MODULE 1 THE NATURE AND PHILOSOPHY OF SCIENCE

UNIT 1 MEANING AND IMPORTANCE OF SCIENCE AND TECHNOLOGY

CONTENTS

1.0 INTRODUCTION

The term ‘science’ has been given several definitions by many scholars. In this unit, you will be introduced to these various definitions and you will also be able to define science based on your understanding of the word. You will also see how science has contributed to the overall development of mankind.

2.0 OBJECTIVES

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

- give various definitions of science by different scholars;
- explain the concept of science; and
- state and explain the importance of science to mankind.

HOW TO STUDY THIS UNIT

- Read through this unit with care.
- Study the unit step by step as the points are well arranged.

NOTE: ALL ANSWERS TO ACTIVITIES AND ASSIGNMENT ARE AT THE END OF THIS BOOK. THIS APPLIES TO EVERY OTHER UNIT IN THIS BOOK.

3.0 WORD STUDY

- **Science** - universal body of knowledge that enables us to investigate into natural phenomenon through the use of scientific skills

- **Knowledge** - familiarity of understanding gained through experience or study

- **Paradigm** - a general accepted model of how ideas relate to one another forming a conceptual framework within which scientific research is carried out.

4.0 MAIN CONTENT

4.1 Definitions of Science and Technology

The word 'science' was originally derived from the Latin expression "Scientia" which means "to know" or to have "knowledge" and from another Latin verb "scio-ire-ivi-iture" which means "to know", "to have skill in" or "to know how to.'' The Latin definition seems to give more support to the definition of science. The above verb therefore describes science as a way of acquiring knowledge or skills. In the same vein, science is also related to the Greek word "Episteme" which when translated into English language becomes "knowledge". These definitions therefore suggest that science is knowledge- yielding enterprise.

On the basis of the above, science can be understood in two broad inter-related senses. First, it could be understood as the persistent desire of man to improve his strategic position in the world by means of dependable method for predicting and whenever possible controlling the events that occur in it. In this regard, scientific activity generally results in the present day production of gadgets and invention of weapons. Secondly, science is an intellectual activity embarked upon by man in order to satisfy his insatiable desire to find out or investigate the natural phenomena. Since man is a rational animal, he is curious and always has a desire to know the world, in which he lives, explains and understands it. These two factors constitute the basic motivations for any scientific activity.

The meaning and definition of science varied with different science scholars. To a layman, science is often seen in terms of scientists who carry out the process of science or their work as applied in technology. Otuka (1983) is of the view that science is man's attempt to understand his environment. This is in line with Ogunniyi (1986) who also sees science as an attempt by human being to organise their

experiences about nature into meaningful systems of explanations. Conant (1951) defines science as interconnected series of concepts and conceptual schemes that developed as a result of experimentation and observation which are useful for further experimentation and observation. Conant's definition implies that science is not permanent but that the products of science are subject to change as soon as further experimentation and observations are made on them.
From the above definitions, science can be seen in three forms.

- Science can be seen in terms of the products that is, knowledge in form of concepts, laws, theories, etc.
- Science can also be seen in terms of the process or method of acquiring knowledge that is, observing, experimenting, measuring, etc.
- Science can also be seen in terms of attitudes of scientists and as a human enterprise where everyone contributes fruitfully towards achieving stated goals.

Technology has its root from a combination of two Greek words "techne" and "logos". The word "techne" means art or craft while the word "logos" means word or speech. The combination of the two words means a discourse on the art and its application. Simply put, the word technology can be seen as the systematic study of techniques for making and doing things. It is the practical application of the products of science for the benefit of mankind. The primary aim of technology is to make life comfortable for mankind. Technology has provided a lot of benefit to mankind. This can be seen in terms of increase in food supply through application of machinery power, fertilizers and pesticides, improved health services, communication transportation and so many others.

4.2 Differences between Science and Technology

Ordinarily, science attempts to give possible explanation to happenings in the universe. When scientist carries out their investigations about nature, they come out with theories, laws, ideas, and principles etc. These are called the products of science. Technology, on the other hand, is the practical application of the products of science for the benefit of mankind. Science produces the required skills and knowledge which technologists use in making their working tools. The Industrial revolution of the 18th century and the socio-economic interchange from the Industrial revolution has made science and technology to come closer.

Technology is neither the cause of happenings nor the explanation of events. It is only science that can explain the causes of events in the natural phenomena. For instance, technology devices motor cars but does not explain how and why motor car move. A technology device a means of curing sickness but it does not explain the cause or the description of the illness.

4.3 Importance of Science and Technology

Science today represents, for many, the paradigm of the progress of human knowledge and achievement. The successes of science were construed as a cumulative process of increasing knowledge and sequence of victories over ignorance and superstitions. In addition, science has made possible an impressive array of gadgets and usages today. The primary aim of science is to find out general explanation, understanding, prediction and control of natural events around us. Science is the most powerful means devised by the mind of man for arriving at truth in respect to matter and energy.

4.4 Relevance of Science and Technology in Our Society

Abdullahi (1975) identified three major reasons why science enjoys prominent positions in any society and all over the world. According to him:

i. No other subject has affected man so directly like science. This is evident in the products of technology in terms of gadgets, communication devices, weapons etc.

ii. No other subjects have attention being paid to the methods of generating new knowledge and information like science.

iii. No other branch of knowledge expands so rapidly like science.

The opinon of Abdullahi as stated above implies that science and technology interact with the society to provide social changes and in fact they are the key elements for future social development of any nation. In addition, the greatness accorded a nation today depends on her scientific and technological advancement. For instance, the United States, Britain, Russia and Japan are regarded as developed nations today because of their advancement in science and technology. Nigeria, among other nations, is regarded as a developing nation because of her low- level development in science and technology.

Other importance of science and technology can be summarised as follows:

a. science has done so much to liberate mankind from bondage due to superstitions, idol worshiping, animism, and associated beliefs.

b. in terms of agricultural practices, the knowledge and information from science have contributed to improved agricultural practices, pest and weed control, curbing the problems of soil erosion and modern ways of cultivation are some of the modern agricultural practices that have helped to improved crop yield.

c. scientific and technological structures of a society have a strong influence on the economic development of that society. For instance, most of the

technological development which resulted in important inventions such as steam engine, printing press and many others brought about economic revolution of the society.

d. science and technology have helped man to beautify his environment and give possible explanation to things that happened in his environment.

e. through science and technology, communication processes have improved and less risky form of transportation and services has been introduced.

f. science and technology have made life comfortable for man and have improved man's standard of living.

g. in terms of medicine, science and technology have helped in increasing the lifespan of man. This can be seen in the discovery of surgery, preventive and curative drugs.

5.0 ACTIVITY

i. a. Explain the Latin definition of science.
   b. State any two definitions of science has given by different scholars.
   c. Define technology in your own words.
ii. Briefly explain the main relationship between science and technology.
iii. Enumerate the importance of science to mankind.
iv. State and explain other ways by which science is important to mankind.

6.0 SUMMARY

In this unit, you have learnt the various definitions of science, starting from the Latin verb to the Greek word. You have also learnt about the relationship between science and technology and the importance of science to mankind. Science has been defined by various authors. To some, it is an organised body of knowledge and the processes of acquiring the knowledge. Others see science in terms of what scientist do in terms of its product and methods, while others see it in terms of its ethics and motives. Furthermore, the role of science and technology in the development of any nation cannot be over emphasised. From the discussion so far, it can be concluded that the strength of a nation today depends on its level of science and technological development. Science has brought a lot of influence on the economic aesthetic and culture of various societies. In the next unit, you will be introduced to the products and processes of science.

7.0 ASSIGNMENT

i. Why do you think science has enjoyed prominent position in the society more than any other discipline? Give reasons for your answer.
ii. Do you think the world would have been better without science and technology? Substantiate your opinion with relevant examples.

8.0 REFERENCES/FURTHER READING

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UNIT 2 PRODUCTS AND PROCESSES OF SCIENCE

CONTENTS

1.0 INTRODUCTION

In the last unit, we examined the definition of science. We also saw how science differs from technology. The main contribution of science and technology to the development and benefit of mankind was also discussed. In this unit, you will be introduced to the products of scientific enterprise and the tools which scientist use in carrying out investigations.

2.0 OBJECTIVES

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

- describe the products and processes of science differently;
- give examples of the products of science; and
- mention and explain some processes of science.

HOW TO STUDY THIS UNIT

- Read through this unit with care.
- Study the unit step by step as the points are well arranged.

NOTE: ALL ANSWERS TO ACTIVITIES AND ASSIGNMENT ARE AT THE END OF THIS BOOK. THIS APPLIES TO EVERY OTHER UNIT IN THIS BOOK.

3.0 WORD STUDY

- **Product** – something that arise as a consequence of something else.

- **Empirical** – philosophy derived solely from experience.

4.0 MAIN CONTENT

4.1 Products of Science

When scientists carry out investigation of natural phenomena, they come out with their findings. These findings could be in form of ideas, principles, laws, theories, etc. These are known as the products of science. In other words, the products of science are the outcome of scientific investigations. The products of science (ideas, facts, principles, concepts, laws and theories) are discussed below.

i. Scientific Ideas

Ordinarily, an idea is a conception or abstraction about something. A scientific idea is a mental image used by scientist to define their terms and test their hypotheses, which if meaningful, entail prediction. Ideas in science are usually formed to test a hypothesis which later leads to formation of concepts in science.

ii. Scientific Fact

A fact is something that can be shown to be true or to exist or to have happened. Scientific facts are based on the use of one or more sensory organs to prove the existence of something. Scientific facts are not based on mere speculations but on observable or demonstrated events. For example, the sun rises from the East and sets in the West.

iii. Scientific Principles

Scientific principles are fundamental truths upon which other truths are founded. In other words, scientific principles are made up of laws that form the basic theoretical structure of a concept. For instance, the basic theoretical structure of physical sciences can be found in Boyle's law and Newton's law of motion. A good example of a scientific principle is the conservation of energy.

iv. Scientific Concepts

A concept in science is an idea or a mental image formed by abstracting common features of a series of experiences. Concepts generally can be classified into two major groups. These are theoretical and empirical concepts. Theoretical concepts are concepts whose meanings are not derived from direct or indirect observation using sensory stimulation. Rather, they are subject to human ability to communicate the imagined idea. Examples include electron, atom, gene, mass, etc.

Empirical concept on the other hand is the direct opposite of the theoretical concept. Empirical concepts are concepts derived from direct or indirect observation or experiences. This means that they are concepts that a scientist can use his sense organs

to observe. Examples include colour, chromosomes, change of state, energy change, etc.

v. Scientific Laws

Scientific laws are generalised statements that have characterised general pattern or regularities in natural happenings. Laws when established usually stand for quite some time before they are changed. Examples of law in science include first and second law of heredity postulated by Gregor Mendel, Boyle's Law, laws of thermodynamics, etc.

vi. Scientific Theory

A scientific theory is a statement put forward to explain the existence of one or several laws. For instance, in Dalton's atomic theory and kinetic theory of matter, several observed facts and a statement connecting the observed facts together were made. Therefore, a theory is put forward to explain the existence of laws. Scientific theories are not permanent but change with time as new facts are discovered. Other examples of theories include theory of natural selection, Big Bang theory, etc.

4.2 Processes of Science

Processes of science are the various tool that scientist use when carrying out their investigations or activities. There are many processes but ten major ones will be discussed. These are:

i.	observation	vi.	communication
ii.	classification	vii.	making operational definition
iii.	inference	viii.	Formulation of questions and hypotheses
iv.	production	ix.	experimentation
v.	measuring	x.	models formulation

i. Observation

This is the very first skill used by scientists in carrying out investigation of natural phenomena. Observation can be direct using all or any of the sensory organs or it can be indirect when the senses are not adequate. This will then involve using machines or other aids to support what is being observed. Data collected as a result of observation could be used to take further action based on the precision of the senses used.

ii. Classification

This is the grouping or ordering of things or objects based on certain common characteristics. For instance, when objects and events are observed, they can be classified based on similarities, differences or any other selected properties.

iii. Inference

This refers to receiving an opinion or decision that something is true or otherwise on the basis of information that has been acquired through observation. Inference requires evaluation and judgment. It leads to prediction.

iv. Prediction

This is the act of saying that something will happen based on regularity of observation about an event or object. Prediction may later be validated or not although it usually has a high- level of certainty. For instance, having observed for several years that rain usually fall whenever there is cloud and high temperature it can then be predicted that rain will fall whenever there is high temperature coupled with cloud formation.

v. Measuring

Measuring is concerned with knowing the size or extent of something especially in comparison within a known standard. In science, measuring can be made directly or indirectly. Data collected from measuring can be used in communicating.

vi. Communication

The outcome of observation and measurement need to be recorded and kept for future use. Communication can be verbal or non- verbal. The verbal communication occurs when scientist interact with one another in the course of their activities. Non- verbal communication on the other hand involves writing, drawing, graphical representation to mention but a few.

vii. Making Operational Definition

Operational definitions are made in order to simplify communication on phenomenal being investigated by scientists. It gives information needed to differentiate terms which are being defined from other similar phenomena.

viii. Formulation of Questions and Hypotheses

In formulating hypothesis and questions when a problem comes up, scientist usually ask questions as to the possible cause(s) of the problem. The questions then form the basis for the foundations and designing an experiment; identifying the possible cause with a view to solving the problems. The questions asked may lead to intelligent guesses about the possible cause of the problem. These intelligent guesses are known as hypothesis.

ix. Experimentation

This is the process of designing and gathering data to test the hypothesis formulated about a problem. Experimentation may involve all or some of the science processes. For instance, in an experiment, observations, classification, prediction etc. are made.

x. Models Formulation

From the result of the test hypothesis in an experiment, a model can be formulated to further explain the problem being investigated from the result of the hypothesis in an experiment. The model can be empirical or theoretical.

5.0 ACTIVITY

i. Make a list of other scientific laws you know or laws from your area of specialisation.
ii. Explain in your own words what you understand by scientific theory. Why are theories not permanent?
iii. Mention some of the sensory organs that can be used for direct observation.
iv. Mention the various ways by which objects and living things can be classified.
v. What are the requirements of inference?
vi. Make a prediction about an event in nature.
vii. Mention some of the instruments and units of measuring things.
viii. Discuss some of the verbal and non-verbal ways of communication in your area of specialisation.
ix. Identify a problem from your area of specialisation and formulate questions and hypotheses based.
x. Design an experiment in your field of specialisation and list out the science processes involved.
xi. Formulate a model from your area of specialisation.

6.0 SUMMARY

In this unit, we have discussed the products and processes of scientific enterprise. You have learnt that the products of science are the outcome of scientific investigations which could be in form of ideas, facts principles, laws and theories to mention but a few. You have equally learnt that the processes of science are the skills which scientist use in carrying out their activities. These skills include observation, classification predicting and experimenting. Both the products and processes of science discussed above constitute the nature of scientific enterprise. Whenever scientists are carrying out their activities they must use the various processes of science to arrive at their findings which form the products of science.

In the next unit, you will be introduced to the attitudes of science and the characteristics of scientists.

7.0 ASSIGNMENT

i. What do you understand by the term products and processes of science?
ii. Mention and explain any two products and two processes of science using relevant examples from your area of specialisation.

8.0 REFERENCES/FURTHER READING

Carin, A. A., & Sund R.B. (1970). *Teaching Modern Science*. Columbus. Ohio Charles: E. Morris.

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UNIT 3 SCIENTIFIC ATTITUDES AND ATTRIBUTES OF SCIENCE

CONTENTS

1.0 INTRODUCTION

In Unit two, you learnt about the nature and philosophy of science. This involves how scientists use various skills (processes) to carry out investigations and arrived at certain outcome known as the products of science. Scientist in the course of carrying out their investigation in the laboratories need to develop certain characteristics which include curiosity, honesty, open mindedness perseverance, etc. these are called scientific attitudes. In this unit, you will learn about some of the major attitudes that scientist need to imbibe in the course of their investigation. Also, you will learn about who a scientist is and some of the major characteristics of a scientist.

2.0 OBJECTIVES

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

- define scientific attitudes;
- list and explain some of the major scientific attitudes;
- describe who a scientist is; and
- mention and explain some attributes of scientist.

HOW TO STUDY THIS UNIT

- Read through this unit with care.
- Study the unit step by step as the points are well arranged.

NOTE: ALL ANSWERS TO ACTIVITIES AND ASSIGNMENT ARE AT THE END OF THIS BOOK. THIS APPLIES TO EVERY OTHER UNIT IN THIS BOOK.

3.0 WORD STUDY

- **Cognitive** – concerned with acquisition of knowledge

- **Affective** - of emotional expression

- **Behaviour** – way in which a person responds to a specific set of condition.

4.0 MAIN CONTENT

4.1 Meaning of Scientific Attitudes

Scientific Attitudes are those things that regulate the behaviour of scientists when they are carrying out scientific activities in the laboratory. It is an internal state that moderates or influences the personal actions of scientist in the course of carrying out investigation in the laboratory.

Proshansky and Seidenberg in Emina (1986) are of the view that scientific attitudes can be considered to have cognitive, affective and behavioural components. The cognitive components refer to ideals, beliefs and convictions about a situation. Affective components refer to feelings which are internal and personal. The behavioural components refer to visible physical response to a specific object or situation.

4.2 Types of Scientific Attitudes

Koslow and Nay (1967) proposed eight attributes or types of scientific attitudes. These are listed as follows:

- critical mindedness
- suspended judgment
- respect for evidence
- honesty
- objectivity
- willingness change
- open opinion mindedness
- questioning

A brief explanation of each is made below.

Critical Mindedness
This is the ability to develop the spirit of appraising something. It involves passing judgment on everything. As a scientist, it involves passing judgment on everything the scientist comes across in the course of his investigation.

Objectivity
This means that scientist should be able to develop the ability to perceive or describe something without being influenced by personal emotions or prejudices. By being objective, scientist should be able to describe objects, events or things as they are.

Suspended Judgment
This means that scientist should not come into conclusion about something he has not got all the evidence.

Willingness to Change Opinion
Knowledge in science is not permanent but keeps changing as new information are acquired. Therefore scientist should develop the habit of changing his opinion whenever there is a change in any findings.

Respect for Evidence
All scientists should always look for evidence and respect it. In the course of carrying out investigation, scientist should not base their conclusion on hearsay.

Open Mindedness
This means that scientists should always be ready to share their findings with other scientists. They should allow their fellow scientist to see and criticize their work so as to improve on it.

Honesty
Scientists should develop the spirit of presenting their findings as they are rather than manipulating. They should be honest in the course of carrying out their investigation.

Questioning
Scientists should be curious by asking questions about events and happenings in their environment.

Other scientific attitudes apart from the above include humility and perseverance.

Humility
Scientists should develop the spirit of humility in the course of carrying out scientific activities. They should be cool- headed and submissive especially to those above them.

Perseverance
Scientists should develop the spirit of perseverance in the process of carrying out their activities especially when they are passing through experimental failures and frustrations. They should endure all difficulties.

4.3 Who is a Scientist?

A scientist is someone who has scientific training or background. According to Ukoli (1985), a scientist is an individual who tries to establish the laws of nature in his various activities using the processes of science. Scientist uses rational and logical reasoning to explain the natural phenomenal. He is always in the laboratory carrying out investigation about natural phenomena.

4.4 Attributes of a Scientist

1. A scientist must develop scientific attitudes such as curiousity, open mindedness, honesty etc.
2. A scientist must be emotionally sensitive in addition to the application of rational and logical approaches in the course of carrying out his investigation
3. A scientist must be sensitive to "chance discovery". This is the ability of making discovery by accident or by chance.
4. A scientist must be kept abreast of development in relevant literature. This means that he is expected to possess sufficient wide range of relevant knowledge so as to be up to date.
5. A scientist must be competent in design and test experiments. He must also develop ability to formulate hypotheses and design experiments to test the hypotheses.
6. A scientist must be ready to understand repeated failure and frustration as they appear in the course of carrying out scientific activities.
7. Must be able to use appropriate language when reporting his findings.
8. A scientist must familiarise himself with the lives and works of the past scientist. This is because they may serve as a source of inspiration to him.

5.0 ACTIVITY

i. Explain how Proshansky and Seidenberg describe scientific attitude.
ii. Give reasons why scientist should develop the above mentioned attitudes in the course of carrying out investigations.
iii. Describe who a scientist is from your own point of view.
iv. Discuss other attributes of scientists you know.

6.0 SUMMARY

In this unit, you have learnt about some of the attitudes that scientist must develop to carry out investigations effectively. In the next unit, you will be introduced to the method which scientist use in carrying out investigations. This is known as scientific method. For anybody to be called a scientist, he must be able to imbibe the various attitudes of science and posses certain characteristic. This is the major difference between science discipline and other fields.

You will also see the various steps involve in scientific method and the induction and deduction method of scientific investigation.

7.0 ASSIGNMENT

i. State and explain three attitudes of science you have learnt.
ii. What are the attributes of a scientist?

8.0 REFERENCES/FURTHER READING

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UNIT 4 THE SCIENTIFIC METHOD

CONTENTS

1.0 INTRODUCTION

In the previous unit, we discussed what scientific attitudes are. We were also able to mention and explain some of the characteristics of a scientist. In this unit, you will be introduced to the concept of scientific method and the steps involved in using scientific method.

2.0 OBJECTIVES

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

- describe scientific method;
- differentiate between inductive and deductive method;
- list the steps involved in scientific method; and
- give an imaginary illustration of scientific method.

HOW TO STUDY THIS UNIT

- Read through this unit with care.
- Study the unit step by step as the points are well arranged.

NOTE: ALL ANSWERS TO ACTIVITIES AND ASSIGNMENT ARE AT THE END OF THIS BOOK. THIS APPLIES TO EVERY OTHER UNIT IN THIS BOOK.

3.0 WORD STUDY

- **Hypothesis** – a tentative explanation for a phenomenon used as a basis for further investigation.

- **Theory** – body of rules, ideas, principles and techniques that to a subject.

4.0 MAIN CONTENT

4.1 Meaning of Scientific Method

Scientific method can be said to be a general principle which guide scientists in the search for new knowledge. Attempts have been made to describe scientific methods in a series of steps but no single description has ever been satisfactory to all concerned. This is because scientists do similar things when investigating, but there are different approaches and different ways by which they evaluate what they find. The exact approach a scientist use depends on the individual doing the investigation as well as the particular field of science being studied. However, there are certain activities that seem to be common to scientists in different fields as they conduct scientific investigations.

4.2 Inductive and Deductive Reasoning

Apart from the scientific method, scientist also uses two philosophic ways of reasoning in the course of carrying out investigation. These are inductive and deductive reasoning. These methods of reasoning were developed by the Greek philosophers. The theories of inductive and deductive reasoning laid the foundation for the scientific method.

Inductive method of reasoning was developed by Francis Bacon. It involves taking particular cases and using them to draw general conclusion. In other words, inductive method involves moving from specific to general. In this method, scientists collect bits of information through a gradual process of investigation and forming them into theories. Deductive method on the other hand is the process of inferring new facts from something already known. Deductive reasoning has to do with using the logic of a theory to generate propositions that can then be tested. Deductive reasoning was developed by the ancient Greek philosopher, Aristotle.

4.3 Stages of Scientific Method

There are six major stages involved in scientific method. These are listed below.

Step 1	Observation
Step 2	Statement of the Problem
Step 3	Formulating Hypotheses
Step 4	Conducting experiments on the basis of hypothesis
Step 5	Collection and Analysis of Data
Step6	Drawing conclusion and Formulation of Theories

Step 1: Observation

Here scientists ask questions out of curiousity about their natural environment. In the process of asking questions they observe. Observation could be direct or indirect. Direct observations involve the use of all the sense organs while indirect observation involves the use of other scientific aids such as microscope, telescope, etc. Most observations made by scientist often lead to identification of problem and this forms the basis of stage two.

Step 2: Statement of the Problem

As a result of observation made, scientist identify problems and state the problem in a researchable form. The statement of the problem could be as a result of series of observations made either directly or indirectly.

Step 3: Formulating Hypothesis

This stage involves formulating hypothesis based on the problem stated in step two. This means that scientist make intelligent guesses pertaining to the possible causes of the problem stated in step two. The formulation of hypothesis often lead to conducting experiments on the basis of the hypothesis and this forms the fourth step.

Step 4: Conducting Experiment

In this stage, experiments are carried out to test the hypothesis formulated in step three. The experiment could be conducted in the laboratory or outside the laboratory depending on the nature of the problem stated. As experiments are conducted, data will be collected and analysis of the data will be will be carried out. This forms the basis for the fifth step.

Step 5: Collection and Analysis of Data

The fifth stage of scientific method is the collection and analysis of data. As the experiment is conducted, information from the experiments is recorded. The data recorded could be in form of drawing graphical, symbolic and pictorial representation. At the end of the experiment, the data collected will be analysed and this will form the basis of the final stage which is the conclusion and formulation of theory.

Step 6: Conclusion and Formulation of Theory

On the basis of the data collected in stage five, conclusions are made and laws and theories are formulated.

4.4 Hypothetical Illustration of the Scientific Method

In a biological garden where albino rats are raised, it was observed (observation) by the curator that some of the animals are dying on a daily basis. This poses a serious problem to the curator. The curator of the rat started making intelligent guesses (hypothesis) about the possible cause of the death of the rats. For instance, some of the possible guesses made could be:

- could it be due to infection by disease?
- could it be due to bad food or water?
- could it be due to action of predators?
- could it be due to harsh weather condition?

All the above questions are intelligent guesses which are also known as hypotheses. On the basis of the hypotheses, experiments are conducted. This means that experiments will be carried out to test each of the hypotheses. For instance, to determine whether the cause of the death is due to infection by disease, the animals (rats) will be taken to a veterinary pathology laboratory for a test. Each of the hypotheses will be tested and eliminated. In the course of carrying out the experiment, data will be collected (connection of data) based on what is observed during the experiment. The data collected will be analysed either in graphical pictorial or in figure forms. Based on the data analysed, a conclusion will be reached as to what is responsible for the death of the rats. Based on the conclusion, a theory will be formed to explain the cause of the deaths of albino rats.

4.5 Limitation of Scientific Method

It should be noted that scientific method has its own limitations. Below are some of the major limitations.

1. Scientific method can only be applied to questions that have factual basis. Questions concerning morals, value, judgement social issues and attitudes cannot be solved using scientific method.

2. Scientific methods cannot be used to solve all the problems of man, for instance the problem of famine, drug abuse and pollution are human caused problems and must be resolved by man. Science may provide some tools for social planners, politicians and ethical thinkers but science does not have nor does it attempt to produce all the answers to the problems of human race.

3. Scientific method is not 100 per cent reliable as it is subject to experimental errors.

5.0 ACTIVITY

i. Describe the scientific method of investigation.

ii. Mention the names of the scholars that developed inductive and deductive reasoning.
iii. Explain how you will use scientific method in to solve a problem in your area of specialisation.
iv. Mention and explain other limitations of scientific method not mentioned above.

6.0 SUMMARY

In this unit, you have learnt what scientific method is all about and the steps involved in the use of scientific method. In the next unit, you will be introduced to the beginning of human history and civilisation.

7.0 ASSIGNMENT

i. State the major differences between inductive and deductive method.
ii. What are the limitations of scientific methods?

8.0 REFERENCES/FURTHER READING

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UNIT 5 THE BEGINNING OF HUMAN HISTORY AND CONTRIBUTION OF EARLY HUMAN CIVILISATION

CONTENTS

1.0 INTRODUCTION

In Unit four, the steps involved in scientific method were defined and described. The limitations of using scientific method were also highlighted. In this unit, you will learn about the beginning of human history and civilisation and you will also see how the ancient civilisation has contributed to the development of modern science.

2.0 OBJECTIVES

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

- describe the nature and origin of man;
- explain the theory of evolution; and
- relate how early human civilisation has led to the development of modern science and technology.

HOW TO STUDY THIS UNIT

- Read through this unit with care.
- Study the unit step by step as the points are well arranged.

NOTE: ALL ANSWERS TO ACTIVITIES AND ASSIGNMENT ARE AT THE END OF THIS BOOK. THIS APPLIES TO EVERY OTHER UNIT IN THIS BOOK.

3.0 WORD STUDY

- **Evolution** – theoretical process by which all species develop from earlier forms of life.

- **Species** – a sub division of genus considered as a basic biological classification and containing individual that resemble one another and may interbreed.

4.0 MAIN CONTENT

4.1 Origin of Life

Many scientists have given possible explanation to the origin of life on earth. Most of the theories are of the view that the first living things on earth emanated from non-living matter. According to this theory, elements and compounds were the only matter present when the earth was formed and that form of energy such as lightning caused simple molecules to combine. This led to larger and more complex molecules which were the type present in living things today.

In 1953, an American scientist, Stanley Miller, performed an experiment based on the theory that the early atmosphere of the earth was much different than it is today. According to him, the early atmosphere probably was made of many gasses such as methane, ammonia and hydrogen. Matter was also present. In Miller's experiment, these gases combined to form amino acids when electric discharges passed through them. These amino acids formed the building blocks of protein which is the basic material of living organism today.

Amino acids contain carbon, hydrogen, nitrogen and oxygen. The first amino acids combined to form proteins and these proteins then combined to form larger and more complex compounds. These compounds have the ability to reproduce themselves such that exact copies of the protein are formed.

According to this theory, the first simple forms of life began in the oceans in form of one –celled organisms from which more complete forms of life developed.

4.2 Theory of Evolution

The first person to make a comprehensive theory of evolution was the French Scientist - Lamark. He tried to derive the whole variety of living things by descent from simpler forms of life. He proposed that all living matters had an inner tendency to evolve from the simpler creatures to the more complex ones. Lamark accounted for this by supposing that simple creatures were being made afresh all the time by spontaneous generation from non- living matter. The diversity noticed in living things today was due to the fact that each creature was striving to adapt itself to its special mode of life.

Other scientist that further proved and refined Lamark's theory were Charles Lyell, John Ray Linneaus and Charles Darwin. Charles Darwin really worked extensively on the theory of evolution and even proved it in his book titled "The origin of Species". In this book, Darwin reviewed the evidence for inherited variations in domestic animals and the way in which selection could give rise to varieties, which could be

inherited and passed to offspring. He also talked on the theory of "Natural selection" in his book.

In 1858, Alfred Wallace, a British biologist in his investigation came to the same conclusion with that of Charles Darwin's. Both Darwin and Wallace in their separate investigations reached the following conclusions that:

- different species of plants and animals were related;
- new species were appearing from the old one and
- other species were disappearing as a result of natural selection.

4.3 Origin of Man

Charles Darwin believed that the origin of man is equally in his theory of evolution. The origin of man is described by Charles Darwin in his book – "the Descent of Man." This theory stated that man had developed from some lower animals. Darwin supported this assertion with available data which pointed out that the living mammals of any specific area were closely related to the fossilised remains of extinct species which had been discovered there. He concluded, therefore, that since the two living primates most closely resemble man (that is, Chimpanzee and Gorilla) and are both found in Africa, it would be reasonable to conclude that man's birth place would eventually be discovered in the African continent.

Another school of thought traced the origin of man to the theory of creation. This theory states that man was specially created by Almighty God and endowed from the very beginning with all the physical and mental attributes of modern man in His own image.

4.4 The Beginning of Early Human Civilisation

The science of which histories are written is usually that of the West and the origin of this Western Science lies deep in the remote human past and in several civilisations.

Civilisation simply means the social process by which societies achieve an advanced stage of development and organisation. A civilised society is a society in an advanced state of social development with complex legal political and religious organisations.

In a nutshell, it is an advanced state of intellectual, cultural and material development in human society marked by progress in arts and science.

It should be noted that the present ways of comprehending the natural world by scientist is a recent development. The ancient civilisation achieved highly developed techniques in term of their perception of the universe, religion and legal system in the complete absence of a conception of science as it is now understood.

5.0 ACTIVITY

Discuss the origin of man from the evolution theory of creation.

6.0 SUMMARY

In this unit, you have learnt about the origin of living things, evolution theory, the origin of mankind as well as the meaning of civilisation. Prominent among the ancient civilisations include, Mesopotamia, Egypt, Greek, China, Maya and Indus River Valley to mention but few.

In the next module, you will see how civilisation in the ancient cities of Egypt and Mesopotamia has contributed to the development of modern science.

7.0 ASSIGNMENT

i. Discuss how the theories of evolution and that of creation can be used to explain the origin of man.
ii. State the major conclusions reached by Charles Darwin and Wallace in their separate experiments on the origin of species.

8.0 REFERENCES/FURTHER READING

Bakker, G.,& Clark L. (1988). *Explanation in an Introduction to the Philosophy of Science*. Mountain View: California Mayfield.

Hoover, R.K. (1984). *The Elements of Social Scientific Thinking*. New York: Martins.

Kuhn, S.T. (1996). *The Structure of Scientific Revolutions*. Chicago: The University of Chicago Press.