochemicals, paints and explosives. They make up the basis of virtually all earthly life procedures with hardly any exceptions.

Inorganic Chemistry

Inorganic Chemistry is one of those typical sensible tasks of science. It covers the formulation, attributes and responses of all chemical elements and their chemical compounds. It is actually proved in the experimentation technique. Inorganic chemistry is related to inorganic compounds. **Inorganic compounds** are of inanimate or have no biological origin. Inorganic compounds lack carbon and hydrogen atoms and are synthesized by the agency of geological systems. The majority of the inorganic compounds are salts, united with cation and anion, and conjoined by electrostatic bond.

Inorganic chemistry can be defined as the branch of chemistry which is concerned with behavior and property of an inorganic compound (elements and all their compounds). Inorganic chemistry covers every chemical compound except carbon-based compounds which normally contain H-C bonds.

A number of inorganic compounds consist anions and cations which are known as ionic compounds, that is, compounds which are bonded with ionic bonding. Example of salt is magnesium chloride that consists magnesium cation and chloride anion that consists sodium cation and oxide anion. In any salts, the proportion of ion is in way that electric charge cancel, therefore the bulk compounds are electrically neutralized.

Examples of inorganic compounds: NaCl - sodium chloride; CO_2 - carbon dioxide; H_2O – water; NO_2 - nitrogen dioxide; HCl - hydrochloric acid; $CuCl_2$ - copper(II) chloride; Fe_2O_3 - iron(III) oxide; $MgCl_2$ - magnesium chloride, etc

Inorganic chemistry is highly used in the areas of science; some country’s economy can be evaluated through their sulfuric acid productivity. Oxygen, aluminum sulfate, nitrogen, ammonia, nitric acid, ammonium nitrate, hydrogen peroxide, ammonium sulfate, hydrogen, black carbon, hydrochloric acid, chlorine, phosphoric acid, titanium dioxide, sodium carbonate, sulfuric acid, sodium chlorate, sodium sulfate, sodium hydroxide and sodium silicate. Fertilizer manufacturing is another practical application of inorganic chemistry in industries.

Physical Chemistry

Physical Chemistry is one of a typical sub-field in chemistry that covers the physical properties of matter, which include their boiling, melting levels, etc. Analyses relating to the nuclear and subatomic particles and chemical systems with reference to physical concepts that include thermodynamics, quantum chemistry kinetics as well as statistical mechanics are the domain of physical chemistry.

Physical chemistry can be explained as the study which includes atomic, macroscopic, particle and sub-atomic topics in chemistry. It consists of four areas such as chemistry, astronomy, earth sciences and physics. Again every one of this sub-divided into categories. The boundary in-between chemistry and physics is a bit arbitrary, as physics is more related with behavior and structure of every atom and chemistry is more related to reactions and properties of a molecule.

Analytical Chemistry

Analytical chemistry deals with analytical methods for getting information about chemical compounds and chemical processes. Analytical chemistry follows one of a typical chemical processes and would always separate materials using the aid of color, odour and melting point, as well as boiling point. Weight and volume are divided with the help of the technique of quantitative chemical analysis. It can be used for medical analysis and ecosystem analysis. Analytical chemistry is defined as a study regarding matter in order to expose its composition, structure and extent. Since these understandings are fundamental in almost every chemical inquiry, analytical chemistry can be used to acquire information, insure safety and solve problems in several chemical areas and is also essential in both theoretical and applied chemistry.

Early analytical chemistry was mainly focused on identifying elements and compounds and finding their attributes. Analytical chemistry can apply to materials in a number of fields, including the food and beverage industry, the pharmaceutical industry, synthetic materials such as polymers and natural materials, including minerals and water samples. As the field grew, analytical chemistry furthermore widened to embrace applications of its methods of forensics and medication. Analytical chemists these days use numerous techniques in their analyses, including some involving robotics, digital microscopes, fourier transform infrared spectophotometers, chip-based technologies, etc.

Biochemistry

Biochemistry is the science in which chemistry is applied to the study of living organisms and the atoms and molecules which comprise living organisms. It treats the chemical reaction by using an organism within the living things. The aim of biochemistry is to understand the structure and behavior of biomolecules. These are the carbon-containing compounds that make up the various parts of the living cell and carry out the chemical reactions that enable it to grow, maintain and reproduce itself, and use and store energy. Among the most important classes of biomolecules are nucleic acids, proteins, carbohydrates, and lipids.

Industrial Chemistry

Chemistry deals with the nature of substances and the generation of entirely new materials by their mutual reaction. Industrial Chemistry, as a subject, therefore, comes in very useful as an application of chemical knowledge to a range of industrial endeavours. Industrial Chemistry is the branch of chemistry which applies physical and chemical processes towards the transformation of raw materials into products that are of benefit to humanity

Industrial Chemistry deals with the application of chemical knowledge in technology, industry and preparation of industrial products. The pharmaceutical petrochemical, soap and detergents, paints, dyes and textiles; insecticides, food and biochemical industries are just some of the enterprise where Industrial Chemistry is applied.

A proper training of students to equip them with sound knowledge of chemical principles and laboratory practice will make it possible for them to help solve problems in such industries. The Industrial Chemistry graduate is a chemist with knowledge linkages in engineering, chemical processing, economics and industrial management

You can access these links for additional information on philosophy of chemistry:

http://hyle.org/

http://ispc.sas.upenn.edu/

http://scienceblogs.com/ethicsandscience/2008/05/why.philosophy_of_chemistry_php

Self Assessment Question No.4

1. List the classes of chemistry and explain each.

Unit 3.4: Biology

In this unit, the following will be focused upon:

- The history of biology
- The contribution of biology to societal development.
- The major personalities behind the development of biology

Objectives

It is envisaged that after going through this unit, you should be able to:-

i. Explain the evolution of biology as a course of study
ii. Enumerate the contribution of biology to societal development

Introduction

This unit provides an account of biology as a discipline, the major concepts, contributions and the personalities behind them.

3.4.1 Definition of Biology

Biology is the study of life; studying living forms, their structure, function, reproduction, growth, organization and relations with the environment. The subject is made up of the following disciplines: botany, taxonomy, zoology, anatomy, physiology, microbiology, embryology, genetics, ecology, evolution. Biology is an old science from the point of view of its beginnings, but young from the point of view of the continuous discoveries.

3.4.2 Brief History of Biology

Knowledge of biology began with prehistoric people and their experiences, such as distinguishing between edible and inedible, or even poisonous plants and habits of animals, and how best to capture them, etc. They knew that a heartbeat meant that someone or some animal was alive and that babies were in some way connected with sexual intercourse.

The Greeks were said to have evolved the practice of critical thinking whereby they sought explanations of natural phenomena. This could be said to be the foundations of biology and most other sciences. Anaximander, a Greek philosopher, is credited with the first written work on natural science, a classical poem entitled *On Nature* in which he presented what may be the first written theory of evolution. He said that in the beginning, there was a fish-like creature with scales, etc. that arose in and lived in the world's oceans. As some of these creatures advanced, they moved onto land, shed their scaly coverings and became the first humans. Another Greek philosopher, Xenophanes, was one of the first people to write about observations of fossils. He thought that fossils were an indication that there was water/mud previously in an area.

Whilst earlier scholars made observations about flora and fauna, Aristotle was the first to use empirical methods and techniques in a proto-scientific method. Aristotle's meticulous methods and record keeping laid out the template for future researchers in the field, namely the later Islamic scholars, who would guard the wisdom of the Greeks and pass it to the Western world. The classification of species **(taxonomy)** was Aristotle's greatest contribution to the foundation of biology, the first known attempt to classify animals into groups according to their behavior and, most importantly, by the similarities and differences between their physiologies. Our current technical terms "genus" and "species" are Latin translations of Greek words first used by Aristotle.

Later, Carolus Linnaeus (Karl von Linné) gets credit for our present-day classification scheme and the system of two-part scientific names for organisms; thus, he has been given the nickname, "The Father of Taxonomy." He was the first to attempt to classify organisms for their own sake (based on things like similar body structures) rather than to serve some human use. He gave two-part Latin names to each organism he knew. For example, Homo sapiens is the scientific name for humans. Another thing Linnaeus did was an attempt to organize all known organisms into a taxonomic hierarchy which he invented. The levels in this hierarchy, in order, are:

Kingdom
Phylum
Class
Order
Family
Genus
Species

Other contributions of biologists include the following areas:

3.4.3 Micro-Organism

By the late 1600s, observations were being made with the first, primitive microscopes. These often had highly-polished grains of sand as lenses. In 1665, Robert Hooke became the first person to see and name cells. He examined (dead) cork bark with a primitive microscope and saw little cubicles which he called cells (cell = room, cubicle). Anton van **Leeuwenhoek** was the first person to observe sperm cells, and with his very primitive microscope, thought he saw tiny body parts in the sperm. He was the first to see and describe bacteria, yeast plants, the teeming life in a drop of water, and the circulation of blood corpuscles in capillaries. Microorganisms are tiny living things which we cannot see with the naked eye. With the discovery of microorganisms, the controversy over spontaneous generation arose. The theory of spontaneous generation suggested that organisms can arise spontaneously from non-living material. In 1668, Francesco Redi did an experiment to debunk the theory. By a simple experiment, he demonstrated that maggot would not arise from decaying meat if the meat were covered to prevent entry of flies. John Needham, in 1745, advanced spontaneous generation by showing that microorganisms appear spontaneously in beef broth, but another scientist, Lazarro Spallanzani, in 1766, disputed the theory by showing that boiled broth would not give rise to microscopic forms of life. Louis Pasteur devised swan-necked flasks that he filled with broth and left open to the air. The flask had a curve in the neck so that microorganisms would fall into the neck, not the broth. There was no spontaneous generation or contamination in the flask, thus encouraging the belief that microorganisms were in the air and could cause disease.

3.4.4 Genetics

In 1865, Gregor Mendel, an Austrian monk, published a paper on genetics that earned him the nickname “the Father of Modern Genetics.” One of Mendel’s jobs at the monastery was to care for the garden. He raised garden peas and made specific crosses between certain plants. From this, he developed a theory of genetics that enabled people to predict the outcome of a genetic cross if the genes of the parents were known. Mendel’s explanation of genetics was not initially understood and accepted by scientists but was only subsequently proved by other biologists. The major argument of Mendel’s theory is that chromosomes are transferred to egg or sperms from the original cells. As a result of the transfer of chromosome from the initial or parent cells, the new cells produced share resemblance with the parent or original cells.

Subsequently, in 1944, Oswald Theodore Avery showed deoxyribonucleic acid (DNA) to be the chemical compound that contains the instructions needed to develop and direct the activities of nearly all living organisms including determining heredity. In 1953, James Watson and Francis Crick in a scientific paper published found out that DNA could be the genetic code material for all living things and suggested a means whereby it could replicate itself. Subsequent chemical analyses of DNA have upheld their prediction. Later developments led to the understanding of how DNA directs the formation of proteins.

In 2006, The Human Genome Project, which was led at the National Institutes of Health (NIH) by the National Human Genome Research Institute, produced a very high-quality version of the human genome sequence. The sequence is not that of one person, but is a composite derived from several individuals. Therefore, it is a "representative" or generic sequence. The Human Genome Project was designed to generate a resource that could be used for a broad range of biomedical studies. With the vast trove of data about human DNA generated by the Human Genome Project, scientists and clinicians have much more powerful tools to study the role that genetic factors play in much more complex diseases, such as cancer, diabetes, and cardiovascular disease. Genome-based research is already enabling medical researchers to develop more effective diagnostic tools, to better understand the health needs of people based on their individual genetic make-ups, and to design new treatments for disease. Many other contributions of biology also abound but are limited to these three for this module. You can also access the links at the end of the unit for further details.

3.4.5 Conclusion

We can observe that biology as a discipline has a long history and provides the foundation of account to understand life of animals and plant. Micro-organism and genetics are two of the key areas in biology that are still very important.

Self Assessment Exercises

1. Explain the importance of the knowledge of micro organism and genetics to the lives of people?

2. You can access these links for additional information on philosophy of biology:

http://plato.stanford.edu/entries/biology-philosophy

www.dartmouth.edu/~dietrich/bios.html

Module Four: Technology and Society

Unit 4.1: Impact of Science and Technology

Unit 4.2: Issues on Technological Development for Developing Countries

Unit 4.1 Impact of Science and Technology

In this unit, the following will be focused upon:

- The distinction between technology and science
- Impact of technology on people.
- Four ideas on technological development
- The future prospect of science and technology

Objectives

It is envisaged that after going through this unit, you should be able to:-

i. Explain the basic relations and distinctions between science and technology
ii. Explain the impact of technology on different spheres of human endeavours.
iii. Identify ideas about the desirability or otherwise of man's quest to acquire technological capacity.
iv. Discuss the enabling condition for technological development.
v. Highlight the implications of technological development.
vi. Distinguish between science and technology

Introduction

The concepts of science and technology often go hand in hand. In this unit, we explain the differences between the two despite their closeness.. In module One, Unit One, we defined science, and in Module Four, we shall define technology. We shall also discuss the impact of science and technology in some major spheres or aspects of human life.

4.1.1 What is Technology?

Technology is defined as "systematic knowledge of industrial art", while others define it as "technical method for achieving a particular purpose". There are, for example, agricultural technology, medical technologies, space technology, ground water technology, irrigation, and the like. Technology means those activities which produce improvement in the material world in order to satisfy human needs. With the help of technology, man should be able to increase food production, harness new sources of energy and improve methods of communication and so on.

In order to understand the meaning of technology, it is necessary to make a preliminary distinction between pure science, applied science or technology. (See Module one, Unit 1 for the definition and classification of science). By pure science is meant a method of investigation in an attempt to satisfy the need to know. It does not concern itself with practical applications. By applied science is meant the use of pure science for some practical purpose. Applied science is application-oriented, but it cannot exist without the pure science. Applied science can provide stimulation for discovery in pure science. The actual distinction between pure and applied science is just the application; otherwise there is no difference between them.

The distinction between pure science, applied science and technology becomes clearer from the example that follows in connection with the American moon landing programme. First, there was the need to know the scientific facts about the laws of the nature, that is gravitation and moon's orbit around the earth. These are purely scientific knowledge (pure science). Next a practical theory is constructed about the space ship, trajectories, rocket size, fuel requirement, etc. This is applied science. Finally, there was the task of construction of the rocket using appropriate material that would actually land on the moon. This part is technology. The moon programme was described by many observers as a technological breakthrough and not scientific breakthrough.

4.1.2 Differences between Science and Technology

There are certain features that differentiate between science and technology. Below are some of the major distinctions.

Time Lag:

Usually, there could be a time lag between the discovery of a theory (pure science) and its application to a practical problem (applied science). For example, Isaac Newton discovered the Law of Gravity in 1687, but it was only around the early eighteenth century that airplane, using the idea of gravity was experimented upon. Can you think of any other example of time lag between a scientific idea and a technology produced as a result? It is worth noting here that time lag affects modern science and technology. There are a group of ancient technologies that have been developed without following the modern scientific method of doing things. For instance, technologies in agriculture, like irrigation, farm implements like hoe etc., were developed by people to solve practical problems through non-scientific ways.

Satisfaction of Practical Needs:

Technology, as mentioned, is concerned with satisfying practical human needs. It must make a device or a process or a system. Sometimes, misunderstanding may result in distinguishing between applied science and technology. Applied science is concerned with the task of discovering applications for pure theory. Technology is more apt to developing empirical laws than theoretical laws. Often, trials and errors or skilled approaches derived from long-term experience are employed by technologists.

Earlier History:

Historically, technology came long before science; it began with early man who needed food, drink, warmth, shelter, clothing, etc. Food gathering was the main occupation of the early man, which consisted of mainly hunting games and gathering of wild fruit and vegetables. Later, man learned to live in groups or societies. In that process, he had to domesticate animal and start farming for raising food production. Various farming tools, although in crude forms, were invented, and irrigation techniques were devised. Technology continued to develop purely to meet human practical needs. Technological development has been rapid during the twentieth century because of the discovery and subsequent usage of fossil fuels and the energy converters such as heat engines.

Impetus for Science:

Technology has long been an aid in providing impetus for pure and applied science. For example, Carnot's law of thermodynamics was a result to improve the efficiency of steam and other heat engines. This resulted in air pollution. The pollution led a number of physical chemists to investigate the properties of extreme dilution which led to some other discoveries.

The line of distinction between application of the theories of pure science, and technology is very thin. According to modern concept of technology, pure science, applied science and technology are all interdependent. Pure and applied sciences have numerous contributions to the progress of technology which has greatly altered our social structure. Modern technology education encompasses knowledge of both pure and applied science as well technical skills.

Technology, therefore, can be viewed as the making of things with or without the knowledge of science.

4.1.3 Impact of Science and Technology on Various Aspects of People's Lives

It has been noted earlier that the line of distinction between science and technology is rather thin because both are interdependent and overlapping. Each has contributed to the development of the other. Both science and technology are jointly responsible for the material progress man has achieved so far. Technical advances have been made in the areas of agriculture, engineering and medicine, among many others. Most of the advances are vividly noticeable in the so-called industrialized countries. The impacts of science and technology on human life can be seen from the following areas:

Food Production:

Although on global scale food production may not seem sufficient to feed every living human being, it has been possible to raise agriculture production per unit of farming land through the use of chemical compounds and machineries. Artificially produced fertilizers improve nutritive values of farm land, soil which can yield more crops than it would otherwise have done. Chemical compounds can be used to control weeds and pests which are harmful to crops production.

Machineries have been used to improve the efficiency of farming operations during the critical period of seeding and harvesting. Irrigation technology has made it possible to produce extra crops during the non-rainy seasons. Better and efficient methods of food processing, storage and distribution have been developed. Technology has made it possible to produce synthetic foodstuffs for human and animal consumption. All these are some of the examples of technological contributions to agriculture.

Housing:

Progress in various branches of engineering has been quite remarkable. Man is now able to live comfortably in houses to protect him against adverse climatic conditions. Air-conditioning devices have added to the comfort of living of man. Multi–storey buildings or skyscrapers have made it possible to lessen space shortages in cities and towns.

Transport:

Developments of vehicles, such as motor cars, ships and planes, have made it easy to transport people and goods by land, sea and air. Man has been able to explore outer space by the use of spaceships such as rockets; man has actually been able to land on the surface of the moon and return safely to earth.

Communication:

Remarkable progress in the field of telephone radio, television, computer and many other microelectronic devices have made it possible to transmit, store and display information on health, education, entertainment and business. Technology has also contributed in harnessing energy sources as well as developing new materials for use by man.

Medicine/Health:

Science and Technology have made significant contribution in the areas of medicine and health care. It has been possible to manufacture a wide range of drugs in large quantities which can be used in the treatment of patients all over the world. Certain deadly diseases, such as small pox, cholera, etc., have been either partially or completely eradicated. Scientific instruments such as electron microscope, X-ray, scanning machines have provided better understanding into the nature of diseases and their possible cure. It is due to technological developments that complicated surgical operation such as heart transplanting has been made possible. Although technology has so far made significant contribution in improving the living standard of man, more is still required even by the reason of rising tide and complex dimension of emerging 'new' diseases.

4.1.4 Conclusion

In conclusion, we can observe that there is a strong interrelationship between science and technology. We can also understand from this that the value of science and technology to human life is enormous if one looks at the wide areas of life which technology affects. From your understanding based on this unit 4.1, is there any sphere of life which technology has not affected? Log on to your facebook and let us discuss this on our facebook group.

Summary

In this unit, the concept of technology is clarified with two definitions. The two definitions emphasise that technology is concerned with the use of knowledge for practical purposes. The unit also explains the distinction between science and technology which are; time lag, satisfaction of practical needs, technology coming earlier than science historically, and technology as impetus for further scientific discoveries. The unit also discusses the impact of science and technology on some key areas.

Unit 4.2: Issues on Technological Development for Developing Countries

In this unit, the following will be focused upon:

- Intermediate and modern technology,
- Transfer of technology for development,
- The role of foreign aid technological development,
- Challenges of science and technology.

Objectives

It is envisaged that after going through this unit, you should be able to:-

i. Explain the concept of intermediate and appropriate technology
ii. Explain the meaning and mode of transfer of technology.
iii. Analyze the role of foreign aid in technological development.
iv. List and explain the social consequence of technological development.
v. Explain the challenges of technological development

Introduction

In this unit, the various ways in which technology is used by society is discussed. Technology is of different grades, ranging from complex, intermediate to the simple. This unit examines the importance of intermediate technology to developing countries; how technologies are transferred from technologically advanced societies to less technologically advanced societies; social consequences of technology as well as challenges of technological development.

4.2.1 Concept of intermediate or appropriate technology:

It has been noted earlier that technology has helped to shape human society through various developments in agriculture, engineering and medicine. Most of the advancements in technology have taken place in the so-called industrialised countries (Europe and America) even though there are some countries outside the industrialised ones which are now advancing technologically (like China, Brazil, Malaysia, etc). The great majority of the nations are relatively under-developed, industrially and economically. These countries are now known as developing countries.

In the effort to improve economic conditions of the develo1ping countries through technological means, the question came-up whether modern technology is suitable or not, for them. It is said that the modern technology is expensive and that the developing countries are therefore unable to generate financial resources, educational and economic infrastructures for building up their modern industrial sectors to the size that would solve development problems of the whole populations. Modern technologies are not only expensive, but require extensive knowledge of science and technology (which is difficult to acquire), such as big industrial complexes, and extensive infrastructure, among others. Therefore, due to these requirements of modern technologies, many analysts are of the view that countries can adopt intermediate or appropriate technologies.

Intermediate technologies which overcome the drawbacks of modern technology are used in developing countries. Another name for intermediate technology is “low cost technology”. By intermediate technology, it is assumed that the technology is not as sophisticated as the modern technology but functional (see, for instance, the gym bicycle in fig 2 which also doubles as grinder: an intermediate technology). The products of intermediate technology are cheaper because of lower manufacturing cost through the use of local raw materials and semi-skilled mechanics and technicians. This type of technology is suitable for food processing and production of fabric and agricultural implements for local consumption. The products of intermediate technology may not compete well with those of modern technology; but that could be useful to developing nations.

Fig. 1 An example of intermediate technology: Gym bicycle which also doubles as grinding machine

However, the use of intermediate or appropriate technology should not mean that developing countries are abandoning modern technology which is still the cheapest and most efficient way of producing large quantity of good quality products demanded by the market. Modern technology must and will continue, and it cannot be replaced by appropriate technology. Intermediate technology is a complement to modern technology, and both should exist side by side in the same society.

4.2.2 Transfer of Technology for Development

Since technological progress is seen as the route for economic development, it is felt that the economic gap between the developed and developing nations can be narrowed by enabling developing nations to progress technologically. Therefore, transfer of technology is identified as one of the ways to do that. It is observed that multinational firms and foreign investors who own patents and technical skills have not been particularly helpful because of the profit maximization motive of the investors and the sale of luxurious products which are not what developing societies need. The motive is in conflict with that of the developing countries which want foreign investors to provide technical assistance which will promote long term, self-sustained economic and social developments. One of the ways to aid developing countries in technological process is transfer of technology. Transfer of technology is defined as the process in which knowledge, skills, technologies, methods of manufacturing, samples, facilities, and development ideas are transferred to wide range of users like individuals, companies, government agencies, educational institutions, etc for further exploitation into new products, processes, applications, or services.

There are two aspects of technology, namely, material aspect and non-material aspect. They are often known as "Hardware" and Software". Hardware comprises machines, tools, products, workshop, etc, while software consists of organizational know-how, information network, policies, institutions, management, structures, marketing and distribution infrastructures. Only the hardware can be transferred from the developed to developing country, but software cannot be transferred. Software is location specific, and it must be developed on site.

Transfer of technology automatically implies the existence of a donor and a recipient country and also the question of assimilation by the recipient country. The developed countries are, of course, the donors and the recipient countries; both have to protect their interests. In any case the donor has to make sure that transfer of technology does not make it lose its markets. The capacity to assimilate technology depends on the technological know-how and availability of skilled operations in the developing countries, and it must be considered before actual transfer of technology takes place. Otherwise, whatever hardware is transferred will not achieve the objectives of the task.

Some scholars have argued that the best way to achieve technological progress in developing countries is through technical education and training, and adoption of the policy of self-reliance or "do-it-yourself".

4.2.3 The Role of Foreign Aid in Technological Development

To finance economic and social development, the developing countries may need foreign resources. The developed countries like the United States of America, Europe and Japan have been giving foreign aid to developing countries. It takes the form of educational grants, special interest loans and technical assistance. Technical assistance also takes the form of services, such as school or on-the-job training, medical teaching, scholarships, surveys, advising, research, etc. This aid is often facilitated by international organisations like International Monetary Fund, World Bank, and others. In some areas, foreign aid has been found to be useful technology to receiving countries.

However, foreign aid has not always produced desired effects of economic developments in the recipient countries. Some of the undesired effects of foreign aid include:

1. At the time of receiving aid, the recipient countries tend to ignore that interests have to be paid and that the debt-servicing cost would be very high.

2. The aid might be used for prestigious but unproductive projects leading to economic catastrophe.

3. In an attempt to protect its own interest, the aid-giving country may give tie-in loans which make provision for spending the money back in the donor country, even though goods may be obtained at a cheaper rate elsewhere, technicians and even managers of the donor country must be employed by the recipient country.

4. In many instances, foreign aid could take the form of non-economic (most military) assistance to friendly government.

5. It has often made the poor country poorer and very dependent on the donor country.

6. Aid has been responsible, in some cases, for destroying the 'self-help' attitude of recipient countries.

4.2.4 Challenges of Science and Technology

As mentioned earlier, human history has been the story of technological change. The future history is also likely to be dominated by technological developments. Historically, there have been two major technological revolutions, namely, agriculture and industrial revolution. Agriculture revolution began some ten thousand years ago in the River Nile Valley, and it spreads all over the world and it is still continuing. Industrial revolution is relatively recent; it began some two hundred years ago in Europe. It is also spreading all over the world. It is expected that the industrial revolution shall spread relatively quickly, and it has enveloped countries of Asia – the so-called 'Asian Tigers'. Some of the challenges and prospects of science and technology include:

Overpopulation:

Technological improvement in medicine, food, environment and other spheres has enabled people to live healthy lives with higher life expectancy in modern times. As a result, the population of the world is constantly increasing leading to overpopulation in many areas. Science and technology's answer to this problem is the inhibition of population growth by some artificial means. However, there is vehement opposition from the religious bodies and others all over the world, who put forward the argument that given proper attitude and cooperation, the world resources are sufficient to support a population far as it exists now.

Food supply:

The problem of food supply is related to the problem of population growth. Technology should play a decisive role in solving the problem of food production. The developing countries must improve their own agricultural sectors through proper management of agricultural technology. At the same time advanced concept in agriculture such as 'nutrient film technique' food growth plants without soil under either partially or fully controlled conditions. Food may also be produced unconventionally in factories and the cost of such food is expected to be much less than that produced by conventional agriculture. It is likely that palatable nutrition food can be mass produced, with the aid of advances in cellulose, petroleum, agricultural wastes, etc. There are already efforts under way to produce single cell protein containing all essential amino acids. Given proper cooperation and political stability, the prospects for food production by developing countries look good. This is not to discount the health implications of such products coming from artificially induced methods.

Energy:

Technological development will be decided on time availability of energy and type of energy. There is already some concern over the possible near term shortage of energy supply as the fossil fuel is seen to be depleted. Two most promising sources of energy are solar and nuclear. Development of both of these energy sources will require new scientific and technological innovations. Solar energy is too dilute, while nuclear energy is too concentrated to be used directly in conventional machineries. Solar energy appears to be inexhaustible. It is expected that with further technological advancement, many developing countries will take advantages of these energy forms.

Raw Materials:

Supply of raw materials for industrial uses has been a serious problem so far. It will be necessary to look for industrial raw materials in the sea beds, which have not so far been exploited. Also, technologies should be developed such that raw materials can be recycled, in which case there will not be any shortage. With the use of nuclear, high temperature energy, it is possible to recycle industrial raw materials.

Pollution:

Although technology has helped to solve many problems, some other problems have also been created. Among these is the environmental pollution caused by emission from motor cars, toxic chemicals and radio-active wastes dumped by industries. It shall be necessary to develop technologies to take antipollution measures. There is already a growing concern in the environmentalist circle for protection of the environment from pollution from industries. It shall be necessary to develop technologies to control pollutions from industrial waste.

4.2.5 Conclusion

Some of the basic problems mentioned above need to be solved urgently if mankind is to survive. Proper solutions to the problems are expected to come from technological responses and developments. Increasingly, other dimensions are emerging with respect to technological development, such as man's state of anxiety arising from fear of global holocaust coming from abuse of nuclear power. There is also the outstanding issue of ozone layer depletion (green house effect) and the attendant consequences of global warming and loss of immunities by man.

Self Assessment Question No.5

1. What is the relationship between science and technology?
2. What are the challenges to technological development?
3. List the role of foreign aid in technological development.

Further Readings

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Module Five: Natural Resources

Unit 5.1: Natural Resources and their categories

In this unit, the following will be focused upon:

- Definition and explanation of natural resources
- Factors that determine the availability/scarcity of natural resources.
- Classification of natural resources

Objectives

It is envisaged that after going through this module, you should be able to:-

i. Define and explain the meaning of natural resources
ii. Appreciate the value of natural resources to the lives of people.
iii. Classify natural resources using five different criteria

Introduction

Human beings cannot live without natural resources as they are essential to life because it is from them that food, clothing, shelter and other essential and non-essential things are generated. However, natural resources are of different types, and the availability varies across space and time. This unit, therefore, explains the meaning, the availability and classification of natural resources.

5.1.1 Definition of Natural Resources

Resources, in general sense, refer to all living and non-living endowments of the earth, including human beings. Others define resources as anything mental or material single or compound, living or dead, extractable or non-extractable, on the surface or in the atmosphere or space, on the earth or other planet which can directly or indirectly be or become useful to man within the level of his technology or skills. A different definition of resources is anything with potential use in creating wealth or giving satisfaction. These definitions of resources have a lot in common; generally, all definitions of resources are human-centered since it is human value system and technological know-how that give roles and socio-economic values to the materials defined as resources.

The quality of the definitions of resources is both in spatial (related to space/location) and temporal context (relating to time); the spatial dimension to the definition of resources stems from the fact that resources are not evenly distributed on the earth surface; some areas are abundantly endowed with a particular resource, while other areas are less endowed. In areas abundantly endowed, the resources may have a diminished value compared to less endowed areas. The temporal context of the definition of resources is in the changing value of material over time. For instance, coal used to be an important energy resource in colonial Nigeria, but development in the petroleum and hydro-electric power generation has reduced the value and dependence on coal as source of energy.

5.1.2 Factors that Affect the Availability and Scarcity of Natural Resources

One other important attribute of resource is its availability/scarcity, which is a function of wide range of factors which include the following:

Physical factors:

Geology, for instance, may be a determinant of the occurrence and abundance of some mineral resources.

Cultural factors:

This may include the tastes and values of a community as they change over space and time.

Social change:

Changes in social roles and functions within society; for instance, the changing role of women.

Technology:

The ability to make use of certain environmental elements may vary with technology; for instance, the mining and usage of certain minerals.

Economic factors:

Price and market demand and supply.

People's view of nature:

Eco-centric or Techno-centric views.

The relative availability and scarcity of resources makes the sustainable management and conservation of resources essential. Thus, the major goal of sustainable management and resources conservation is to ensure a sustained production of flow resources and the preservation of stock resources.

5.1.3 Classification of Natural Resources

There are numerous ways of classifying or categorizing natural resources. Each classification emphasises some aspects different from another classification. Thus, natural resources are classified based on a wide range of criteria, such as

A. Renewability,
B. Origin of Resources,
C. Stages of Development, and
D. Ownership.

Renewability

Renewable resources, as the name implies, means resources that can be replaced even after they have been used. On the basis of renewability, resources can be categorized into:

1. ***Renewable resources or Flow resources***: These are resources that can be replaced or replenished after its usage; for example, forest or vegetal resources, fishery, wind (see Fig. 3), etc. These types of resources, after their depletion, can be replaced within a human time frame. Energy resources are not all unlimited in supply. Some are renewable, and others are non-renewable. Renewable resources are the type of resources that are less or not affected by how much quantity of it is being consumed because they are quickly replenished; for instance, solar, wind, geothermal and hydroelectric energy.

2. ***Non-renewable resources or Stock resources***: These are resources that cannot be replenished once depleted. Their cycle of regeneration takes a very long time that exceeds the human time frame (million(s) or billion(s) of years). Non-renewables are finite and can eventually be exhausted due to the fact that their formation rates are infinitesimal (they can take millions of years to form), and, unfortunately, the rate at which it is consumed is greater than the rate at which it is replaced,; for example,

fossil fuel, nuclear. Resources in this category include mainly mineral resources and fossil fuels, such as coal and petroleum.

3. ***Perpetual resources***: These are resources that are of continued supply in the environment; their quantity is not affected by human consumption; examples of resources in this category include sunlight, air, etc.

Fig. 2 showing a wind mill utilising wind as a renewable resource

Origin

Origin of resources means the concern with the sources from which resources are generated. On the basis of origin, resources can be classified into:-

1. ***Biotic resources:*** These are resources obtained from the biosphere, and they include flora (plants) and fauna (animal) population (see fig. 4), aquatic organisms and minerals formed from the remains of once living organism, such as coal, petroleum and limestone.

2. ***Non-biotic resources****:* These are resources derived from non-living components of the environment. Resources in this category include metallic minerals, such as iron, gold, copper, etc; land and atmospheric resources (air).

Fig. 3 Cows and plants are examples of biotic resources

Stages of Development

On the basis of stages of development, resources can be categorized as:

1. ***Potential resources***: These are resources that are not actually exploited, but their existence in a particular region is established; for instance, . the availability of petroleum in the Chad basin, until it is actually drilled out and put to use, it remains a potential resource.

2. ***Actual resources***: These are resources whose quality and quantity are determined, and the resources are fully exploited and put to use; for example, the exploitation of petroleum in the Niger Delta region of Nigeria.

3. ***Stock and reserved resources***: These are resources whose existence is established, but there is no technology or immediate need to enable or warrant their full development ; for instance, the radioactive elements discovered in some parts of Nigeria and Niger Republic which can be used to generate nuclear energy. It is a valuable resource, but Nigeria and Niger Republic do not have the technology to develop the resources. Reserved resources are resources that are yet untapped and are preserved for future use.

Distribution

By distribution of resource, it means there is a concern as to where the resources are found. Based on distribution, resources can be categorized into:

1. ***Ubiquitous resources****:* These are resources found everywhere; examples include water, air and solar radiation.

2. ***Localized resources****:* These include mainly mineral resources, forest gallery and landscape that support the utilization of associated resources, such as water fall for hydro-electricity generation.

Ownership

Based on Ownership, resources can be categorized into:

1. ***Individual resources*:** These are resources personally owned by individuals; they have exclusive right to access and use the resources. Examples of these include land, orchard, etc.

2. ***Communal or National resources***: These are resources collectively owned by a community or nation whose access and utilization are regulated or restricted. Examples of resources in this category are the National Parks (Yankari, Gashaka-Gumti and Kainji Parks, etc.), Grazing and Forest Reserves, etc.

3. ***International resources*:** These are resources shared by two or more countries; examples of these resources include the Chad Basin and Rivers Benue and Niger. Resources in these basin and rivers are shared amongst Nigeria and other countries along the bank of the water (Chad, Niger, Cameroun and Central African Republic in the case of Chad Basin. Cameroon (river Benue), Niger and Mali, in the case of Niger.

Summary

In this unit, natural resources are defined with examples. All the two definitions of natural resources emphasise usefulness of resources to man. The unit also discusses factors that affect the availability of natural resources which are physical factors, cultural factors, social change, technology, economic factors, and people's view. The unit also discusses natural resources and their classifications. The categories are based on renewability, origin, stage of development, distribution and ownership.

5.1.4 Conclusion

Finally, there exist wide disparities on perception of resource; these disparities are, for instance, discernible amongst various economic groups and civilizations (Level of economic and technological development). Nomadic herdsmen, for example, regard the Savannah Grasslands as pasture resources for their herds, while farmers regard the grassland as weeds to be eliminated for farm expansion. An analysis of perception of resources from civilization viewpoint can also be seen in energy resource, whereas developing countries regard biomass as a major source of household energy developed countries preserve the biomass for its aesthetic value.

Resources are themselves components of the geophysical system of the environment; therefore, their finiteness and pattern of distribution make resources conservation very important, especially in ecologically fragile lands. Mismanagement /misuse or abuse of resources will result in chain repercussions with deleterious consequence for human economic interest.

Further Readings

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Follow these links to access more sources on natural resources:

http://practicalaction.org/video/category/Energy/

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Self Assessment Question No.6:

1. List and explain the various classifications of natural resources.

Module Six: Man and his Energy Resources

Unit 6.1: Energy Resources

Unit 6.2: Power Generation and the Environment

Unit 6.1: Man and his Energy Resources

In this unit, the following will be focused upon:

- Definition and explanation of energy resources
- Sources of energy resources.

Learning Outcomes for Unit 6.1

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

i. List sources of energy

ii. Define the meaning of energy resources

Introduction

In this unit, the various sources of energy will be explained. The explanation starts from the early sources of energy used by name up to modern time. Also, in this unit, the term energy will be defined.

6.1.1 Availability of Energy

The sun, after its creation, stood as the first energy source to man. It provided light and heat. The day light was used to search for food. The fire put to start by struck of lightning provided light for vision at night, thermal energy for cooking and making of tools for hunting, and to some extent protection from cold and dangerous animals while in the cave.

The sun and the woods gave man energy for a long time until about 5,000 years ago that people started using other sources of energy. People began using the wind to move from one place to another. They built boats with sails that captured the wind, and they could travel to new places. Wind was the first energy source used for transportation. About 2,500 years ago, people began using windmills and water wheels to grind grain. Later, these simple machines were used to pump water and run sawmills. Oil and coal were discovered and provided alternatives for fuel wood. It also assisted in powering trains and boats. But until 150 years ago, the sun and wood provided most of the energy. As communities began to grow more and more sources of energy were needed. Natural gas and oil were later discovered and used to generate electricity -the most desired of all forms of energy. Do you know the source of public electricity used in your village, town or city? It can be from any of the above sources.

ITQ1. List the sources of energy?

A. They are the sun, woods, coal, oil and gas, natural gas, wind, biomass, geothermal, hydro energy, wind, nuclear, solar, waves and tides. They provide energy for human beings.

Now that we have identified the sources of energy, we will now go ahead to explain what energy is. **Energy** is the capacity or ability to perform or do work. It cannot be created nor destroyed, but it can be transformed from one form to another: mechanical, light, chemical, heat, electrical, sound and nuclear energy. There are many sources of energy. The most commonly used energy resources are: fossil fuels (like petroleum), biomass, geothermal, hydro energy, wind, nuclear, solar, waves and tides. Energy resources are not all unlimited in supply. Some are renewable, and others are nonrenewable (see module 5.2).

ITQ2. What is Energy?

A. Energy is the ability or capacity to work. Energy cannot be created or destroyed but can be transformed from one form to another. Forms of energy include mechanical, light, chemical, heat, electrical, sound and nuclear.

6.1.2 Conclusion

Energy as we have seen in the explanation here is the ability to perform or work. People in order to be able to do various types of work use different sources to generate their energy.

Unit 6.2: Energy Generation and the Environment

In this unit, the following will be focused upon:

- Various forms of energy resources
- Problems of generating energy resources.
- Renewable and non-renewable sources of energy

Learning outcome for Unit 6.2:

It is envisaged that after going through this unit, you should be able to:-

i. Explain the various forms of energy resources

ii. Identify problems of generating conventional and modern energy resources

Introduction

For human being to do any work, energy must be expended. That also applies to communities or societies at large. This unit is concerned with explaining the numerous forms of energy that are available to the society. However, each form of energy has its own advantages and disadvantages for which choices have to be made.

6.2.1 Energy Generation and the Environment

In modern society, most of man's energy needs are satisfied through the conversion of electrical energy into the useful forms desired (light, sound, heat and mechanical). The task, therefore, is acquiring the technology (through research and development) of converting the available sources of energy into electricity. Making electricity available is, to some extent, equivalent to making the other useful forms of energy available. Conventionally, fossil fuels, waterfalls and thermal reactors have been used.

However, the methods of generating electricity are not without associated environmental problems. Burning fossil fuels releases dangerous pollutants (sulfur dioxide, sulfur trioxide, carbon monoxide, nitrogen oxides, carbon dioxide and particulate matters) into the atmosphere. Apart from causing health problems, the carbon dioxide sets up greenhouse in lower atmosphere causing its temperature to increase (which leads to global warming) which in turn causes environment problems like heat waves, melting of ice caps and eventually causes flooding, etc. Some other pollutants deplete the ozone layers that protect us from the burning effect of ultraviolet radiation. On the other hand, collapsed dams and nuclear explosion can be highly catastrophic; they can kill people and wipe away close settlements. This means that these sources of energy may not be clean and may not be environmentally friendly. Moreover, sources like nuclear and fossil fuels are themselves exhaustible (they can finish one day). Renewable energy (energy that cannot finish and can be created again) alternatives are, therefore, a necessity because of the declining interest in the use of these conventional and non-renewable energy sources. Hydropower is conventional, though renewable, but its large-scale use has become increasingly difficult to achieve in recent years because of the competing use of land and water (for example, to restore wildlife habitats). The use of fossil fuels, on the other hand, is much more developed and accepted in society, but have some disadvantage like pollution, even though it is widely used.

ITQ1. What is renewable energy?

ANS. Renewable energy is energy that cannot finish and can be created again. For example, renewable energy include hydroelectric dam, solar, wind, bio-fuels, etc

Wind and solar energy are, for instance, sources that have a wide geographical spread and could be harnessed near the load centers without the need of high-voltage transmission lines running through rural and urban landscapes. Renewable energy sources are clean because they do not generate tons of carbon-dioxides, sulfur oxides and nitrogen oxides which are harmful to the environment. Because of their cleanliness and friendly nature, some countries in Europe, Asia and America have already put in use these methods of generating electricity.

Another form of renewable energy resource is the biomass. Biomass produces bio-fuels like bio-gas, ethanol, methanol and bio-diesel. Bio-fuels are liquid or gaseous fuels that are derived either from agricultural/municipal wastes or from energy crops like sugar beet, wheat, maize, rapeseed and sunflower. Fuels obtained from biomass can be used to generate electricity. Biogas can be used as heat source for the boiler of conventional steam turbine. Electricity can also be generated from woody biomass by gasification of the biomass and the use of process heat captured in steam turbines. The gasification process is similar to coal or oil shale gasification where the solid is converted by heat and pressure to a gas which is then used to generate electricity.

ITQ: What are some of the problems that are associated with energy production?

ANS: Some of the problems associated with energy production are: (1) release of dangerous gasses in the atmosphere as a result of burning oils (fossil fuels); (2) collapsed dams or over-flooded dams will cause damages to farms, settlements and threaten lives, (3)nuclear accident can lead to loss of lives and diseases; (4) bio-fuel can lead to shortage of food for people.

On the other hand, the production of methanol, ethanol and bio-diesel from energy crops as fuels in the name of environmentally friendly source of energy will, of course, be a threat to human food security as more and more grains and vegetable oil which should have been used for food are being turned into bio-fuels for transportation. It is still argued whether the current process for producing bio-fuels actually produces more carbon dioxide than the resultant bio-fuels saved. Turning food into bio-fuels may even be worse for the climate than using petrol or diesel. This is because more land, including forests and grasslands, has to be cleared and the process of which releases vast amounts of carbon dioxide into the atmosphere, and because more fertilizers have to be used for large-scale production of these crops, it also means more effect on the climate. In fact, agro-based bio-fuels may bring more problems for humanity and the climate. Following the production processes of bio-fuels, it is certain that it may not be cost effective unless, of course, subsidized in all its ramifications.

6.2.2 Conclusion

We have discussed in this unit the various sources of energy, both renewable and non renewable. We have also observed that some energy sources can lead to environmental problems. There is the need for people everywhere to decide how best to satisfy their energy needs and environmental and health concerns.

Self Assessment Question No. 6

1. Define renewable energy and list four examples of renewable sources of energy.
2. Explain three problems associated with energy generation.

Module seven: Chemical and Radio-chemical Hazards

Unit 7.1 Introduction to Various Forms of Hazards

Unit 7.2 Chemical Hazards

Unit 7.3 Radioactive Hazards

Unit 7.1 Introduction to Various Forms of Hazards

In this unit, the following will be focused upon:

- Definition and explanation of hazards
- Classification of hazards
- Examples of hazards

Objectives

It is envisaged that after going through this unit, you should be able to:-

i. Define and explain the meaning of hazards
ii. Classify hazards
iii. Give various examples of hazards

Introduction

Despite scientific and technological achievement of human societies which have made life relatively easier, human beings live with numerous hazards that threaten them. Some hazards are related to human inventions, some to biological matters, and others have to do with the type of work or activities human beings engage themselves in. In this unit, the major forms of hazard affecting the life of people are identified and explained.

7.1.1 Defining Hazard

A hazard is generally anything that can hurt you or make you ill. There are four main types of hazards: physical, biological, ergonomic and chemical.

Physical hazards

are the most common and will be present in most workplaces at one time or another. They include unsafe conditions that can cause injury, illness and death. They are typically easiest to spot, but, sadly, too often overlooked because of familiarity (there are always cords running across the aisles), lack of knowledge (they are not seen as hazards), resistance to spending time or money to make necessary improvements or simply delays in making changes to remove the hazards. Examples include electrical hazards (frayed cords, missing ground pins and improper wiring); unguarded machinery and moving machinery parts; constant loud noise; high exposure to sunlight/ultraviolet rays, heat or cold; working from heights (including ladders, scaffolds, roofs, or any raised work area), etc

Biological hazards

come from working with animals, people or infectious plant materials. Work in day care, hospitals, hotel laundry and room cleaning, laboratories, veterinary offices and nursing homes may expose you to biological hazards. The types of things you may be exposed to include blood or other body fluids, fungi, bacteria, viruses, plants, insect bites, animal and bird droppings.

Ergonomic hazards

occur when the type of work, body position and working conditions put strain on your body. They are the hardest to spot since you don't always immediately notice the strain on your body or the harm these hazards pose. Short-term exposure may result in "sore muscles" the next day or in the days following exposure, but long term exposure can result in serious long-term injuries. Ergonomic hazards include poor lighting, improperly adjusted workstations and chairs, frequent lifting, poor posture, awkward movements (especially if they are repetitive), having to use too much force (especially if you have to do it frequently).

Chemical hazards

are present when a person is exposed to any chemical preparation in the workplace or other places in any form (solid, liquid or gas). Some are safer than others, but to some workers who are more sensitive to chemicals, even common solutions can cause illness, skin irritation or breathing problems. Chemical hazards can come in the form of liquids -like cleaning products, paints, acids, solvents (especially chemicals in an unlabelled container); vapours and fumes (for instance, those that come from welding or exposure to solvents); gases (like acetylene, propane, carbon monoxide and helium); flammable materials (like gasoline, solvents and explosive chemicals).

Summary

In this unit, the concept of hazard is defined as anything that can hurt and make a person ill. The unit provides the classification of hazard as physical, biological, ergonomic, and chemical

7.1.2 Conclusion

Numerous hazards are encountered in the course of life of human beings. Because hazards lead to injuries, there is the need to identify them in order to prevent them.

Self Assessment Question No. 7

1. List the four types of hazards and explain two in detail.

UNIT 7.2 Chemical Hazards

In this unit, the following will be focused upon:

- Definition and explanation of chemical hazard
- Effects of chemical hazards on human beings.
- Causes of chemical hazard
- Type of toxic chemicals

Objectives

It is envisaged that after going through this unit, you should be able to:-

i. Define and explain the meaning of chemical hazard
ii. Explain the causes of chemical hazard
iii. Classify toxic chemicals.

Introduction

Earlier, in unit 7.1, we defined hazard and explained the various classification of hazard. One of the hazards we read about is chemical hazard. In this unit, additional explanation of human exposure to chemicals is provided. The unit also provides explanation on how chemicals enter the body and in what form. The elaboration on chemical hazard is because of the widespread use and availability of chemicals in recent time.

7.2.1 Human Exposure to Chemicals

Chemicals are a part of everyone's life. There are five to seven million different chemicals known in the world. At least 400 million tons of chemicals are produced worldwide each year, including agricultural chemicals, food additives, pharmaceuticals, fuels for power production, chemical consumer products, etc. In North America, alone, at least 1,200 new chemicals are produced.

The frightening reality is that, for the vast majority of the chemicals used and being developed, little or nothing is known about their possible immediate or long-term effects on the health of the workers who produce them or use them at work. Yet workers continue to be required to work with potentially toxic (poisonous or harmful to the worker) substances. In some countries, workers are required to work — with little or no protection — with chemicals that are known to be hazardous to human health.

Workers in some developing countries are often required to work with toxic chemicals that have been banned in developed countries because of their hazardous effects. Similarly, agriculture workers in developing countries (and in non-union agriculture jobs in some developed countries) often spray herbicides and pesticides without any form of protection. In most developed countries, workers using these same chemicals dress up almost like spacemen in protective clothing to avoid contamination from the chemicals, and are provided with washing facilities and regular medical check-ups.

In many countries, chemicals are literally dumped into the environment, often with serious human and environmental consequences. Depending on the chemicals dumped, the results can be serious health problems for the workers (who usually do not know about the dangers from the chemicals) and the community, and permanent damage to the environment. In other countries, the laws about chemical disposal are strict in order to protect people and the environment.

Nearly all workers today are exposed to some sorts of chemical hazard because chemicals are used in every type of industry, from mining, welding, mechanics and factory work, to office work, etc. In fact, chemical hazards are the most serious health hazards for workers today. Your first line of defence against chemicals is to learn as much as possible about the substances you work with and to prevent exposure to them, no matter how "safe" you may think they are, or how "safe" you have been told they are!

7.2.2 How Toxic Chemicals Enter the Body

There are a variety of chemicals that are commonly used in various industries, homes, schools, hospitals, etc. Due to human error, accidents or poor handling chemicals can enter the body (routes of entry) in the following ways:

1. Inhalation through the lungs;
2. Absorption through the skin;
3. Ingestion through the mouth.

Once toxic chemicals get into the body, they can cause a variety of harmful effects, including immediate (acute) effects or long-term (chronic) effects which may not show up for a number of years after the exposure occurred. Toxic chemicals can also produce local and systemic effects, depending on the nature of the chemical and the route of exposure.

7.2.3 Effects of toxic chemicals

There are a number of factors that determine the type of toxic effect a chemical can have on human beings. These factors include:

1. The chemical composition of the hazardous substance (certain substances are more harmful than others because of their chemical structure);
2. The physical form of the chemical (dust, vapour, liquid, etc.);
3. The route of entry by which the chemical gets into the body (chemicals have different routes of entry. Some chemicals can enter the body in more than one way. Different health effects can occur depending on the route of entry);
4. The particular tissues and organs in which the chemical collects or localizes;
5. The frequency, concentration, and length of exposure; and
6. The worker's individual response to the chemical, which can vary a great deal from person to person.

The following figures help to explain how chemicals can enter the body and the effects they can have once they are in the body.

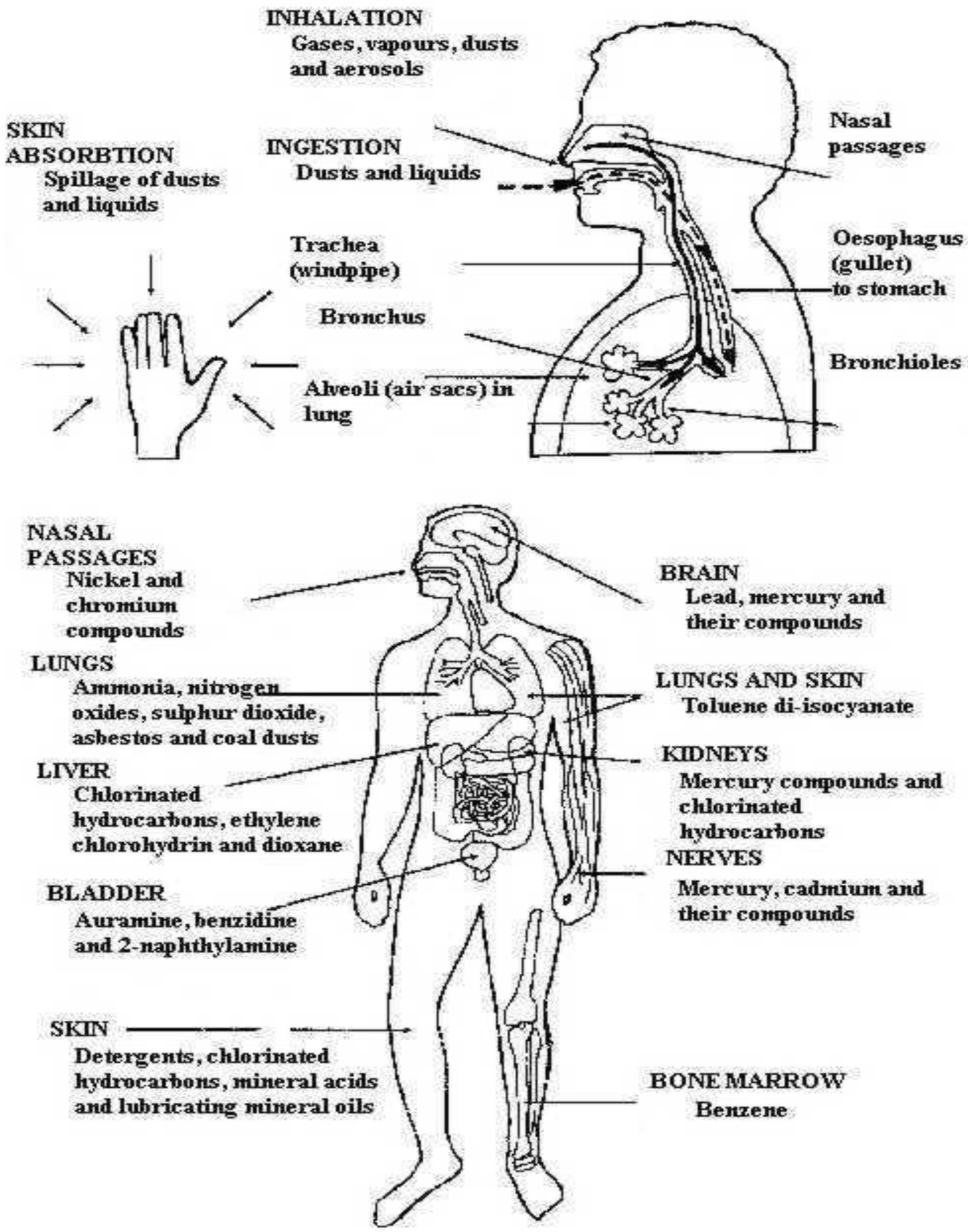

Fig.4 On top of the figure you can see the routes of entry of chemicals into the human body; skin, inhalation and ingestion. Below it are the organs and tissues that may be affected by particular toxic industrial chemicals: nasal, lungs, liver, bladder, skin, brain, skin, kidney, nerves and bone marrow

It is important to understand that workers may show different physiological responses to industrial chemicals, just as people may show varied responses to different medicines, foods, etc. Some employers may try to select workers who are more “resistant to hazards” (so-called “superworkers”) and remove workers who show any signs of poor health. It is also common for employers to refuse to employ women of childbearing age on work processes that are known to affect the development of the foetus in the womb (such as work involving lead).

7.2.4 Forms of Toxic Chemicals

The physical form of a chemical can affect how it enters the body and, to some extent, the damage it causes. The main physical forms of chemicals are solids, dusts, liquids, vapours and gases.

A. Solids

- Solids are the least likely of the chemical forms to cause chemical poisoning. However, certain chemical solids can cause poisoning if they get onto your skin or food and you then ingest them. Personal hygiene is important to prevent the ingestion of chemical solids.
- The greatest danger with solids is that some work processes can change them into a more dangerous form. For example, wood that is being cut can turn into wood dust which can then be inhaled. Welding rods can decompose into fumes and gases. Polyurethane foam is safe in its normal solid form but gives off deadly gases if it burns.
- Chemicals in solid form can give off toxic vapours which can be inhaled, and solids can be flammable and explosive, and corrosive to the skin.
- Effective control measures should be used with chemical solids, particularly during work processes which may change them into more hazardous materials.

B. Dusts

- Dusts are tiny particles of solids.
- You can be exposed to dust in the workplace from materials that normally exist in dust form (for example, bags of cement), or from work processes that create dust (for example, handling glass fibre can produce toxic dust).

- The main danger from harmful dusts is that you can breathe (inhale) them into your lungs. When breathed in, the larger dust particles are usually trapped by hairs and mucus and then removed by the body. Smaller particles, however, are more dangerous because they can get deep inside the lungs where they can have damaging effects, or they can be absorbed into the bloodstream and travel to other parts of the body where they can cause damage. They can also cause eye damage.
- Dusts can be hard to see — you often cannot even see a cloud of tiny dust particles except with special lighting.
- Under certain conditions, dusts can explode. An example of this is an explosion in a grain silo or flour mill.
- Effective control measures should be used to keep dust in the workplace at "safe" levels.

C. Liquids

- Many hazardous substances, such as acids and solvents, are liquids when they are at normal temperature.
- Many liquid chemicals give off vapours which you can inhale and which may be highly toxic, depending on the chemical.
- Liquid chemicals can be absorbed by your skin. Some liquid chemicals may cause immediate skin damage (they may or may not be absorbed into the bloodstream as well). Other liquids pass directly through the skin into the bloodstream, where they can travel to different parts of the body and cause damaging effects.
- Effective control measures should be used with liquid chemicals to eliminate or reduce the possibility of inhalation, skin exposure and eye damage.

D. Vapours

- A vapour is the gas phase of a material which is normally liquid under standard conditions.
- Tiny droplets of liquid which are suspended in the air are called mists.
- Many liquid chemicals evaporate at room temperature, which actually means that they form a vapour and stay in the air.
- The vapours from some chemicals can irritate your eyes and skin.

- There can be a variety of serious health effects from inhaling certain toxic chemical vapours.
- Vapours can be flammable or explosive. To avoid fire or explosion, it is important to keep chemicals that vaporize away from any sparks, sources of ignition or incompatible chemicals.
- Controls should be used to prevent worker exposure to vapours from liquids, solids or other chemical forms.
- Gasoline and water are two examples of liquids which generate vapour under standard conditions.

E. Gases

- Some chemical substances are in the form of a gas when they are at a normal temperature. However, some chemicals in liquid or solid form become gases when they are heated.
- You can detect some gases easily by their colour or smell, but there are other gases that you cannot see or smell at all — you can only detect them with special equipment.
- Gases can be inhaled.
- Some gases produce irritant effects immediately. The health effects of other gases may be noticeable only after your health has already been seriously damaged.
- Gases may be flammable or explosive. Extreme caution should be used when working around flammable or explosive gases.
- Workers should be protected from the potential harmful effects of chemical gases with effective control measures in the workplace.
- Some examples of gases are: nitrogen, nitrogen dioxide, carbon monoxide, carbon dioxide and oxygen.

Summary

In this unit, the various ways in which people are exposed to chemicals are explained. People are exposed to chemicals in various sectors ranging from work place, hospitals, schools or the natural environment. The unit also discusses the effects of toxic chemicals and how chemicals enter the body. Finally, five different forms of toxic chemicals are explained.

7.2.5 Conclusion

It can be observed that people are generally exposed to numerous chemical hazards due to interaction with directly (as workers in chemical sectors) and indirectly (from the environment, schools, hospitals, etc). While it is virtually impossible to absolutely avoid contact with chemicals in modern societies, people should be very cautious so as to minimize injuries as a result of exposure to chemicals.

Self Assessment Question No. 7

1. Explain in your own words how toxic chemicals can enter the human body.
2. List the forms of toxic chemicals we have and explain one in detail

Unit 7.3: Radioactive Hazard

In this unit, the following will be focused upon:

- Definition and explanation of radioactivity
- Types of radioactive decay
- Effects of radioactivity on human beings

Objectives

It is envisaged that after going through this unit, you should be able to:-

i. Define and explain the meaning of radioactivity
ii. Classify radioactive decays
iii. Explain the effects of radioactivity on human health
iv. Give various examples of radioactive decays

Introduction

The creation of huge quantities of long-lived radioactive waste is the most formidable problem facing the nuclear power industry today. The difficulty of waste disposal was not considered to be a big problem during the time when power plants were first introduced; it was assumed that waste could be recycled or buried. Unfortunately, finding safe ways of storing radioactive wastes so that they do not leak radiation into the environment has proved to be a much more difficult task than anticipated.

7.3.1 What is Radioactivity?

Radioactivity is the spontaneous emission of radiation, and radiation is a way in which energy moves from one place to another. Although radiation, if properly harnessed, is useful to human beings (in medicine, communication, electricity, etc), it is also very dangerous to all living things. Radioactivity occurs when unstable nuclei of atoms decay and emit particles. These particles may have high energy and can have bad effects on living tissue.

Radiations are of two types, ionizing and non-ionizing. Non-ionizing radiations affect only those components which absorb them and have low penetrability. Ionizing radiations have high penetration power and cause breakage of macromolecules.

Man-made sources of radiation pollution are mining and refining of plutonium and thorium, production and explosion of nuclear weapons, nuclear power plants and fuels and preparation of radioactive isotopes.

7.3.2 Types of Radioactive Decay

There are three main types of radiation:

Alpha Decay

The reason alpha decay occurs is because the nucleus has too many protons which cause excessive repulsion. In an attempt to reduce the repulsion, a Helium nucleus is emitted. The way it works is that the Helium nuclei are in constant collision with the walls of the nucleus and because of its energy and mass, there exists a nonzero probability of transmission. That is, an alpha particle (Helium nucleus) will tunnel out of the nucleus

Beta Decay

Beta decay occurs when the neutron to proton ratio is too great in the nucleus and causes instability. In basic beta decay, a neutron is turned into a proton and an electron. The electron is then emitted.

There is also **positron emission** when the neutron to proton ratio is too small. A proton turns into a neutron, and a positron and the positron is emitted

The final type of beta decay is known as **electron capture** and also occurs when the neutron to proton ratio in the nucleus is too small. The nucleus captures an electron which basically turns a proton into a neutron.

Gamma Decay

Gamma decay occurs because the nucleus is at too high an energy. The nucleus falls down to a lower energy state and, in the process, emits a high energy photon known as a gamma particle.

7.3.3 Effects of Radiation on Humans

Radiation occurs when unstable nuclei of atoms decay and release particles. When these particles touch various organic materials, such as tissue, damage may occur. Radiation can cause burns, cancers and death.

The unit used to measure radiation dosage is the rem, which stands for roentgen equivalent in man (rem). It represents the amount of radiation needed to produce a particular amount of damage to living tissue. The total dose of rems determines how much harm a person suffers. At Hiroshima and Nagasaki, people received a dose of rems at the instant of the explosions, then more from the surroundings and, in limited areas, from **fallout**. Fallout is composed of radioactive particles that are carried into the upper atmosphere by a nuclear explosion and that eventually fall back to the earth's surface.

Although a dose of just 25 rems causes some detectable changes in blood, doses to near 100 rems usually have no immediate harmful effects. Doses above 100 rems cause the first signs of radiation sickness including:

- nausea
- vomiting
- headache
- some loss of white blood cells

Doses of 300 rems or more cause temporary hair loss, but also more significant internal harm, including damage to nerve cells and the cells that line the digestive tract. Severe loss of white blood cells, which are the body's main defense against infection, makes radiation victims highly vulnerable to diseases. Radiation also reduces production of blood platelets, which aid blood clotting; hence, victims of radiation sickness are also vulnerable to hemorrhaging. Half of all people exposed to 450 rems die, and doses of 800 rems or more are always fatal. Besides the symptoms mentioned above, these people also suffer from fever and diarrhea. Presently, there is no effective treatment; so death occurs within two to fourteen days.

In time, for survivors, diseases such as leukemia (cancer of the blood), lung cancer, thyroid cancer, breast cancer and cancers of other organs can appear due to the radiation received.

7.3.4 Effects of Types of Radiation

1. UV Rays.

Short waves having wavelength 100-300 nm and high energy. UV rays of 260nm wavelength are most effective against DNA. It damages the cells of cornea leading to permanent blindness. It injures cells of germinative layer of skin and produces blisters and reddening of skin (skin cancer). Normally our skin possesses pigmentation to protect against UV rays, but some lack this pigmentation and are more probable cases. This state is called xeroderma pigmentosum. UV rays increase incidences of cancer and mutations in man.

Cosmic rays.

They have radiations less than 0.001Å and high energy sufficient to disintegrate every organic compound on which they fall. But fortunately they are trapped in stratosphere and only a little amount reaches the earth.

Other radiations are X-rays, background radiations from nuclear fallout which have reached to such an extent they have slowed evolution of various organisms on earth.

Effects were noted in 1909 when uranium miners were found to suffer from sun burns and cancer. High altitude plants have developed polyploidy as a protective mechanism against radiations. During a nuclear fallout immediate effect is through isotopic I-131 and Sr-90. Radioactive I-131 gets concentrated in thyroid gland like ordinary iodine (I-127). It causes damage to WBCs, bone marrow, spleen, lymph nodes, etc.

It impairs eyesight and produces sterility, skin cancer and lung tumours. Radioactive Sr-90 is mistaken for calcium and enters bones to cause bone cancer; for instance, Historic examples of heinous nuclear fallout are atomic bomb dropping at Nagasaki and Hiroshima (Japan, 1945)

7.3.5 How nuclear waste enters the body

The planet's water cycle is the main way radiation gets spread about the environment. When radioactive waste mixes with water, it is ferried through this water cycle. Water cycle is the series of movement of water above, on and below the surface of the earth. The water cycle consists of four distinct stages: sorage, evaporation, precipitation and run-off. Radionuclides in water are absorbed by surrounding vegetation and ingested by local marine and animal life.

Radiation can also be in the air and can get deposited on people, plants, animals and soil. People can inhale or ingest radionuclides in air, drinking water or food. Depending on the **half life** of the radiation, it could stay in a person for much longer than a lifetime. The half life is the amount of time it takes for a radioactive material to decay to one half of its original amount. Some materials have half-lives of more than 1,000 years!

Radioactive Hazards come in many different forms including the following:

- protective clothing of people in contact with radioactive materials
- the remains of lab animals used in experiments with radionuclides
- cooling water, used fuel rods and old tools and parts from nuclear power plants
- mill tailings from uranium-enrichment factories
- old medical radiation equipment from hospitals and clinics
- used smoke detectors which contain radioactive americium-241 sensors

Summary

In this unit, the word radioactivity is defined. It is also stated that radioactive decay is divided into three: alpha, beta and gamma. In the unit, also, the effect of two specific types of radiation is explained. Finally, there's an explanation of how nuclear waste enters the body. The water cycle is very influential in the process of how radiation enters the body.

7.3.6 Conclusion

Radioactivity is one of the most dangerous processes to human life on earth. Despite its usefulness in some aspects of life, it needs to be properly handled such that it can be less threat to human existence.

Self Assessment Questions

1. Explain radiation and its effects on human beings.
2. Explain radioactivity and the types of radioactive decays

Module Eights: Environmental Effects of Chemicals, Plastics, Wastes and Other Materials

Unit 8.1 Pollution

Unit 8.2 Environmental Effects of Pollutants

Unit 8.3 Environmental Effects of Plastics and Other Wastes

Unit 8.1 Pollution

In this unit, the following will be focused upon:

- Definition of pollution
- Types of pollution
- Causes of pollution

Objectives

It is envisaged that after going through this module, you should be able to:-

i. Define and explain the meaning of pollution
ii. Classify pollution
iii. Explain the causes of pollution
iv. Give examples of pollution

Introduction

In this unit, pollution is defined, and various forms of it are explained.

Definition of Pollution

Pollution is the introduction of contaminants (substance that does the contamination) into an environment that causes instability, disorder, harm or discomfort to the ecosystem, that is, physical systems or living organisms. Pollution can take the form of chemical substances or energy, such as noise, heat, or light. Pollutants, the elements of pollution, can be foreign substances or energies, or naturally occurring; when naturally occurring, they are considered contaminants when they exceed natural levels. Pollution is often classed as point source or nonpoint source pollution.

8.1.2 Environmental Pollution

Environmental Pollution in broad terms may be defined as an undesirable change in physical, chemical or biological characteristics of air, water and land that may or will harmfully affect human lives, lives of desirable species, living conditions or will deteriorate raw materials resources. Pollutants are substances, chemicals or factors which cause adverse effect on natural quality of any constituent of environment. Pollutions are generally bye products or waste - products. There are nine basic types of environmental pollution, and each one has detrimental effects on wildlife, human habitation and the quality of life in the affected area. They are as follows:

Air Pollution:

Air pollution is defined as any contamination of the atmosphere that disturbs the natural composition and chemistry of the air. This can be in the form of particulate matter such as dust or excessive gases like carbon dioxide or other vapors that cannot be effectively removed through natural cycles, such as the carbon cycle or the nitrogen cycle. Air pollution comes from a wide variety of sources. Some of the most excessive sources include vehicle or manufacturing exhaust, forest fires, volcanic eruptions, dry soil erosion, other natural sources and building construction or demolition, among others

Depending on the concentration of air pollutants, several effects can be noticed. Smog increases; higher rain acidity, crop depletion from inadequate oxygen, higher rates of asthma, and global warming are all related to increased air pollution.

Water Pollution:

Water pollution involves any contaminated water, whether from chemical, particulate, or bacterial matter that degrades the water's quality and purity. Water pollution can occur in oceans, rivers, lakes, and underground reservoirs, and as different water sources flow together the pollution can spread. Causes of water pollution include increased sediment from soil erosion, improper waste disposal and littering, leaching of soil pollution into water supplies and organic material decay in water supplies. The effects of water pollution include decreasing the quantity of drinkable water available, lowering water supplies for crop irrigation and impacting fish and wildlife populations that require water of certain purity for survival.

Soil Pollution:

Soil, or land pollution, is contamination of the soil that prevents natural growth and balance in the land whether it is used for cultivation, habitation, or a wildlife reserve. Some soil pollution, such as the creation of landfills, is deliberate, while much more is accidental and can have widespread effects. Soil pollution sources include Hazardous waste and sewage spills, non-sustainable farming practices, such as the heavy use of inorganic pesticides, strip mining, deforestation, and other destructive practices, household dumping and littering. Soil contamination can lead to poor growth and reduced crop yields, loss of wildlife habitat, water and visual pollution, soil erosion and desertification.

Noise Pollution:

Noise pollution refers to undesirable levels of noises caused by human activity that disrupt the standard of living in the affected area. Noise pollution can come from traffic, airports, railroads, manufacturing plants, construction, demolition or concerts. Some noise pollution may be temporary, while other sources are more permanent. Effects may include hearing loss, wildlife disturbances and a general degradation of lifestyle.

Radioactive Pollution:

Radioactive pollution is a type of pollution that is rare but extremely detrimental, even deadly, when it occurs. Because of its intensity and the difficulty of reversing damage, there are strict government regulations to control radioactive pollution. Sources of radioactive contamination include nuclear power plant accidents or leakage, improper nuclear waste disposal and uranium mining operations. Radiation pollution can cause birth defects, cancer, sterilization, and other health problems for human and wildlife populations. It can also sterilize the soil and contribute to water and air pollution.

Thermal Pollution:

Thermal pollution is excess heat that creates undesirable effects over long periods of time. The earth has a natural thermal cycle, but excessive temperature increases can be considered a rare type of pollution with long-term effects. Many types of thermal pollution are confined to areas near their source, but multiple sources can have wider impacts over a greater geographic area. Thermal pollution may be caused by Power plants, urban sprawl, air pollution particulates that trap heat, deforestation and loss of temperature moderating water supplies. As temperatures increase, mild climatic changes may be observed, and wildlife populations may be unable to recover from swift changes.

Light Pollution:

Cities cause light pollution. Light pollution is the over-illumination of an area that is considered obtrusive. Sources include large cities, billboards, nighttime sporting events and other nighttime entertainment. Light pollution makes it impossible to see stars, therefore interfering with astronomical observation and personal enjoyment. If it is near residential areas, light pollution can also degrade the quality of life for residents.

Visual Pollution:

Visual pollution – eyesores – can be caused by other types of pollution or just by undesirable, unattractive views. It may lower the quality of life in certain areas, or could impact property values and personal enjoyment. Sources of visual pollution include power lines, construction areas, billboards and advertising or neglected areas or objects such as polluted vacant fields or abandoned buildings. While visual pollution has few immediate health or environmental effects, the other types of pollution that cause an eyesore can have detrimental effects.

Personal Pollution:

Are you polluting yourself? Personal pollution is the contamination of one's body and lifestyle with detrimental actions. These may include: excessive smoking, drinking or drug abuse, emotional or physical abuse, poor living conditions and habits or poor personal attitudes. In some cases, personal pollution may be inflicted by caregivers, while in other cases, it is caused by voluntary actions. Taking positive steps in your life can help eliminate this and other types of pollution so you can lead a more productive, satisfying life.

Self Assessment Question

1. Explain pollution and list the various types of environmental pollutions we have.

Unit 8.2: Environment Effects of Pollutants

In this unit, the following will be focused upon:

- Definition of pollutants
- Types of pollutants
- Control of pollutants

Objectives

It is envisaged that after going through this module, you should be able to:-

i. Define and explain the meaning of pollutant
ii. Classify pollutants
iii. Explain how pollutants are controlled

Introduction

In the previous unit (Unit 8.1 Module Eight), pollution was explained, including its types and causes. Pollution was defined as the introduction of contaminants into an environment which causes instability, disorder, harm or discontent to ecosystem. In this unit, pollutant, which is the substance that causes pollution, is explained with its various types.

8.2.1 What is a pollutant?

A pollutant is a waste material that pollutes air, water or soil, and it is the cause of pollution. Three factors determine the severity of a pollutant: its chemical nature, the concentration and the persistence. Some pollutants are biodegradable and therefore will not persist in the environment in the long term. That is, they can decay and dissolve easily. However, the degradation products of some pollutants are themselves polluting. Examples of such are insecticides produced from DDT (dichlorodiphenyltrichloroethane), a type of chemical pesticide which is hazardous to living things. Now that you know what a pollutant is, we can move forward to explain the form of pollutant available. Now can you differentiate between pollution and pollutants?

8.2.2 Types of Pollutants based on Absorption

Based on absorption (that is, how the pollutants are sucked-up by the environment), pollutants can be divided into two: stock and fund pollutants. Read the explanation below.

Stock pollutants

Pollutants that the environment has little or no absorptive capacity are called stock pollutants (e.g. persistent synthetic chemicals, non-biodegradable plastics, and heavy metals). Stock pollutants accumulate in the environment over time. The damage they cause increases as more pollutant is emitted, and persists as the pollutant accumulates. Stock pollutants can create a burden for future generations by passing on damage that persists well after the benefits received from incurring that damage have been forgotten.

Fund pollutants

Fund pollutants are those for which the environment has some absorptive capacity. Fund pollutants do not cause damage to the environment unless the emission rate exceeds the receiving environment's absorptive capacity (e.g. carbon dioxide, which is absorbed by plants and oceans). Fund pollutants are not destroyed, but rather converted into less harmful substances, or diluted/dispersed to non-harmful concentrations.

Now that we have discussed the two types of pollutants, we can go ahead to discuss the specific effects of different pollutants to the environment.

8.2.3 Consequences of Pollutant on the Environment

The following are the consequences or outcomes of different types of pollution on the environment:

Air Pollutants

Air pollution is the presence of materials in the air in such concentrations which are harmful to man and his environment. Various causes of air pollution can be seen on the table 1 below.

The major causes of pollution in urban areas are automobiles (vehicles) which inefficiently burn petroleum, release 75% noise, and 80% air pollutants. Concentration of industries in one area is another major cause.

Category	Examples	Important pollutants
1. Chemical plants	Petroleum refineries, fertilizers, cements, paper mills, ceramic clay products, glass manufacture	H_2S, sulphur oxide, fluorides, organic vapours and dust
2. Crop spraying	Pesticides and herbicides	Organophosphates, chlorinated hydrocarbons, lead, arsenic
3. Fuel burning	Domestic burning, thermal power plants	Sulphur and nitrogen oxides
4. Metallurgy plants	Aluminium refineries and steel plant	Metal flumes (Pb and Zn) fluorides and particulates
5. Nuclear device testing	Bomb explosions	Radioactive fall out, Sr-90, Cs-137, C-14 etc.
6. Ore preparations	Crushing, grinding and screening	Uranium and beryllium dust, other particulates
7. Spray painting, ink, solvent cleansing	Printing and chemical separations, furniture, dyeing	Hydrocarbons and other organic vapours
8. Transportation	Cars, trucks, aeroplanes and railways	CO, NO, NO2, Pb, smoke, soot, smoke organic vapours etc.

Table 1 showing the major types of air pollution and their effects.

Water Pollutants

Water pollution adversely changes the quality of water. It degrades the quality of water so that it either becomes health hazard or unfit for use. Surface water is never pure. Soil erosion, leaching of minerals from rocks, decaying of organic matter is the natural sources of water pollution. Most of water pollution is man-made. The effects of water pollutants are:
(a) Eutrophication, which is a natural process observed in lakes and tanks where rich growth of micro-organisms consumes much of dissolved oxygen, depriving other organisms. It is generally found at bottom layers of deep lakes. It is harmful to fish and other aquatic life.
(b) Foam formation in waters by soaps, detergents and alkalines which makes the water polluted.

Biological magnification.

Chlorinated hydrocarbons, e.g. DDT (dichlorodiphenyltrichloroethane), a type of chemical pesticide, also enter into the water of the surrounding environments where they are used. Aquatic animals like fish and other that use such water also absorb these chemicals while feeding. The increased accumulation of toxic substances in food pyramids is called biological magnification. Many species of predatory birds like eagles and hawks also show adverse effect of chemical accumulation in their bodies. It interferes with egg shell production in many birds. Shells are thin and are easily broken by bird's weight during incubation. It adversely affects the developing embryos.

Soil Pollutants

These include Fluorides that affect plant photosynthesis, cause leaf and fruit abscission. Maize is the sensitive indicator of fluoride pollution. In human beings, mottling of teeth (fluorosis) is an indication of fluorination. Bone fluorosis results in weak bones, boat-shaped posture and knocking of knee. Also, Nitrogen fertilization (nitrates + nitrite) toxic concentration in leaves and fruits enters into food chain. In the stomach, activity of bacteria changes nitrates into nitries. The latter enters blood and combines with haemoglobin to form meta-haemoglobin which causes reduction in oxygen transportation in the body. It gives rise to a disease called methanaemoglobinaemia. In infants, it causes cyanosis (blue babies due to bluish tint of skin).

Community waste waters.

Community waste water includes discharge from homes, commercial and industrial establishment connected to public sewage system. Composition of sewage varies from place to place. Major components are human and animal excreta, food residues, cleaning agents, detergents and other wastes. It is rich in bacteria and organic substrates. Scum and sludge formed by organic wastes make the water unfit for recreation and industrial use.

Industrial Pollutants.

Composition of industrial wastes depends upon the form of industry and type of water processing employed and its bye-products. The table below lists common industrial pollutant and their consequences:

Table 2 showing the various types of industrial pollutants

Type of Industry	Inorganic Pollutants	Organic Pollutants
Chemical plants	Various acids and alkalies, Chlorides, sulphates nitrates of metals, phosphorus, fluorine, silica and suspended particles	Aromatic compounds solvents, organic acids, nitro compounds dyes etc.
Detergent and soap	Tertiary ammonium compounds alkalies	Fats and fatty acids, glycerol polyphosphates, sulphonated hydrocarbons
Food processing	--	Highly putrescible organic matter and pathogens
Iron and steel	Suspended solids, iron cyandies	--
Mining	Mine wastes: Chlorides, various metals, ferrous sulphate, sulphuric acid, hydrogen sulphide ferric hydroxide, surface wash offs, suspended solids, chlorides and heavy metals.	--
Paper and pulp	Sulphides, bleaching liquors.	Cellulose fibers, bark, wood sugars, organic acids.
Pharmaceuticals	--	Protein, carbohydrates organic solvents, intermediate products

Agricultural Pollutants

Use of high yielding varieties of crops increased the demand for fertilizers; they are carried to ground water by leaching. They are also added through surface run off. Many pesticides are non-degradable. Huge amount of animal excreta -dung, piggeries- is either discharged into grazing fields or dumped into pits.

These are later carried either by surface run-off or get percolated into ground water. Lack of potable drinking water supply, unhygienic habits and poor waste disposal have aggravated the problem of water pollution. To evade water pollution regulations and to avoid cost of treatment, industries are disposing off their wastes on ground which has lead to large scale pollution of underground water.

8.2.4 Conclusion

In this unit, pollutants are defined and the types and effects of various pollutants are discussed.

Unit 8.3: Environmental Effects of Plastics

In this unit, the following will be focused upon:

- Definition of plastics
- Harmful Effects of plastics on the environment

Objectives

It is envisaged that after going through this module, you should be able to:-

i. Define plastics
ii. Explain the harmful health effects of plastic waste

Introduction

One of the commonest pollutants in our environment is plastic and its bye-products. In this unit, we discuss what plastic is and how harmful it is to the environment.

8.3.1 Definition of Plastic

A plastic material is any of a wide-range of synthetic or semi-synthetic organic amorphous solids used in the manufacture of industrial products. Plastics are typically polymers of high molecular mass, and may contain other substances to improve performance and/or reduce costs. The raw materials used to make most plastics come from petroleum and natural gas. There are two types of plastics: thermoplastics and thermosetting polymers. Thermoplastics will soften and melt if enough heat is applied; examples are polyethylene, polystyrene, polyvinyl chloride and polytetrafluoroethylene (PTFE). Thermosets can melt and take shape once; after they have solidified, they stay solid.

Plastic bags are very popular with both retailers as well as consumers because they are cheap, strong, lightweight, functional, as well as a hygienic means of carrying food and other goods. Even though they are one of the modern conveniences that we seem to be unable to do without, they are responsible for causing pollution, killing wildlife and using up the precious resources of the earth.

8.3.2 Harmful Effects of Plastics

Billions of plastic bags are used each year across the globe. Do you also use plastics? Okay, whatever your answer, here are some of the harmful effects of plastic bags:

Plastic bags litter the landscape.

Once they are used, most plastic bags go into landfill or rubbish tips. Each year, more and more plastic bags are ending up littering the environment. Once they become litter, plastic bags find their way into our waterways, parks, beaches and streets. And, if they are burned, they infuse the air with toxic fumes.

Plastic bags kill animals.

About 100,000 animals, such as dolphins, turtles whales and penguins are killed every year due to plastic bags. Many animals ingest plastic bags, mistaking them for food, and therefore die. Worse still, the ingested plastic bag remains intact even after the death and decomposition of the animal. Thus, it lies around in the landscape where another victim may ingest it.

Plastic bags are non-biodegradable.

One of the worst environmental effects of plastic bags is that they are non-biodegradable. The decomposition of plastic bags takes about 1000 years.

Petroleum is required to produce plastic bags.

As it is, petroleum products are diminishing and getting more expensive by the day, since we have been using this non-renewable resource increasingly. Petroleum is vital for our modern ways of life. It is necessary for our energy requirements – for our factories, transport, heating, lighting and so on. Without viable alternative sources of energy yet on the horizon, if the supply of petroleum were to be turned off, it would lead to practically the whole world grinding to a halt. Surely, this precious resource should not be wasted on producing plastic bags; should it?

Adverse Health Effects of Plastics.

In addition to creating safety problems during production, many chemical additives that give plastic products desirable performance properties also have negative environmental and human health effects. These effects include:

- Direct toxicity, as in the cases of lead, cadmium, and mercury
- Carcinogens, as in the case of diethylhexyl phthalate (DEHP)
- Endocrine disruption, which can lead to cancers, birth defects, immune system suppression and developmental problems in children.

People are exposed to these chemicals not only during manufacturing, but also by using plastic packages, because some chemicals migrate from the plastic packaging to the foods they contain. Examples of plastics contaminating food have been reported with most plastic types, including Styrene from polystyrene, plasticizers from PVC, antioxidants from polyethylene and acetaldehyde from PET.

Among the factors controlling migration are the chemical structure of the migrants and the nature of the packaged food. In studies cited in Food Additives and Contaminants, LDPE, HDPE and polypropylene bottles released measurable levels of BHT, Chimassorb 81, Irganox PS 800, Irganix 1076, and Irganox 1010 into their contents of vegetable oil and ethanol. Evidence was also found that acetaldehyde migrated out of PET and into water.

Module Nine: HIV/AIDS

Unit One: HIV/AIDS

In this unit, the following will be focused upon:

- What HIV/AIDS is all about
- How HIV causes AIDS
- The means of transmission and symptoms of AIDS
- The control and prevention of HIV/AIDS infection

Objectives

At the end of this unit, you should be able to:

i. Explain what HIV and AIDS means
ii. Discuss how to detect HIV infection
iii. List and explain how HIV is transmitted
iv. Explain how HIV develops to AIDS
v. Discuss the worldwide pattern of infection with HIV/AIDS
vi. Explain how to control and prevent the spread of HIV/AIDS

Introduction

HIV/AIDS is a form of disease that affects many people in the world. As an important health issue, it is important for people all over to know about it in such a way that its spread can curtailed and those affected can get proper care. This unit therefore explains HIV/AIDS, its causes, transmission modes, as well as prevention and control.

9.1.1 The Meaning of HIV/AIDS

HIV is short for Human Immunodeficiency Virus. This is the virus that causes the Acquired Immunodeficiency Syndrome (AIDS). The HIV is a type of virus called retrovirus, which uses Ribonucleic Acid (RNA), genetic material of certain viruses (RNA viruses) and, in cellular organisms, the molecule that directs the middle steps of protein production) not Deoxyribonucleic Acid (DNA), genetic material of all cellular organisms and most viruses. DNA, as its genetic messenger. In unit 3.4, we explained DNA as the compound that explains the blueprint that determines the characteristics of living things, including determining heredity. RNA is the genetic material of certain viruses. Scientists have identified two types of this virus – HIV-1 and HIV-2. HIV-1 is the primary cause of AIDS worldwide. HIV-2 is found mostly in West Africa. In 1981, homosexual men with symptoms of a disease that are now considered typical of AIDS were first described in Los Angeles and New York. The men had an unusual type of lung infection (pneumonia) and rare skin tumors, called Kaposi's sarcomas. The patients were noted to have a severe reduction in CD4 or T cells. CD4 or T cells are immune system cell in the body which are vulnerable to HIV. In 1983, two groups of researchers in the United States and France, working independently, described the virus that causes AIDS, now known as the human immunodeficiency virus (HIV).

9.1.2 Replication and Disease Process

Replication is concerned with how HIV viruses multiply. HIV is a complicated virus that replicates primarily in specialized cells of the body's immune system called CD4 lymphocytes. During HIV replication, the CD4 cells are destroyed. Over a period, that may last from a few months to up to 15 years, HIV may destroy enough CD4 lymphocytes that the immune system becomes unable to function properly. If the number of CD4 cells falls below 200 per cubic millimeter, or if some other special conditions occur, the person is defined as having AIDS. These special conditions include infections and cancers that take advantage of the way that HIV suppresses the immune system. An infected person develops multiple life-threatening illnesses from infections that normally do not cause illnesses in people with a healthy immune system. Some people who have HIV infection may not develop any of the clinical illnesses that define the full-blown disease of AIDS for ten years or more.

HIV infection is generally a slowly progressive disease in which the virus is present throughout the body at all stages of the disease and can be spread to others through unprotected sex or contact with blood or some other body fluids.

Three stages of HIV infection have been described. These are as follows:

1. The initial stage of infection (primary infection), which occurs within weeks of acquiring the virus, and often is characterized by a "flu-" or "mono-"like illness that generally resolves within weeks. The most common symptoms of primary HIV infection are fever, aching muscles and joints, sore throat and swollen glands (lymph nodes) in the neck.

2. The stage of chronic asymptomatic infection (meaning a long duration of infection without symptoms) lasts an average of eight to 10 years.

3. The stage of symptomatic infection, in which the body's immune (or defense) system has been suppressed and complications have developed, is called the Acquired Immunodeficiency Syndrome (AIDS). The symptoms are caused by the complications of AIDS, which include one or more unusual infections or cancers, severe loss of weight, intellectual deterioration (called dementia), fever for more than a month, diarrhoea lasting for more than one month, persistent dry cough lasting more than one month, swelling around the neck, arm pit and private parts and other illnesses, including pneumonia and tuberculosis.

9.1.3 Transmission

HIV transmission occurs when a person is exposed to body fluids infected with the virus, such as blood, semen, vaginal secretions, and breast milk. The primary modes of HIV transmission are

1. Sexual relations with an infected person;
2. Sharing hypodermic needles or accidental pricking by a needle contaminated with infected blood;
3. Transfer of the virus from an infected mother to her baby during pregnancy, childbirth, or through breast-feeding; and
4. Through transfusions of infected blood or blood clotting factors. Scientists and medical authorities agree that HIV does not survive well in the environment, making the possibility of environmental transmission remote.

Some people fear that HIV might be transmitted in other ways; however, no scientific evidence to support any of these fears has been found. If HIV were being transmitted through other routes (such as through air, water or insects), the pattern of reported AIDS cases would be much different from what has been observed. For example, if mosquitoes could transmit HIV infection, many more young children and preadolescents would have been diagnosed with AIDS.

9.1.4 Diagnosis

Diagnosis is concerned with detecting or identifying a disease affecting a person. Within two to six weeks of an exposure, the majority of infected people will have a positive HIV antibody test, with virtually all being positive by six months. The test used most commonly for diagnosing infection with HIV is referred to as an ELISA (Enzyme Linked Immunosorbent Assay). If the ELISA finds the HIV antibody, the presence of the antibody is confirmed by a test called a Western blot. There are now several rapid antibody tests that can be performed on blood or saliva and provide preliminary results within 20 minutes. These tests are fairly accurate but also need to be confirmed with a Western blot. HIV testing is important to diagnose those who are newly infected, to identify previously unrecognized infections and to relieve the minds of those who are not infected. HIV testing is also used to reduce the risk of transmission during blood transfusions and tissue transplantation. Routine HIV testing of adolescent and adult patients in all health-care settings and of all pregnant women is recommended. Thus, HIV testing is considered part of routine medical practice, similar to tests that screen for other diseases. People who are at high risk for HIV should be tested at least annually. Sometimes, doctors request or require testing as part of evaluation and treatment for other conditions, such as women undergoing treatment with assisted reproductive technologies for infertility.

9.1.5 Treatment

No treatment that cures AIDS is available . The goals of drug therapy are to prevent damage to the immune system by the HIV virus and to halt or delay the progress of the infection to symptomatic disease. Known as antiretroviral therapy, these drugs target different stages in the life cycle of HIV. Therapy for HIV includes combinations of drugs that decrease the growth of the virus to such an extent that the treatment prevents or markedly delays the development of viral resistance to the drugs. The best combination of drugs for HIV has not yet been defined, but one of the most important factors is that the combination be well tolerated so that it can be followed consistently without missing doses.

9.1.6 Epidemiology

Since the beginning of the epidemic, almost 60 million people have been infected with HIV, and 25 million people have died of HIV-related causes. According to a United Nations report in 2008, nearly 7,500 people worldwide become newly infected with HIV, and 5,500 others die from AIDS, every day. But because of improved prevention programs, the rate of new infections is slowing, falling from 3 million in 2001 to 2.7 million in 2008. Moreover, fewer people are dying from AIDS, with the rate dropping from 2.2 million in 2005 to 2.0

million in 2008. However, because HIV-infected individuals are living longer, their numbers are increasing, rising from an estimated 29.5 million in 2001 to 33.4 million in 2008. Sub-Saharan Africa is home to 67% of all people living with HIV, most of whom are female, and 91% of all new infections among children. HIV prevalence is generally low in Muslim countries, for example countries in North Africa, the Middle East, Indonesia and parts of India. This may be due to factors such as circumcision in men and stricter social control of female sexuality.

AIDS has provoked panic, stigmatization and scapegoat-finding in the same way as other plagues of historical dimension, but in many ways, it is different. It is caused by a persistent infection and has a silent period of many years between infection to the onset of serious symptoms. HIV is integrated into the very genome of the cells it attacks. Therefore, in contrast to other major epidemics, the AIDS epidemic has no rapid rise, obvious peak or rapid decline. It targets people in productive ages, strong young adults, which have serious economic, political, demographic consequences. It is 100% fatal without life-long treatment with antiretroviral drugs. It is sexually transmitted, and such infections are renowned for being difficult to control, even when treatment is available. It is also transmitted vertically, from mother to child. The subject of AIDS is emotionally and politically charged, and denial has frequently prevented rational countermeasures.

9.1.7 Prevention and Control

The only realistic way to combat the spread of HIV and AIDS is to prevent infections with HIV occurring. In other words, limit transmission of the virus. AIDS prevention and control measures include:

1. Informing the general public about HIV transmission and explaining those behaviours that place individuals at risk of infection

1. Counseling HIV infected persons
2. Ensuring the safety of blood and blood products
3. Taking action to reduce HIV transmission among intravenous users, and
4. Preventing transmission from mother to child.

The best way to avoid sexual transmission is abstinence from sex. If abstinence is out of the question, the next best method is having only one uninfected sexual partner (ideally for life) and the use of latex barriers, e.g. condom. To prevent the spread of HIV, as well as other diseases, including hepatitis, needles should never be shared. At the beginning of the HIV epidemic, many individuals acquired HIV infection from blood transfusions or blood products, such as those used for haemophiliacs. Currently, however, because blood is tested for both antibodies to HIV and the actual virus before transfusion is done, the risk of acquiring HIV from a blood transfusion is small.

There is little evidence that HIV can be transferred by casual exposure, as might occur in a household setting. For example, unless there are open sores or blood in the mouth, kissing is generally considered not to be a risk factor for transmitting HIV. This is because saliva, in contrast to genital secretions, has been shown to contain very little HIV. Still, theoretical risks are associated with the sharing of toothbrushes and shaving razors because they can cause bleeding, and blood can contain large amounts of HIV. Consequently, these items should not be shared with infected people. Similarly, without sexual exposure or direct contact with blood, there is little if any risk of HIV contagion in the workplace or classroom.

9.1.8 Conclusion

AIDS has become one of the great scourges facing mankind, and much effort is placed in public education to control it. So far, little have been achieved by way of development of curative treatment. With alarming reports of increasing incidence of AIDS and despite the increasing data being obtained on the syndrome, mankind can win against AIDS only if effective control measures are found.

Self Assessment Questions

1. What is the difference between HIV and AIDS?
2. What are the stages of HIV/AIDS infection?

Tutor Marked Assignment No.2

Answer the following questions by selecting either true or false:

1. The three stages of HIV infection are initial, chronic asymptomatic, and symptomatic infection (True or False).

2. HIV is a fast progressive disease, and it is spread by air (True or False).
3. There are two types of HIV infection; HIV-1 and HIV-2 (True or False).
4. Anti-malarial therapy is given to people infected with HIV to halt or delay the progress of HIV infection (True or False).
5. HIV is a retrovirus that uses DNA as genetic messenger (True or False).
6. Transfusion of infected blood is of the non-primary modes of HIV transmission (True or False).
7. A person is said to be infected with HIV if it is noted to have increased in CD4 ot T-cells (True or False).
8. HIV is transmitted by mosquitoes (True or False).
9. There is strong evidence that HIV can be transferred through genital secretions (True or False).
10. The commonest test done to diagnose HIV is known as Enzyme Linked Immunosorbent Assay (ELISA) (True or False).

Glossary

AIDS stands for acquired immunodeficiency syndrome.

Biomass- waste plant materials (e.g. wood) or animal waste (e.g. animal dung)

Chemical energy- stored energy (e.g. food and battery) which can release through chemical reaction

DDT

Electrical energy- energy produced by movement of charged particles, e.g. electric current and static electricity.

Deoxyribonucleic Acid (DNA), genetic material of all cellular organisms and most viruses. DNA carries the information needed to direct *protein synthesis* and *replication*. Protein synthesis is the production of the proteins needed by the cell or virus for its activities and development. Replication is the process by which DNA copies itself for each descendant cell or virus, passing on the information needed for protein synthesis

Fossil fuels- transformed organic materials which were buried underground over long time

Geothermal energy- heat from the sub-surface of the earth

Hydropower- power generated from falling waters

HIV is short for human immunodeficiency virus, the virus that causes AIDS.

Mechanical energy- these are of two different: kinetic energy acquired by motion of body and potential by virtue of position of body.

Nuclear energy- energy produced from the bombardment of nuclear materials like uranium and deuterium.

Light energy-from electron transition in atoms

Ribonucleic Acid (RNA), genetic material of certain viruses (RNA viruses) and, in cellular organisms, the molecule that directs the middle steps of protein production)

Solar energy- energy from the sun