COURSE CODE:	GNS 204
COURSE TITLE:	LOGIC AND HISTORY OF SCIENCE
NUMBER OF UNITS:	2 Units
COURSE DURATION:	Two hours per week

COURSE DETAILS:

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COURSE CONTENT:

This is a course in general studies: it examines some of the conceptual and theoretical foundations of logic and science. It also investigates how logic can be applied to life and the problems confronting science with specific emphasis on Nigeria. The topics to be studied include: General introduction to logic (what is logic?), Nature of Arguments (inductive and deductive arguments), Validity and Soundness (truth and validity), Language and Definition, Fallacies, Problems of Induction, Nature of Science, Methods of Science (observation, hypothesis, experiments and scientific explanations), Problems of Scientific Technological Development in Nigeria and science and Society.

COURSE REQUIREMENTS:

This is a compulsory course for all students in the University. In view of this, students are expected to participate in all the activities and have a minimum of 75% attendance to be able to write the final examination.

READING LIST:

- A. G. A Bello (2000) *Introduction to Logic*, Ibadan: University Press PLC
- Born, Max (1949), *Natural Philosophy of Cause and Chance*, Peter Smith, also published by Dover, 1964. From the Waynflete Lectures, 1948.
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- Copi Irving M. *An Introduction to Logic* (11 ed.) New York: Macmillan.
- Daniel Flage, (1995) *Understanding Logic*, Englewood Cliffs, New Jersey: Prentice-Hall inc.
- Deborah Benneth, (2005) *Logic Made Easy*, London: Penguin Books
- D.N. Ucheaga, *Rudiments of Logic* (University of Calabar Press)

- Fleck, Ludwik (1975), *Genesis and Development of a Scientific Fact*, Univ. of Chicago, (written in German, 1935, *Entstehung und Entwickelung einer wissenschaftlichen Tatsache: Einführung in die Lehre vom Denkstil und Denkkollectiv*) English translation
- Godfrey-Smith, Peter (2003), *Theory and Reality: An introduction to the philosophy of science*, University of Chicago Press.
- Gauch, Hugh G., Jr. (2003), *Scientific Method in Practice*, Cambridge University Press, http://books.google.com/?id=iVkugqNG9dAC 435 pages
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- Kuhn, Thomas S.(1962), *The Structure of Scientific Revolutions*, University of Chicago Press, Chicago, IL, 2nd edition 1970. 3rd edition 1996.
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- Popper, Karl R., *The Logic of Scientific Discovery*, 1934, 1959.
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- S. F. Baker (1965) *The Elements of Logic*, New York: McGraw-Hill Book Company.
- Quine, W. V. O (1967) *Methods of Logic*, Revised ed. New York: Holt Rinehart & Winson.

LECTURE NOTES

WEEK 1

What is logic?

Etymologically, "logic" is a term derived from the Greek word, *logos.* It is sometimes translated to mean "sentence", "discourse", "reason", "rule" or "ratio". In the former sense, logic can be defined as *the study of the principles of correct reasoning*. Reasoning involves making inferences, particularly, from one set of information to another set of information. Some inferences are good while others are bad. For example,

a. If I see a smoke and infer that there is a fire, this seems like a good inference
b. If I see a smoke and infer that the moon is made of cheese, this doesn't seem like a good inference.

Argument is about making good inferences. It requires that the premises provide grounds for the truth of the conclusion. To make a valid argument, the conclusion must necessarily be derived from the evidence provided by the premises. Look at more examples:

If there is smoke, there is fire

There is smoke
Therefore, there is fire
(This could be classified a good argument because the conclusion in some sense follows from the premises).

If there is smoke, there is fire
There is smoke
Therefore, I am the President of Nigeria
(This could be classified a bad argument because the conclusion has nothing to do with the premises).

Logic is studied to make good inference. In formal logic, we focus on a particular kind of inference, called an argument.

The central problem of logic is separating bad (incorrect) arguments from good (correct) arguments. Logic thus teaches the techniques and principles to distinguish correct from incorrect arguments. This does not mean that only logic students can distinguish between bad and good arguments but since practice makes perfect, there is every tendency that a student of logic will do better.

The main principles of logic are the *principles governing the validity of arguments* - whether certain conclusions follow from some given assumptions or evidence. If the premises provide adequate grounds for accepting the conclusion, if asserting the premises to be true warrants asserting the conclusion to be true also, then the reasoning is correct. Otherwise, the reasoning is incorrect. For example,

If Akin is a philosopher, then Akin is eccentric	(Premise)
Akin is a philosopher.	(Premise)
Therefore, Akin is eccentric.	(Conclusion)

If Abeokuta is in Ogun State, then Abeokuta is not in Cameron.	(Premise)
Abeokuta is in Ogun State.	(Premise)
Therefore, Abeokuta is not in Cameron.	(Conclusion)

These two arguments here are obviously good arguments in the sense that their conclusions follow from the assumptions. If the assumptions of the argument are true, the conclusion of the argument must also be true. All the above examples are cases of a particular form of argument known as "*modus ponens*".

Logic is mainly concerned with the correctness of the completed reasoning process and not in the actual reasoning process (psychology). Logic is about the validity of arguments. It also studies consistency and logical truths, and properties of logical systems such as completeness and soundness. However, these concepts are also very much related to the concept of validity.

Distinction between Logic and Psychology:

Logic is not the same thing as psychology. Logic is the study of principles of *correct* reasoning while psychology studies the process of human reasoning. Psychology deals with empirical matters like the actual reasoning habits of people, including their mistakes but logic is not about empirical matters. It is solely about pattern of reasoning.

Distinction between formal and informal logic

The term "informal logic" is often used as critical thinking. It deals with the study of reasoning and fallacies in the context of everyday life. "Formal logic", on the other hand, is concerned with formal systems of logic (rules for testing validity of arguments). They can either be *Sentential logic/* "Propositional logic" or *Predicate Logic*.

Nature of Argument:

Argument in logic is not about disagreement or fight among people but an activity of inferring where one proposition is affirmed on the basis of one or more other propositions that are accepted at the starting point of the process. Logician is concerned with the propositions at the initial and the end points of that process, and the relation between them. An argument is a list of statements, one of which is the *conclusion* and the others are the *premises* or *assumptions* of the argument. The premises are intended to support or justify the conclusion. It is not enough for people to make claim. A claim is justified by evidence to back it up.

To give an argument is to provide a set of premises as reasons for accepting the conclusion. To give an argument is not necessarily to attack or criticize someone. Arguments can also be used to support other people's viewpoints or to win people to your own side.

Propositions are used to construct arguments. Propositions are either true or false, so, they differ from questions, commands, and exclamations. Propositions are declarative statements, questions are interrogative, commands are imperative while exclamations are exclamatory sentences. For example,

Declarative	**the window is shut, it is raining, 2 + 2 = 4, Ade is a student**
*Interrogative	is the window shut? Are you hungry?
*Imperative	shut the window, shut the door

Declarative statements are always part and peculiar to a language whereas propositions are not peculiar to any language. Proposition is the meaning or idea a sentence is carrying.

Logic deals with declarative sentences, that is, statements capable of being true or false. A statement expresses a proposition i.e. the meaning of a statement. While a statement is something concrete (symbol or a sound wave), a proposition is abstract. Snow is white and "Yinyin funfun" are different statements expressing the same proposition. We have two types of statements, simple and compound statements. Simple statements convey just one simple idea. For example, Abeokuta is in Ogun State, Copper is a metal, water boils at 100^0c. A compound statement conveys more than one idea. Compound statements are conjoined by prepositions in natural language but in logic, by five logical connectives which are "and/**.**", "either…or/v", "if…then/ ⊃ conditional statement, "if and only if/ ≡ bi-conditional statement and negation (~/it is not the case that).

When two ideas are brought together, they form a compound statement. For example, Lagos is in Nigeria and Abuja is the capital of Nigeria (pq); Either Bola is in Abuja or Akin is in London (p v q); if Bola puts to bed then Bola is a mother (p ⊃q); Akin is a father if and only if Bola is the mother the baby (p ≡q).

Copi (1973:2) defines an argument as "any group of propositions or statements, of which one is claimed to follow from the others, which are alleged to provide grounds for the truth of that one". Every argument has a structure comprising premises and conclusion. The conclusion of an argument is that proposition which is affirmed on the basis of other propositions in the argument. Premises

are other propositions which provide grounds or reasons for accepting the conclusion of the argument. Conclusion and premises are relative terms for propositions. For example:

All humans are mortal. (Premise)
Socrates is human. (Premise)
Therefore, Socrates is mortal. (Conclusion)

If you want to find a good job, you should work hard. (Premise)
You do want to find a good job. (Premise)
So, you should work hard. (Conclusion)

If the liquid is acidic, the litmus paper would have turned red. (Premise)
The litmus paper has not turned red. (Premise)
Therefore, the liquid is not acid. (Conclusion)

The first two sentences in the above examples are the premises of the argument, and the last sentence is their conclusion. To give this argument is to offer the premises as reasons for accepting the conclusion.

A few points to note:

- Dogmatic people tend to make assertions without giving reasons. When they are criticized they often fail to give arguments to defend their own opinions.
- To improve our critical thinking skills, we should develop the habit of giving good arguments to support our opinions.
- To defend an opinion, think about whether you can give more than one argument to support it. Also, think about potential objections to your opinion, e.g. arguments against your opinion. A good thinker will consider the arguments on both sides of an issue.

How to look for arguments:

How do we identify arguments in real life? There are no easy mechanical rules, and we usually have to rely on the context in order to determine which are the premises and the conclusions. But sometimes the job can be made easier by the presence of certain premise or conclusion indicators. For example, if a person makes a statement, and then adds "this is because ...", then it is quite likely that the first statement is presented as a conclusion, supported by the statements that come afterwards. Other words in English that might be used to indicate the premises to follow include **since, firstly, secondly ...,for, as, after all, assuming that, in view of the fact that, follows from, as shown / indicated by, may be inferred / deduced / derived from**

Of course whether such words are used to indicate premises or not depends on the context. For example, "since" has a very different function in a statement like "I have been here since noon", unlike "X is an even number since X is divisible by 4".

Conclusions, on the other hand, are often preceded by words like, **therefore, so, it follows that, hence, consequently, suggests / proves / demonstrates that, entails, implies**

Definition of relative terms in constructing arguments:

i. Premiss: Premises are other propositions which provide grounds or reasons for accepting the conclusion of the argument.

ii. Conclusion: The conclusion of an argument is that proposition which is affirmed on the basis of other propositions in the argument.

iii. Inference: Inference is a term in logic which refers to the process by which one proposition is affirmed or arrived at on the basis of the truism of other proposition(s). For example in the argument, "If Taiwo is a mother then Taiwo is a parent. It is not the case that Taiwo is a perent. Therefore, Taiwo is not a mother.

iv. Statement: statements are declarative sentences. They are truth functional in nature. Logic deals with affirmative statements alone, that is, statements that can either be affirmed or denied. The way statements are denied in logic differs from the way they are denied in ordinary natural language. We negate propositions in logic by stating "it is not the case that…". So, if you want to say that Bayo is not a man, it will be stated logically as "it is not the case that Bayo is a man" or if you want to deny that Lagos is in Nigeria and Abuja is the capital of Nigeria, it will be stated as "it is not the case that both Lagos is in Nigeria and Abuja is the capital of Nigeria". This shows that the whole compound statement is negated. Statements are negated in logic this way so that it will be easier to manipulate them when testing for the validity of an argument.

v. Proposition: A proposition is a statement that is either true or false/ either asserted or denied. Proposition differ from question, command or exclamation. Questions are asked, commands given and exclamations uttered but none of them can be affirmed or denied (none can be judged to be either true or false). A proposition is a term otherwise used for a statement in an argument and it could either be a premise or a conclusion depending on the position it occupies in a particular argument. If a proposition is a claim it becomes the conclusion, if it provides reason or support to others in establishing a claim, it becomes a premise.

vi. Truth: As truth is to a statement/proposition so is validity to an argument. Every declarative statement in logic has a truth value, which means, it is either true or false.

vi. Validity: An argument is correct or valid if the logician examines the initial proposition(s)/premise(s), the final proposition (claim/conclusion) and the relationship between them and make a deduction from the truth of the premises to establish the conclusion, then such an argument so constructed is said to be valid.

Why study formal systems of logic?

There are many reasons for creating and studying formal systems of logic:

- There are many reasons for studying formal logic. One is that formal logic helps us identify patterns of good reasoning and patterns of bad reasoning, so we know which to follow and which to avoid. This is why studying basic formal logic can help improve critical thinking. Systems of logic helps to separate good reasoning from bad reasoning.
- The understanding of logic is presupposed in all disciplines. It is used to analyze complex arguments and make clear your thoughts.
- Logic helps in making rational decisions among many alternatives.
- Logic helps to make predictions, particularly for science students who need to make logical inferences during the course of carrying out experiments.

- Systems of logic can be used to *formalize* arguments in *natural languages*. A natural language is a language that is used for normal everyday communication in a human society. So languages such as Yoruba, English, Japanese, Irish, and French are all natural languages. By *formalization* we refer to the process of translating arguments or sentences in natural languages into the notations of formal logic. The reason for carrying out formalization is that very often they can help us **understand the logical structure of arguments better**, by identifying patterns of valid arguments. Also, the rules of proof in a formal system of logic are precisely specified. By formalizing an argument we can use the rules of proof to check whether the argument can indeed be proved to be valid.
- Because the rules of formal systems of logic are defined very clearly, we can program them into a computer and get a computer to construct and evaluate proofs quickly and automatically. This is particularly important in areas such as *Artificial Intelligence*, where many researchers teach computers to use formal logic in reasoning.
- Linguists are scientists who study natural languages. Many linguists also study formal languages and use them to compare and contrast with natural languages.
- Many philosophers are also interested in formal systems of logic. One reason is that natural languages are sometimes not precise enough to express certain ideas clearly. So sometimes they turn to formal systems of logic instead.
- Formal systems of logic are also interesting in their own right. Logicians and mathematicians are interested in finding out what they can or cannot prove, and also their many other logical properties. Formal systems of logic also play an important role in understanding the foundations of set theory and mathematics.
- Logic helps students to develop critical minds of evaluation and help them think fast.

Test Questions:

1. What is Logic?
2. Is there any difference between Logic and Psychology?
3. Distinguish between formal and informal Logic
4. What is an argument? Distinguish between sentence and statements in Logic.
5. Define the following terms: Premise, conclusion, validity, statement, truth, proposition and inference.
6. Mention four reasons why we study Logic?
7. Mention three each among premise and conclusion indicators that you know.

WEEK 2

Types of arguments:

Apparently, there are two types of arguments, **inductive** and **deductive** arguments.

- **Inductive Argument:**

An argument is inductive if its premise(s) only provide some support but do not guarantee its conclusion. The premises in inductive argument are only supposed to make the conclusion more likely, but not necessarily certain. Inductive argument is structured in such a way that from some set of factual propositions (premises), a conclusion is inferred. For example,

There is smoke
Therefore, there is fire
(The truth of the premise here only makes the conclusion more likely, it does not guarantee it)

This ripped tomato is red;
That other ripped tomato is red
Therefore, all ripped tomatoes are red.

Copper, a metal conducts electricity.
Bronze, a metal conducts electricity.
Aluminum, a metal conducts electricity
Therefore, all metals conduct electricity.

I bought bread in the shop on Tuesday and it was stale.
I bought bread in the shop on Wednesday and it was stale.
I bought bread in the shop on Thursday and it was stale.
Therefore, if I buy a loaf of bread in the shop by Friday it will be stale.

In the first throw, the coin turned tail.
In the second throw, the coin turned tail.
In the third throw, the coin turned tail.
Therefore, in the fourth throw, the coin will turn tail.

From the above examples, it is observed that the first sets of proportions (**premises)** give support to the last stated proposition (**conclusion**) either strongly or weakly as the case may be.

The evidence provided in inductive arguments only makes the argument either strong or weak. The conclusion is always found to be more informative than the premises. Inductive reasoning has its root in the notion of "uniformity of nature" which holds that tomorrow will be like the past. Scientists, as defenders of uniformity of nature, do point out that many events and processes in nature occur the same way over and over again to eternity. For example, because it has been observed over times that the following happens, the scientists thus conclude that:

(a). Lightning is followed by thunder. (b) Iron rusts whereas gold does not.
(c) Chickens lay eggs, but goats do not. (d) Mammals suckle their young ones, While reptiles do not.

Scientists on the basis of uniformity of nature projects and predicts what happens in the future. They rely on the fact that the future shall always be like the past and the present will repeat itself. Looking at the examples above, we discover that there is nothing in the premises of the arguments that shows that their conclusions are necessarily certain or is there anything in the premises to compel us to accepting that their conclusions are true. For example, observing two instances of ripped tomatoes do not guarantee the fact that other ripped potatoes will be red. The premises only support the conclusion but do not guarantee that all ripped tomatoes would be red. There is nothing that guarantees us that in future a ripped tomato will be red. It is possible for the scientists in the

future to come up with specie of tomatoes that will not be red when ripped. Again, in the other example, there is nothing in the premises that assures us that the next loaf of bread I will buy will be stale; rather, the premises only support the conclusion, it does not guarantee it. There is only a 50% chance of buying a staled-loaf of bread in the shop on Friday.

Inductive arguments cannot be "valid" or "invalid" in the sense in which the terms are applied to deductive arguments. They are evaluated as better or worse, according to the degree of support given to their conclusion by their premises. Thus, the greater the likelihood, or probability, that its premises confer on its conclusion, the greater the merit of an inductive argument. Even if all its premises are true, it must fall short of certainty. Therefore, the support offered by the premises to the conclusion in inductive arguments are either said to be high (strong) or low (weak) or none at all. The premises of inductive arguments offer high/low or no degree of probable support to the conclusion. Let's look at the following Examples:

i. Akin studied hard and passed his examination.
Dele studied hard and passed his examination.
Mabel studied hard and passed her examination.
Therefore, all who study hard will pass their examination.
*** The premises offer a low degree of support to conclusion.**

iii. Iron, a metal expands when heated.
Copper, a metal expands when heated.
Bronze, a metal expands when heated.
Therefore, all metals rust when exposed to air.
***The premises do not support the conclusion at all.**

If an argument is valid (deductive argument), nothing additional in the world will make it more valid; if a conclusion is validly inferred form some set of premises, nothing can be added to that set to make that conclusion follow more validly or more strictly or more logically. But, the relation between premises and conclusion claimed for even the best inductive argument is much less strict and very different in kind. Addition of other premises can only make it either stronger or weaker. For example,

Most philosophers are atheist.
John is a philosopher.
Therefore, John is probably an atheist.

This is a good inductive argument; if its first premiss is true, and if its second premiss is also true, its conclusion is more likely true than false. But, in case new premises are added, they will either strengthen or weaken the argument. Suppose I add these premises, John is a Pastor with Redeem Christian Church and that most Pastors in the Redeem Christian Church are not atheist.

Then, the conclusion will no longer seem very probable but otherwise because the original inductive argument has been greatly weakened by the presence of this additional information about John. In fact, if the final premiss were transformed into the universal proposition "No Pastors in Redeem are atheist", the opposite of the original conclusion would now follow deductively, that is, validly, from the set of premises affirmed.

Inductive inferences are sometimes said to move from the particular to general while deductive argument move from general to particular. On analysis, this may not be so. Inductive argument need not rely on particular premises but may have universal (general) propositions for its premises as well as for its conclusions. For example,

All cows are mammals and have lungs.	(Premise)
All whales are mammals and have lungs.	(Premise)
All humans are mammals and have lungs.	(Premise)
Therefore, probably all mammals have lungs.	(Conclusion)

So also is it possible for an inductive argument to have a particular proposition for its conclusion. For example,
Samuel Doe was a dictator and was ruthless.
Abacha was a dictator and was ruthless.
Gaddafi was a dictator.
Therefore, Gaddafi is probably ruthless.

Deductive Argument:
In deductive argument the premises not only support but guarantee its conclusion: the premises provide absolutely conclusive grounds for the truth of its conclusion. A deductive argument is valid if its premises and conclusion are so related to the extent that it is impossibly for the premises to be true and the conclusion false. Deductive argument is valid if its conclusion is necessarily and logically drawn from its premise(s). Deductive argument is most particularly about clarifying the relationship that exists between the premises and the conclusion. Every deductive argument is either valid or invalid because they are only about the logical relation existing between premises and conclusion. Examples of deductive arguments includes,

1. Those that go from general to particular

i. All women are liars	All husbands are responsible
Toyin is a woman	Akin is a husband
Therefore, Toyin is a liar	Therefore, Akin is responsible.
ii. All metals conduct electricity	All husbands are responsible
Iron rod is a metal	Akin is a husband
Therefore, Iron rod conducts electricity	Therefore, Akin is responsible.
iii. All human beings are mortal	All dogs are mammal
Tade is a human being	Bingo is a dog
Therefore, Tade is mortal	Therefore, Bingo is mammal

2. Those that go from general to general

i. All women are human beings	All academician are educated
All mothers are women	All scholars are academicians
Therefore, all mothers are human beings	Therefore, all scholars are educated
ii. All human beings are mortal	All gutter boys are wayward
All UNAABites are human beings	All Yahoo boys are gutter boys
Therefore, all UNAABites are mortal	Therefore, all Yahoo boys are wayward

iii. All physicians are University graduates
All members of Nigerian Medical Association are physicians
Therefore, all members of Nigerian Medical Association are University graduates.

3. Those formulated according to Rules of Inference (one of the laws of logic)
Modus Ponens:

i. If shade puts to bed then shade is a mother	$p \supset q$	(conditional statement)
Shade puts to bed	p	(antecedent affirmed)
Therefore, Shade is a mother	$\therefore q$	(consequent affirmed)

Note: if the antecedent of a conditional statement is true and affirmed, then its consequent necessarily follows, else we would be committing **fallacy of affirming the antecedent**.

Modus Tollens:

i. If Shade puts to bed then Shade is a mother	$p \supset q$	(conditional statement)

Shade is not a mother ~q (consequent denied)
Therefore, Shade does not put to bed ∴/~p (antecedent denied)

Note: if the consequent of a conditional statement is denied, then its antecedent cannot be affirmed in the conclusion, else, we would be committing **fallacy of affirming the consequent**.

Hypothetical Syllogism:

i. If UNAAB is in Abeokuta then UNAAB is in Ogun State p ⊃q
if UNAAB is in Ogun State then UNAAB is in Nigeria q ⊃r
Therefore, if UNAAB is in Abeokuta then UNAAB is in Nigeria ∴/ p ⊃r

ii. If Joke is wayward then Joke is dangerous p ⊃q
If Joke is dangerous then Joke is unmanageable q ⊃r
Therefore, if Joke is wayward then Joke is unmanageable ∴/ p ⊃r

Deductive Arguments vs. Inductive Arguments

It may seem that inductive arguments are weaker than deductive arguments because there must always remain the possibility of their arriving at false conclusions, but that is not entirely true. With deductive arguments, our conclusions are already contained, even if implicitly, in our premises. This means that we don't arrive at new information - at best, we are shown information which was obscured or unrecognized previously. Thus, the sure truth-preserving nature of deductive arguments comes at a cost.

Inductive arguments, on the other hand, do provide us with new ideas and thus may expand our knowledge about the world in a way that is impossible for deductive arguments to achieve. Thus, while deductive arguments may be used most often with mathematics, most other fields of research make extensive use of inductive arguments.

4. Differences between Inductive and Deductive Arguments

Inductive Argument	Deductive Argument
1. Premises only provide some support to the conclusion but do not guarantee it.	Premises do not only support but also guarantee the conclusion.
2. Inductive reasoning offers at best a very high degree of probability (up to 99.99%) but not certainty. E.g. Logic helps us to identify and eliminate fallacies. Logic helps us to predict with precision. Logic sharpens people's critical awareness. Logic helps us in taking rational decisions. Logic is vital in clarifying and evaluating our language. Logic helps us in efficient planning. Logic is the money of the mind Therefore, Logic should be taken and passed by all University students.	Deductive reasoning offers certainty. E.g. All ladies are lairs Shade is a lady Therefore, Shade is a lair.
3. There is no limit to the number of its premises.	Limited to maximum of two (2) premises.
4. Classified as good or bad, weak or strong; adequate or inadequate.	Classified as valid or invalid; sound or unsound.
5. Conclusion contains more information than the premises. It even projects into the future.	Conclusion contains less information than the premises. There is no information in the conclusion which is not already contained in the premises.

6. Are of two types: i. Those that go from particular to general; and ii. Those that go from Particular to particular.	Are of three types: Those that go from General to particular; and Those that go from General to general; and Those formulated according to the Rules of Inference (Laws of Logic).

7. Relies heavily on experience, facts, content, evidence, etc.	It does not rely on evidence, experience or observation to establish its conclusion. Emphasis is on the structure of the argument rather than its content.
8. Inductive reasoning is the method of science and scientific theories took their origin from it.	It is not the method of science; hence, not so useful to scientists.

Test Questions:

1. How many types of arguments do we have? Name them.
2. Give two examples each of inductive and deductive arguments.
3. What makes an argument valid, invalid, weak or strong?
4. State at least four differences between inductive and deductive arguments.

WEEK 3

VALIDITY AND SOUNDNESS

Definition of validity

One desirable feature of arguments is that the conclusion should follow from the premises. But what does it mean for the conclusion to follow from the premises? Consider these two arguments:

i. John is over 70 years old. So, John is over 20 years old.
ii. John is over 20 years old. So, john is over 70 years old.

Intuitively, the conclusion of the first argument follows from the premise, whereas the conclusion of the second argument does not follow from its premise. But how should we explain the difference between the two arguments more precisely? Here is a thought: In the first argument, if the premise is indeed true, then the conclusion cannot be false. On the other hand, even if the premise in the second argument is true, there is no guarantee that the conclusion must also be true. For example, John could be 30 or 40 years old.

Therefore, the above idea can be used to define a *deductively valid argument*, or *valid argument*.

An argument is valid if and only if there is no logically possible situation where all the premises are true and the conclusion is false at the same time.

The idea of validity provides a more precise explication of what it is for a conclusion to follow from the premises. Applying this definition, we can see that the first argument above is valid, since there is no possible situation where John can be over 70 but not over 20. The second argument is not valid because there are plenty of possible situations where the premise is true but the conclusion is false.

Consider a situation where John is 25 or one where he is 85. The fact that these situations are possible is enough to show that the argument is not valid, or *invalid*.

Validity and truth

What if we have an argument with more than one premise? Consider this example:

All cows can fly.

Anything that can fly can swim.

So, all cows can swim.

Although, it is obvious that the two premises of this argument are false, this is actually a valid argument. To evaluate its validity, ask yourself whether it is possible to come up with a situation where all the premises are true and the conclusion is false. (We are not asking whether there is a situation where the premises and the conclusion are all true- we are not talking about empirical facts but logical possibility.) Of course, the answer is 'no'. If pigs can indeed fly, and if anything that can fly can also swim, then it must be the case that all pigs can swim. Remember that logic is about reasoning pattern and not empirical facts.

So the above example has only told us that **the premises and the conclusion of a valid argument can all be false**.

Note: Hopefully you will now realize that validity is not about the actual truth or falsity of the premises or the conclusion. Validity is about the **logical connection** between the premises and the conclusion. A valid argument is one where the truth of the premises guarantees the truth of the conclusion, but validity does not guarantee that the premises are in fact true. All that validity tells us is that **if the premises are true; the conclusion must also be true**.

Showing that an argument is invalid

Let's consider this argument:

John loves Bola. Bola loves Tony. So, John loves Tony.

This argument is not valid, for it is possible that the premises are true and yet the conclusion is false. Perhaps John loves Bola but does not want Bola to love anyone else. So John actually hates Tony. The mere possibility of such a situation is enough to show that the argument is not valid. Let us call these situations *invalidating counterexamples* to the argument. Basically, we are defining a valid argument as an argument with no possible invalidating counterexamples. To sharpen your skills in evaluating arguments, it is therefore important that you are able to discover and construct such examples.

Notice that a counterexample need not be real in the sense of being an actual situation. It might turn out that in fact that John, Bola and Tony are members of the same family and they love each other. But the above argument is still invalid since the counterexample constructed is a possible situation, even if it is not actually real. All that is required of a counterexample is that the situation is a

coherent one in which all the premises of the argument are true and the conclusion is false. So we should remember this:

An argument can be invalid even if the conclusion and the premises are all actually true.

Another point to remember is that **it is possible for a valid argument to have a true conclusion even when all its premises are false**. Here is an example:

All pigs are purple in colour.
Anything that is purple is an animal.
So, all pigs are animals.

Note:

1. The premises and the conclusion of an invalid argument can all be true
2. A valid argument should not be defined as an argument with true premises and a true conclusion.
3. The premises and the conclusion of a valid argument can all be false.
4. A valid argument with false premises can still have a true conclusion.

The concept of validity provides a more precise explication of what it is for a conclusion to follow from the premises. Since this is one of the most important concepts in this course, you should make sure you fully understand the definition. In giving our definition we are making a distinction between truth and validity. In ordinary usage "valid" is often used interchangeably with "true" (similarly with "false" and "not valid"). But here validity is restricted to only arguments and not statements, and truth is a property of statements but not arguments. As truth is to statement, validity is to argument.

SOUND AND UNSOUND ARGUMENTS

Soundness

It should be obvious by now that validity is about the logical connection between the premises and the conclusion. When we are told that an argument is valid, this is not enough to tell us anything about the actual truth or falsity of the premises or the conclusion. All we know is that there is a logical connection between them, that the premises entail the conclusion.

So even if we are given a valid argument, we still need to be careful before accepting the conclusion, since a valid argument might contain a false conclusion. What we need to check further is of course whether the premises are true. If an argument is valid, and all the premises are true, then it is called a *sound* argument. Of course, it follows from such a definition that a sound argument must also have a true conclusion. In a valid argument, if the premises are true, then the conclusion cannot be false, since by definition it is impossible for a valid argument to have true premises and a false conclusion in the same situation. So given that a sound argument is valid and has true premises, its conclusion must also be true. So if you have determined that an argument is indeed sound, you can certainly accept the conclusion.

An argument that is not sound is an *unsound* argument. If an argument is unsound, it might be that it is invalid, or maybe it has at least one false premise, or both.

Sound argument: A sound argument in a deductive argument has its premises and conclusion true. The premises guarantee the conclusion and the conclusion is necessarily drawn from the premises. Every sound argument must be valid and has its premises and conclusion true. For example,

All human beings are mortal (True)
Socrates is a human being (True)
Therefore, Socrates is mortal (True)

All philosophers are academia (True)
All academia are educated (True)
Therefore, all philosophers are educated (True)

It is possible to have a valid argument with false premises and a true conclusion. For example,

All Nigerians are American (False)

Obama is a Nigerian (False)

Therefore, Obama is an American (True)

It is also possible to have a valid argument with false premises and a false conclusion. For example,

All fish are mammals (False)

All mammals are carnivorous (False)

Therefore, all fish are carnivorous (False)

However, it is not possible to have a valid argument with true premises and a false conclusion.

Validity is related to soundness of an argument. An argument that guarantees truth is sound. An argument is sound if it is not only valid but its premises and conclusion are also true. Therefore, if an argument is valid and its premises are true, its conclusion must also be true.

Unsound argument: An argument became unsound when its premises are true and conclusion false or when both the premises and conclusion are false. For example,

All human beings are mammal (True)
All dogs are mammal (True)
Therefore, all dogs are human beings (False)

All women are liars (False)
All men are liars (False)
Therefore, all men are women (False)

Test Questions:

1. What makes an argument valid?
2. What is a sound argument? When does an argument become unsound?
3. Distinguish between valid and invalid arguments.
4. Distinguish between valid and sound argument.
5. Distinguish between validity and truth.

6. Give two examples each for a sound and an unsound argument.

WEEK 4

LANGUAGE AND DEFINITION

LANGUAGE

Language is the vehicle of communication in the sense that it is the means by which ideas, thoughts, feelings, emotions, etc. are conveyed from one individual to another in daily social living. However, it is also a very complex phenomenon, because of the multiplicity of its uses. So very often, people fail to achieve their set purposes for engaging in discussions just because of the inability to realize this simple fact. What is meant is utterly dependent on the manner in which it is expressed or communicated, as well as the **context** of language use. The logician's primary interest lies in arguments and their analysis. Thus, language is considered important in Logic because it is the means by which argumentation is carried out, as well as analysed. Although language has a plethora of functions and uses, below are the three major divisions into which they can be categorized for easier identification and the purposes of our study:

a. Informative
b. Expressive
c. Directive

a. Informative language:

Language is commonly used to pass information. It is used informatively to describe the world of facts and to reason about it. It is 'reportive' in the sense that it reports facts to one's listeners or readers. Since it is possible for facts to be misrepresented, our idea of "informative" here also includes that of misinformation; false as well as true propositions, incorrect and correct arguments, etc. As long as what is reported can pass as true or false, language has been used informatively. Scientific language is a typical example of this type of language use. News broadcasting, minutes of meetings, newspapers, magazines, history, etc. are all included in this category. It states simply, as a matter of fact, that a given state of affairs did or did not obtain; that a certain fact is or is not the case; that a certain predicate does or does not belong to a given subject term.

This is the type of language normally used to affirm or deny propositions or to present arguments. Because of this, the informative use of language has been seen as the ideal language use in which the logician is primarily interested, besides the fact that emphasis is placed on what is stated, not primarily on the accuracy or otherwise of what is reported. Examples of the informative use of language include:

1. The Greenwich Meridian passes through Tema in Accra, Ghana.
2. Communism was a sworn enemy of liberal democracy.
3. Quantity is not a preferable ideal to quality.
4. Some birds are not able to fly.

b. Expressive language:

This is the language use in which a speaker or writer tries to convey his feelings or emotions to the audience or readers by means a clever choice of words that makes the latter become emotionally involved. Here, the speaker tries to change the attitude of the listeners by expressing certain inner emotional states, which, in turn, arouse or evoke similar feelings in the audience. Thus, language is used here to vent or arouse sentiments.

The expressive language should not be confused with when we sometimes speak of "expressing" opinions, beliefs, or convictions; such usage, at bottom, refers to the informative usage of "stating" or "declaring". This is because, strictly speaking, to express an opinion is basically to state or declare it. It does not mean to use language expressively in the sense just enunciated above, because expressive language use refers to the expression of emotions, not to the passing of information, or the stating of facts.

Examples of expressive language use abound in everyday life: "Oh, my!" "That's too bad"; shouts of enthusiasm, like, "Wow!" or love, "Darling", used to express delicate passion. Poems,

worship, or lyrics are normally filled with the expressive use of language. But the bottom line is that the expressive language hardly qualifies—as does the informative—as true or false because one can hardly qualify exclamations as "True" or "False". The reason is simply that the aim of the speaker is not to pass information, or receive affirmation, but primarily to convey strong feelings.

c. Directive language:

This is the type of language use intended to cause or prevent overt action; e.g. commands and requests. It is intended to get results, by virtue of causing or preventing action of the indicated kind. E.g. "Two, please", said to the waiter in a bar, directs him to serve two bottles of drink. Also, "Don't move", said by the policeman to a driver, is meant to effect the cessation of movement; "Eat!" barked by an angry mother at her child indicates the command to perform the stated action; etc.

The difference between a command and a request becomes clear, then, when we realize that a request is often accompanied by a soft tone of voice, as well as the subtle addition of such expressions as, "Could you …", "If you don't mind…", "May I …", "please", "kindly", etc. A question may become directive if it requests an answer. But the directive discourse is, like the expressive type, neither true nor false; it can only be reasonable and proper, or unreasonable and improper.

Finally, reasons can also be given as to why a command or a directive may be obeyed; and when the statement of those reasons accompanies the command or request, the whole discourse translates into an argument, e.g.,

Avoid casual sex.

Many have died as a result of not believing that AIDS is real.

FORMS OF DISCOURSE

Form of language refers to any of the four groups to which a language ordinarily belongs: declarative, interrogative, imperative, and exclamatory; while the *function* refers to how it has been used or the function it is intended to perform within a given context. Thus, **form** and **function** must not be confused. This point is of utmost importance because language may be of any form—declarative, interrogative, imperative, and exclamatory—and yet result into any function whatsoever, depending on the intended meaning. This is why the focus must be on the function or meaning of the user instead of on the form. For example, the expression, "He is a dangerous person", is certainly declarative in form; but it might function as a directive to avoid him or to be careful when one deals with him. Also, "I enjoyed myself at your party", although declarative in form, is primarily expressive of the utterer's thanks and appreciation to the celebrant for inviting him or her to the party.

"Aren't we late?" may be interrogative in form; but it may also boil down to a simple directive to hurry up. Again, depending on context, "Keep your mouth shut!", which is primarily imperative in form, may function informatively by reporting that a delicate situation is around the corner, and hence, the need for careful talk. Alternatively, it may be an expression of strong disagreement with another's view. "O my God!" is exclamatory in form, but can still pass for an expression of horror or disgust, or it may be informative to the effect that the worst has happened.

This distinction between the form of discourse and its intended function must be taken seriously to mind because it is of utmost importance in Logic. Hence, as students of Logic, we must be able to identify and disentangle the informative function of language from all others through a careful attention to the function being performed by an expression. Although the grammatical structure of a sentence could sometimes indicate its function, there is no necessary connection between function and grammatical form; between function and content—in the sense of what is asserted therein.

However, one possible way of resolving this problem is by taking a close look at the context, which, and which, alone can determine the function and intended meaning. But it must be reiterated that there is no mechanical method of distinguishing between informative or argumentative language from languages of other functions. Besides studying the context, **this requires careful thought and an awareness of, and sensitivity to, the flexibility of language and the multiplicity of its uses**.

WEEK 5

DEFINITION

Language, as was said in the last section, has a multiplicity of uses; and this often leads to undue disagreements and disputations. Due to this problem, it is necessary to define one's terms in order to minimize misunderstanding and ambiguity so that knowledge can be aided. Thus, another important element in the study of Logic is Definition. A definition is **a statement which breaks a logical term down into its constituent or essential parts, namely genus and difference (in a process of description)**. We generally define an object, or a concept, by distinguishing within it those sensible notes or characteristics that make it the kind of thing it is and no other. One function of definition, in general, is to set limits to the meaning of the thing to be defined, in such a way as to narrow it down to ease comprehension. If I define 'paper' as *a material made from wood on which writing is done especially in modern times*, I automatically exclude other kinds of materials from the definition, such as sand, stone, cloth, plastic, glass, rubber, metal, etc. Thus, the purpose of definition and division, each in its own way, is to improve and perfect our conceptual knowledge of objects that are known only in a confused and imperfect sort of way. Thus, in defining a word, term or phrase, we are actually describing it by giving its properties, in order to arrive at its exact meaning, pass information around, and so communicate effectively. In what follows, attempt is made to explain the essential mechanisms that come into play in definition, the types, as well as purposes of definition.

Genus and difference

While *genus* refers to the family or group to which a thing naturally belongs, i.e. the sensible notes it shares with certain other things of the same type, *difference* refers to the other notes that differentiates a thing from other types of things belonging to other families distinct from the one to which that thing belongs. For instance, the term, 'human', belongs to the genus, 'rational', which, at the same time sets it apart from all other things, say 'plants'. Thus, in definition, a thing is placed in its genus, which affords it a difference that also sets it apart from other things the mind can possibly conceive. Furthermore, the definition of 'clock' as *a device used for measuring time* immediately places it in the genus, 'device', and, at the same time, sets it apart from other things that do not belong that genus. This is what is meant by saying that a thing is defined by breaking it down into its genus and difference.

Definiendum and Definiens

Every definition has two components, viz: **definiendum** and **definiens**. The definiendum refers to the concept, symbol, word, phrase or term to be defined, while the definiens is the group of words, phrases or sentence actually used in rendering the definition. E.g.

Definiendum → **Democracy**

Definiens → A form of government in which the active and free participation of all the citizens of a state is the operating policy, sometimes through duly elected representatives.

If we take the above as an adequate definition, then *democracy* is the definiendum, i.e. the concept to be defined, while the whole of "A form of government in which … duly elected representatives," becomes the *definiendum.*

Purposes of definition:

To increase vocabulary: When the meaning of a concept, or a word, is not known to us, we can ask for its definition from the person who has used it, or look it up from the dictionary, in order to enrich our personal word power.

To eliminate ambiguity, confusion and misunderstanding: Quite often, a given word can have more than one meaning, in such a way as to confuse one's listeners or readers, each of whom would bring with them different interpretations, understandings or conceptions of that given expression. If this is

the case, then it can only be worthwhile to clarify the intended meaning by defining the particular sense of the word or concept, in order to carry one's audience along, especially during a public discussion.

To reduce vagueness and set out limits in borderline cases: 'Vagueness' and 'ambiguity' must not be confused. A term is vague when there are borderline cases (that is, grey areas) of its application, but a term is ambiguous when it has no specific meaning or connotation. Examples of vague words include youth, adult, development, vehicle, democracy, child, etc. Most countries of the world take 18 years as the age of adulthood, while for some others, it is 21; in fact, the same country may even put adulthood at 18, and still maintain that voting age is not until 21. So also, an infant is a child, while a person of 30 or more years remains a child to her parents. 'Vehicle' is clearly vague because it can refer to a car, a ship, an airplane, an army tank, or even a wheelbarrow.

To explain theoretically: Here, definition is a tool used, in a scientific manner, to explain how things or phenomena relate or connect to one other in nature. E.g. is the word, 'force' used by Isaac Newton, a renowned physicist, to refer to the "product of mass and acceleration".

To influence attitudes: There are cases when a writer or speaker defines words in such a way as to appeal to the emotions of his readers or audience, influencing their attitudes in a desired direction. In this way, the writer moves the readers or audience to jettison a generally accepted idea and embrace his or her own.

To resolve dispute: To resolve disputes, we need to define the actual sense(s) in which words are used by arriving at some common ground where every party to the dispute can connect. This saves us from unnecessarily long and fruitless argumentation, which may even have been sparked off by different interpretations of the same expression.

Types of definition

There are many types of definition, depending on the context and purpose which they are meant to serve. Thus, the purpose of definition often determines the nature of the definition to be employed. Here are the main types of definition:

Nominal or stipulative definition: This is a type of definition that arises from the deliberate assignment of (new) meanings to words or phrases. Sometimes, writers offer a completely, or slightly, different or new interpretation of a concept through a rigorous re-examination of the existing popular conceptions of that word, exposing the underlying inadequacies in the ordinary understanding of that concept by people.

Real or essential definition: This, as the name readily suggests, is a definition that says what something is in essence, i.e. its exact nature. A real definition places a subject one is defining in its proper category. E.g. A *spinster* is a woman who has never married.

Lexical definition: A lexical definition is a dictionary-based definition. It does not necessarily give a definiendum a meaning it lacked before, but simply reports a meaning it already has, especially as understood and used in the community of the speakers of that language. In this way, it *reports* how words are actually used by the owners of a language. For instance, the English word, 'story' means something a person naturally enjoys listening to; and this is the primary sense of the word among the English people. However, to the average Nigerian, 'story' is something one would rather hate to hear.

Precising definitions: These serve to reduce ambiguity and vagueness by giving the precise meaning or sense intended in a piece of writing or speech, especially if the context is not clear. When terms that have borderline applications (i.e. terms not clearly belonging to one or other of two or more categories of meaning), or many closely related meanings, are used, a précising definition may help in indicating the one being referred to. For instance, the term, *adult*, may be precisely defined as *a person who is 18 (or 21) years and above*.

Theoretical or operational definition: A definition may attempt to formulate a theoretically adequate, or scientifically useful, description of the objects to which a term applies. In science, a new definition is periodically given to support a new theory or to modify existing ones.

Persuasive definition: This is used to persuade or influence the attitude of one's readers or audience to get them to agree with the definer, disagree with the definer's opponent, or to do both.

Ostensive definition: (From the Latin verb, *ostendere*, meaning "to show", or "to expose") This type of definition is effected by directly pointing to physical instances of the thing or object to be defined, in much the same way as a child receives her first lessons of the names of objects around her. E.g. is showing someone the front tyres of an airplane as a means of getting them to understand why they are designed in a way different from ordinary car tyres.

Rules of Definition

1. **A definition must be co-extensive with the thing defined.** In other words, a definition must neither be too wide—as to entail more than is contained in the definiendum—nor too narrow as to exclude some essences of the definiendum.

2. **A definition must not be expressed in negative sentences, except when absolutely necessary.**

3. **A definition must not be circular.** This rule is closely related to the fallacy of begging the question. Imagine 'cooking pot' being defined as "a pot used for cooking"; or 'evolution' being defined as "the process by which life evolved". Such definitions are self-defeating because they leave one with little clue as to the actual meanings of the terms being defined, especially if one is seeing the terms for the first time.

4. **A definition must not be rendered in ambiguous or metaphorical language, but in simple, univocal terms.** For instance, *bride* need not be defined as "the apple of the groom's eye".
5. **A definition must state the *essential* attributes of the definiendum, not its peripheral attributes.** In other words, it must give the exact essence or nature of the concept or phenomenon being defined, rather than other accidental or dispensable characteristics it happens to have. Thus, it seems better to define 'university' as *a place where people acquire higher education*, rather than just a place where students go to do photocopy.

Test Questions:

1. Why is language of central importance in Logic?

2. What is the fundamental difference between forms and functions of language?

3. State one possible way of resolving the problem of confused language usage?

4. What is the central importance of definition in Logic?

5. How do the rules of definition facilitate the attainment of knowledge?

WEEK 6

INFORMAL FALLACIES

From the foregoing discussions, a major challenge to correct reasoning, which definition helps to resolve, is that of logical fallacies. Fallacies, therefore, are mistakes usually made by people in the cause of reasoning or argumentation, which most often lead to false or baseless judgment. Thus, a fallacy is simply defined as **any kind of mistake or error in reasoning or incorrect argument**. Fallacies are particularly dangerous because they can be rather so subtle as to fool us in the course of reasoning or argumentation, especially if we are not well practiced in the art of independent thought or reasoning. They are able to do this because they are usually couched in emotional languages that naturally appeal to humans—who are emotional beings by nature. As such, it becomes an arduous task for an average person to avoid them completely, or even detect them. However, since such mistakes in reasoning can be deliberate as well as unintended, we shall use the word "fallacy" to refer to any form of mistake or error in reasoning or argumentation.

Informal fallacies are primarily dependent on what the constituent propositions of an argument assert, i.e. on the meaning of the propositions themselves, rather than their logical structure as such. Informal fallacies are divided into **fallacies of relevance** and **fallacies of ambiguity**. As the name readily suggests, all fallacies of relevance ignore the issue at stake only to reach a conclusion that has little to do with the premises on which it is supposed to rest. Thus, fallacies of relevance are committed when an argument relies on premises that are not relevant to the intended conclusion, and that, therefore, do not possibly establish its truth. Fallacies of ambiguity, as we shall see presently, arise from linguistic mistakes or confusion, also proceeding from premises to unwarranted conclusions.

There are many kinds of informal fallacies. For the purpose of brevity, only a few of them will be included here, in order to enable the student understand what they are and how they function. The few included here are used as a guide to the student, who is encouraged to carry out further research for a more comprehensive and broader listing. Below are listed thirteen examples of fallacies of relevance, with their Latin names, as a matter of tradition; in fact, these Latin names have even been incorporated into the English language, and are, sometimes, used in place of their English equivalents.

a) **Argument from ignorance or appeal to ignorance** (*argumentum ad ignorantiam*): This fallacy is based on the assumption that a proposition must be true simply because it has not been proved false; or that it must be false since nobody has succeeded in conclusively establishing its truth. E.g. is the age-old debate between natural scientists and theologians about God's nature and existence, in which some scientists argue that God does not exist simply because he cannot be made physically manifest, while some theologians argue, on the other hand, that since science has not been able to prove conclusively that God does not exist, one is left with no other choice but to infer his existence from the order, intelligence and design found in nature.
b) **Appeal to (inappropriate) authority** (*argumentum ad verecundiam*): This is the tendency to claim that something is true by appealing to parties with no legitimate claim to authority in a specific area of knowledge. This fallacy is common among young people, who often make claims based on the authority of their parents or other adult relatives, who have told them so. It may not be far removed from the fact that children often think, albeit mistakenly, that adulthood is a veritable sign of wisdom and knowledge. They then assume that their parents know everything about anything under the sun.
c) **Complex question:** This involves asking a question in such a way as to presuppose the truth of some other conclusion(s) buried in that question. It is like two or more questions cleverly rolled up into one, and is typically used by lawyers during cross-examination to confuse a defendant or a witness. An example of a typical complex question runs as follows: "Were you not on your way to Lagos last week when you wittingly threw banana peels out of your

car window, which slipped the tyres of other cars off the highway, thereby causing an accident, in which innocent people's lives were endangered?"

This seems like one question; but it actually has at least four other presuppositions: 1) that you travelled to Lagos; 2) that it was last week; 3) not only did you throw something out of your car window, but that it was banana peels; and 4) that you caused an accident in which people's lives have been affected. Other complex questions are: "Have you spent the money you robbed from the bank?" "Is that your wife cooking *our* dinner inside your kitchen?" "Is it next Monday that you will give me a car?"

d) Appeal to the person (*argumentum ad hominem*, literally: attack against the person): It is not uncommon to find people who think they are excellent thinkers when, in fact, they are only indulging themselves in abusing other people or their personalities, totally ignoring the issue under consideration and shifting attention from themselves. This fallacy is typically common in Nigerian politics, where contestants often waste valuable time casting slurs on their opponents, as a strategy for hiding their ignorance and incompetence. As the name implies, this fallacy attacks the personality of the individual(s) with whom one is debating or arguing, thereby distracting attention from the argument itself, which is what is important. Yet arguments are supposed to address issues directly, rather than persons or personalities.

e) Accident: This fallacy is usually committed by applying a generalization to parts or individuals of the whole with acute rigidity. For instance, although it is always good to be honest, it must be realized that sometimes, in practical life, telling a lie can save life or prevent disaster.

f) Converse accident, on the other hand, is when we extend a generalization or characteristic from individual cases to the whole, moving from the parts to the whole. An example is concluding from the abuse of a particular thing, say TV watching, to its complete abolition; or arguing that we should stop all almsgiving since almsgiving may sometimes lead to indolence.

g) False Cause: This refers to attributing a wrong cause to a phenomenon. Scientists and other researchers can be so easily misled by this type of fallacy. Here, two completely distinct and unconnected events closely following each other are wrongly interpreted in such a way as to make one the cause or the effect of the other. This is merely as a result of the habit of wrongly associating two (or more) distinct phenomena simply because they happen to appear side by side, or simultaneously.

h) Begging the question (*petitio principii*): To beg the question, in one way or another, is to assume as proved the very point that is in need of being clearly explained, proved or conclusively established. In other words, it means to include the same point at issue as one of the propositions of an argument, in a vicious circle, and then proceed to prove it by means of that same proposition, but this time as the conclusion. As we noted, this fallacy is closely related to circular definitions, which would incorporate the same word being defined into the definiens. The following are some examples of this fallacy:

1. The holy book is the word of God because it is written therein.
2. The colour of your eyes is a hereditary factor because it is a trait you inherited from your parents.
3. Tomorrow will be like today because experience shows that the future is usually like the past.
4. Snow is always white because it is in the nature of snow to be white.
5. A king without a throne does not have a throne.
6. I was late to the meeting simply because I was late.

The power of an explanation, or a definition, lies in its ability to teach us something we did not know before—i.e. in its capability to satisfy intellectual curiosity.

i) **Appeal to the populace** (*argumentum ad populum*): This fallacy appeals to the people's prejudices, emotions, and local interests, in order to 'sell' one's own cause either to oneself or to others. It is a fallacious appeal to the logic of the majority, typically instantiated and justified by the inconsequential idea that everybody else is doing the same thing or maintaining the same opinion on a given issue.

j) **Appeal to pity** (*argumentum ad misericordiam*): As the name suggests, this is a fallacious argumentation in which the altruism and mercy of the audience are the special emotions appealed to, while the crucial question of whether the concerned person has committed a given offence is disregarded.

k) **Appeal to force** (*argumentum ad baculum*): People commit this fallacy by using force, coercion and blackmail, instead of reason or persuasion, in order to get someone, usually a subordinate, a colleague, or a counterpart, to accept their viewpoint, comply with their demands, or follow their directives. It is very commonly used by superiors, who threaten their subordinates with loss of job; and parents also, who threaten to cease supporting their children financially if they fail to obey their instructions and directives. Eedris Abdulkareem's well-known song, *Mr. Lecturer*, may be taken as a classical representation of this fallacy.

l) **Slippery slope:** This is the unwarranted belief or expectation that things must always turn out in a particular way, no matter what happens. Analogously, it is like rolling a ball down a slope and expecting that it must continue all the way to the valley below. But practical experience rather shows that this may not always be the case. Sometimes, it is possible for something, like friction, or some other obstacle, to intervene along the way, stopping the ball in its tracks.

m) **Hasty conclusion**: As the name clearly suggests, this is the tendency to rush to a conclusion even before considering all the necessary and available evidence. A number of factors may be responsible for this: the conclusion could be emotionally enticing to the person, rendering them incapable of assessing the facts objectively; or the person may have some personal interest in the matter, even when completely in the dark about all the relevant circumstances surrounding it. Sometimes, the individual may know that the conclusion is likely to be false, and still insists on it. In any case, the fallacy of hasty conclusion represents a disservice to truth and knowledge, both of which are the core targets of Logic.

FALLACIES OF AMBIGUITY (LINGUISTIC FALLACIES)

These are arguments with ambiguous phrases or words, whose meanings shift and change in the course of argumentation. The premises start off with a different connotation of the terms or phrases, and then reach a conclusion that utterly invalidates the whole argumentation. They are also called linguistic fallacies because they usually derive from faulty linguistic constructions.

1. **Equivocation:** This refers to the tendency by some arguments to confuse the several meanings of a particular word or phrase, either deliberately or accidentally; e.g. the expression, "have faith in" in the following sentences:
   a. She *has faith in* Logic (She is rather obsessed with it);
   b. She *has faith in* the president (she knows he will deliver);
   c. She *has faith in* swimming (she enjoys it a lot);
   d. She *has faith in* God (she believes God will help her).

   Depending on what is predicated, the meaning of 'has faith in' keeps shifting, such that if we have an argument in which the premises and conclusion have different senses of the phrase, then the argument becomes invalid, inferring a conclusion that is not supported by the premises.
2. **Amphiboly:** When the premises of an argument are stated with an interpretation that makes them true, and a conclusion is drawn from it based on an interpretation that falsifies it, we have the fallacy of *amphiboly*. Amphiboly often results from loose adverbial and prepositional phrases, dangling particles, and misplaced relative clauses; e.g. "While wagging

his tail, the hunter played with the tiger's cub." This sentence tacitly suggests that the hunter has a tail, whereas the adverbial phrase in the first part of the sentence was a reference to the cub. Such fallacious expressions are common among writers, and results from careless sentential constructions.

3. **Accent:** This fallacy rises from the different meanings that can be conveyed by the same sentence or proposition, due to misplaced emphasis upon a syllable, word or phrase in a sentence. Due to the shift in emphasis on different parts of a proposition, the meaning arrived at in the conclusion renders the whole argumentation invalid. Take a look at the following sentences:
   a. *You* may think as you please (Nobody else may do the same …);
   b. You *may* think as you please (It is permissible, but I'd rather you did not …);
   c. You may *think* as you please (As long as you do not *act* it out …);
   d. You may think *as* you please (Not as it *displeases* you …);

   Notice the dramatic change in the meaning of this particular sentence as the emphasis or stress moves from one word to the next. Semantic consistency—i.e. the ability to be consistent in meaning—is very crucial in Logic. This is because, as we saw in earlier chapters, language and meaning are central in Logic. Any failure in this regard only results in unnecessarily long argumentation that only leads nowhere near truth and knowledge.

4. **Parallel word construction:** This refers to the tendency to assume that because two words are similar in structure, they must in that respect, be similar in the direction of their respective meanings. For instance, the fact that *impossible* means "not possible" and immortal means "not mortal" does not, in anyway, automatically imply that *immemorial* and *ingenious* would then mean "not memorial" and "not a genius" respectively; nor that because "invisible" means "not visible", therefore "invaluable" would mean "not valuable", etc.

AVOIDING FALLACIES

There are many fallacies, and the ability to avoid them sanitizes the reasoning process. But in what ways can we possibly avoid fallacies? Here are a few concise suggestions:

1. There is need to be aware of the existence of fallacies, as well as their nature, since one cannot avoid what one does not even know is in existence.
2. Understanding that language is very slippery, and can easily be twisted to mean *anything*. This involves the realization that language has a plethora of uses and meanings, and that what is meant in every speech generally depends on how language has been used.
3. Following from (1) and (2), there is need for constant vigilance, both in reading and in writing, so as to be able detect any misuse of language that could lead to fallacy.
4. Careful definition of terms in order to avoid misunderstanding, confusion, vagueness, ambiguity, and undue or unfruitful argumentation.

Test Questions:

1. What is fallacy?
2. What is distinction between fallacy and 'lie'?
3. Explain the major difference between formal and informal fallacies.
4. What is the difference between fallacies of relevance and those of ambiguity?
5. Mention three ways of avoiding fallacy.

WEEK 7

NATURE OF SCIENCE

The core issues discussed are:

Science is the cumulative body of systematized knowledge obtained through observation, experiment and reasoning. Science advances as scientists accumulate more detailed facts and gain a better understanding of these fundamental principles and laws. A theory developed by a scientist cannot be accepted as part of scientific knowledge until it has been verified by the studies of other researchers. Scientific progress depends on new ideas expanding and replacing old ones.

Importance of science:

1. Science provides the basis of much of modern technology – the tools, machines, techniques, and sources of power that make our lives and work easier.

2. Discoveries of scientists help to shape our views about ourselves and our place in the universe.

3. Scientific and technological inventions such as computers, automobiles, airplanes, television, communication satellites, have transformed human life.

Please note that applied knowledge is very vital for this topic.

Test questions:

1. What are the qualities that make science what it is?

2. What is its essence?

3. What differentiates science from other intellectual matters?

5. How do we distinguish between genuine research and pseudo research?

6. What is the importance of science?

7. To what extent have scientific discoveries help to shape our views about ourselves and our place in the universe?

WEEK 8

METHODS OF SCIENCE

Introduction

Scientific methods are founded on some basic philosophical assumptions such as **"**reality is objective and consistent", "humans have the capacity to perceive reality accurately", and the fact that "the real world can be rationally explained". On this background, the logical positivist the empiricism, the falsificationist, and other theorists have tried to explain the logic of science but none is without criticism. If reality is granted objective and consistent, it will mean that it does not change but does it? Is it true that human has the capacity to perceive reality accurately when philosophy claims that appearance differs from reality? And if reality can truly be rationally explained, then it will mean that science has answers to all mysteries in the world. But, how do we explain the mysteries surrounding the UFO (Unidentified Flying Object), the Bermuda Triangle on the high sea, the Mind/Body problem,

Spirit and Ghost, Intentionality and God to mention but a few? How do we then reconcile these scientific assumptions with the truism of life?

A Brief History of scientific methods:

The development of the scientific method is inseparable from the history of science itself. In the Ancient Egyptian documents, we have empirical methods described in astronomy, mathematics, and medicine. The ancient Greek philosopher **Thales** in the 6th century BC was found to have refused to accept supernatural, religious or mythological explanations for natural phenomena, proclaiming that every event had a natural cause. Also, the development of deductive reasoning by Plato was discovered to be an important step towards development of the scientific method. On the part of Aristotle, Empiricism seems to have been formalized with his view that universal truths could be reached via induction.

One of the first ideas regarding how human vision works came from the Greek philosopher Empedocles around 450 BCE. Empedocles reasoned that the Greek goddess Aphrodite had lit a fire in the human eye, and vision was possible because light rays from this fire emanated from the eye illuminating objects around us. While a number of people challenged this proposal, the idea that light radiated from the human eye proved surprisingly persistent until around 1,000 CE, when a Persian scientist advanced our knowledge of the nature of light and, in so doing, developed a new and more rigorous approach to scientific research.

There are hints of experimental methods from the Classical world (e.g., those reported by Archimedes in a report recovered early in the 20th century CE from an overwritten manuscript), but the first clear instances of an experimental scientific method seem to have been developed in the Arabic world (Iraq), by Muslim scientist (See Alhazen 965 CE) who introduced the use of **experimentation** and **quantification** to distinguish between competing scientific theories set within a generally empirical orientation, perhaps by Alhazen in his optical experiments reported in his Book of Optics (1021).

The modern scientific method crystallized not later than in the 17th and 18th centuries. In his work *Novum Organum* (1620) — a reference to Aristotle's *Organon* — Francis Bacon outlined a new system of logic to improve upon the old philosophical process of syllogism. Then, in 1637, René Descartes established the framework for a scientific method's guiding principles in his treatise, *Discourse on Method*. The writings of Alhazen, Bacon and Descartes are considered critical in the historical development of the modern scientific method, as are those of John Stuart Mill.

In the late 19th century, Charles Sanders Peirce proposed a schema that would turn out to have considerable influence in the development of current scientific method generally. Peirce accelerated the progress on several fronts. Firstly, speaking in broader context in "How to Make Our Ideas Clear" (1878), Peirce outlined an objectively verifiable method to test the truth of putative knowledge on a way that goes beyond mere foundational alternatives, focusing upon both *deduction* and *induction*. He thus placed induction and deduction in a complementary rather than competitive context (the latter, induction, of which had been the primary trend at least since David Hume**,** who wrote in the mid-to-late 18th century). Secondly, and of more direct importance to modern method, Peirce put forth the basic schema for hypothesis/testing that continues to prevail today. He examined and articulated the three fundamental modes of reasoning **abductive, deductive, and inductive** inference. Thirdly, he played a major role in the progress of symbolic logic itself.

Beginning in the 1930s, Karl Popper argued that there is no such thing as inductive reasoning. All inferences ever made, including in science, are purely deductive according to this view. Accordingly, he claimed that the empirical character of science has nothing to do with induction—but with the deductive property of falsifiability that scientific hypotheses have. Contrasting his views with inductivism and positivism, he even denied the existence of scientific method. According to him,

(1) There is no method of discovering a scientific theory

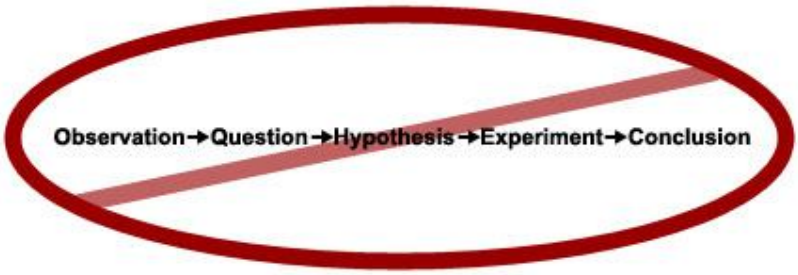
(2) There is no method for ascertaining the truth of a scientific hypothesis, i.e., no method of verification;

(3) There is no method for ascertaining whether a hypothesis is 'probable' or probably true". Instead, he held that there is only one universal method, a method not particular to science: The negative method of criticism, or colloquially termed **trial and error**. It covers not only all products of the human mind, including science, mathematics, philosophy, art and so on, but also the evolution of life.

Following Peirce and others, Popper argued that science is fallible and has no authority. In contrast to empiricist-inductivist views, he welcomed metaphysics and philosophical discussion and even gave qualified support to myths and pseudo-sciences. Popper's view has become known as **critical rationalism**.

The classic and the contemporary conceptions of scientific methods:

Traditionally, the classical scientists believe that scientific methods are linearly ordered in five stages: observation, question, hypothesis, experimentation and conclusion. This process of investigation is often defined in many textbooks and science courses as a **linear** set of steps through which a scientist moves from **observation** through **experimentation** and to a **conclusion** as shown below:



But, the contemporary scientists reject this view and claim that this is a general misconception in science. They claim that science does not provide facts or "truth" about any subject. For them, science is not collection of facts; rather, it is a process of investigation into the natural world and the knowledge generated through that process.

The contemporary scientists argue that classic view of scientific method is inherent with a number of problems. In the first place, science is not a **linear** process, that is, it does not have to start with an observation or a question, and it commonly does not even involve experiments. Instead, the scientific method is a much more dynamic and robust process. At times, scientists get their inspiration from the natural world, from reading what others have done, from talking to colleagues, or from experience. They use multiple types of research toward investigating phenomena, including experimentation, description, comparison, and modeling. Some scientific investigations employ one of these methods, but many involve multiple methods, or some studies may even have characteristics of more than one method. Results from one research study may lead in directions not originally anticipated, or even in multiple directions as different scientists pursue areas of interest to them. For this reason, it is worthy of note that:

i. the practice of science involves many possible pathways and that the classic description of the scientific method as a linear or circular process does not adequately capture the dynamic but rigorous nature of the practice.

ii. scientists use multiple research methods to gather data and develop hypotheses. These methods include **experimentation**, **description**, **comparison**, and **modeling**.

iii. scientific research methods are complementary; when multiple lines of evidence independently support one another, hypotheses are strengthened and confidence in scientific conclusions improves.

Although procedures may vary from one field of inquiry to another, identifiable features distinguish scientific inquiry from other methods of obtaining knowledge. Scientific inquiry is generally intended to be as objective as possible, to reduce biased interpretations of results. Another basic expectation is to document, archive and share all data and methodology so they are available for careful scrutiny by other scientists, giving them the opportunity to verify results by attempting to reproduce them. This practice, called *full disclosure*, also allows statistical measures of the reliability of these data to be established. On reliability, Einstein says, **"No amount of experimentation can ever prove me right; a single experiment can prove me wrong."**

In the 20th century, Ludwik Fleck (1896–1961) and others argued that scientists need to be critical about their experiences and avoid biases. He wants them to be more exact when describing their experiences because belief may indeed alter observations. Biases can influence a person to seeing things differently and reinforcing his belief, even if another observer would disagree. Researchers have often admitted that the first observations were a little imprecise, whereas the second and third were "adjusted to the facts". It means that people do observe what they expect to observe, until shown otherwise. It is for this reason that scientific methodology prefers that hypotheses be tested in controlled conditions which can be reproduced by multiple researchers. With the scientific community's pursuit of experimental control and reproducibility, cognitive biases diminished.

A scientific theory hinges on empirical findings, and remains subject to falsification if new evidence is presented. That is, no theory is ever considered certain. Theories very rarely result in vast changes in human understanding. Knowledge in science is gained by a gradual synthesis of information from different experiments, by various researchers, across different domains of science. Theories vary in the extent to which they have been tested and retained, as well as their acceptance in the scientific community.

The classical steps of scientific method:

i. Observation:

Observation is the key tool of the scientist. The scientific method requires observations of nature to formulate and test hypotheses. Observation helps a researcher to identify promising aspects of natural phenomena that are worth knowing about. The scientist is specifically looking for causal relationships in nature that (taken together with other knowledge) will help to explain in the broadest terms how natural systems work.

For the purpose of reproducibility, standardization and possible human errors, it is best for observers to compare notes. To magnify human powers of observation, other scientific instruments such as weighing scales, clocks, telescope, microscopes, thermometers, cameras, tape recorders etc. were developed. Instruments such as indicator dyes, voltmeters, spectrometers, infrared cameras, oscilloscopes, interferometers, Geiger counters, x-ray machines, radio receivers and so on were also developed to assist human translate into perceptible the imperceptibles of the human senses.

However, there is a significant problem with observation called the *observer effect* in science that needed to be talked about. For example, it is not normally possible to check the air pressure in an automobile tire without letting out some of the air, thereby changing the pressure. For this reason,

science tries as much as possible to reduce the effects of observation to insignificance by using better instruments.

ii. Questions:

Inductive questions are asked as to what, why and how certain things have to happen the way they are happening. This will eventually lead to formulating ideas and concepts. Deductions are thus made which influences a hypothesis that will be tested.

iii. Hypothesis:

A hypothesis is simply an untested fact or a specific statement of prediction. It describes in concrete (rather than theoretical) terms what you expect will happen in your study. Not all studies have hypotheses. Sometimes a study is designed to be exploratory (see inductive research). The word hypothesis basically means "a possible solution to a problem based on knowledge and research". It is a statement that defines what you think the outcome of your research will be or a reasoned proposal suggesting a possible correlation between or among a set of phenomena. Normally, hypotheses have the form of a mathematical model. Sometimes, but not always, they can be formulated as existential statements, stating that some particular instance of the phenomenon being studied has some characteristic and causal explanations, which have the general form of universal statements, stating that every instance of the phenomenon has a particular characteristic. For example, if I notice that some tomatoes on my farm are doing well than others, I may want to make inquiry into the reason why. My hypothesis may be, some of the tomatoes are doing better than the others because they are positioned in a place where they receive more sunlight than the others.

- **Hypothesis and Predictions:**

Any useful hypothesis will enable predictions by reason of induction or deduction. It might predict the outcome of an experiment in a laboratory setting or the observation of a phenomenon in nature. The prediction can also be statistical (about probabilities) or otherwise. It is essential that the outcome is currently unknown. It is only in this case that the eventuations increase the probability that the hypothesis be true. If the outcome is already known, it is called **a consequence** and should have already been considered while formulating the hypothesis. If the predictions are not accessible by observation or experience, the hypothesis is not yet useful for the method, and must wait for others who might come afterward, and perhaps rekindle its line of reasoning. For example, a new technology or theory might make the necessary experiments feasible.

iv. Experiments:

Once predictions are made, they can be tested by experiments. If test results contradict predictions, then the hypotheses are called into question and explanations may be sought. Sometimes experiments are conducted incorrectly and are faulty. If the results confirm the predictions, then **the hypotheses are considered likely to be correct,** yet, might still be wrong and are subject to further testing. The **experimental control** is a technique for dealing with **observational error**. This technique uses the contrast between multiple samples (or observations) under differing conditions, to see what varies or what remains constant. We vary the conditions for each measurement; to help isolate what has changed. Depending on the predictions, the experiments can have different shapes. It could be a classical experiment in a laboratory setting, a double-blind study or an archaeological excavation.

Scientists assume an attitude of openness and accountability on the part of those conducting an experiment. Detailed record keeping is essential, to aid in recording and reporting on the

experimental results, and providing evidence of the effectiveness and integrity of the procedure. They will also assist in reproducing the experimental results.

- **Experiment and its Problematic**

At any stage of experimentation, it is possible to refine its accuracy and precision so that some considerations may lead the scientist to repeat an earlier part of the process. Failure to develop an interesting hypothesis may lead a scientist to re-define the subject they are considering. Failure of a hypothesis to produce interesting and testable predictions may lead to reconsideration of the hypothesis or of the definition of the subject. Failure of the experiment to produce interesting results may lead the scientist to reconsidering the experimental method, the hypothesis or the definition of the subject.

- **The need for Confirmation in Experimentation**

Science is a social enterprise, and scientific work tends to be accepted by the community when it has been confirmed. Crucially, experimental and theoretical results must be reproduced by others within the scientific community. Researchers have given their lives for this vision. For example, Georg Wilhelm Richmann was killed by ball lightning (1753) when attempting to replicate the 1752 kite-flying experiment of Benjamin Franklin (See, *Physics Today*, 59, 1 :42), Richmann was electrocuted in St. Petersburg in 1753). To protect against bad science and fraudulent data, governmental research-granting agencies such as the **National Science Foundation**, and **Science Journals** including *Nature* and *Science*, have a policy that researchers must archive their data and methods so that other researchers can access it, test the data and methods and build on the research that has gone before.

- **The need for Communication among Science Community**

Frequently a scientific method is employed not only by a single person, but also by several people cooperating directly or indirectly. Such cooperation can be regarded as one of the defining elements of a scientific community. Various techniques have been developed to ensure the integrity of that scientific method within such an environment.

- **The Relevance of Peer review to Experimentation**

Scientific journals use a process of *peer review*, in which scientists' manuscripts are submitted by editors of scientific journals to (usually one to three) fellow (usually anonymous) scientists familiar with the field for evaluation. The referees may or may not recommend publication, publication with suggested modifications, or, sometimes, publication in another journal. This serves to keep the scientific literature free of unscientific or pseudoscientific work, to help cut down on obvious errors, and generally otherwise to improve the quality of the material. The peer review process can have limitations when considering research outside the conventional scientific paradigm: problems of "groupthink" can interfere with open and fair deliberation of some new research.

- **The Importance of Documentation and Replication in Experimentation**

Sometimes experimenters may make systematic errors during their experiments, unconsciously veer from a scientific method for various reasons, or, in rare cases, deliberately report false results. Consequently, it is a common practice for other scientists to attempt to repeat the experiments in order to duplicate the results, thus further validating the hypothesis.

- **The Importance of Archiving**

Researchers are expected to practice scientific data archiving in compliance with the policies of government funding agencies and scientific journals. Detailed records of their experimental

procedures, raw data, statistical analyses and source code are preserved in order to provide evidence of the effectiveness and integrity of the procedure and assist in reproduction. These procedural records may also assist in the conception of new experiments to test the hypothesis, and may prove useful to engineers who might examine the potential practical applications of a discovery.

- **The Relevance of Data Sharing**

When additional information is needed before a study can be reproduced, the author of the study is expected to provide it promptly. If the author refuses to share data, appeals can be made to the journal editors who published the study or to the institution which funded the research.

- **Some Limitations to Experimentation**

Since it is impossible for a scientist to record *everything* that took place in an experiment, facts selected for their apparent relevance are reported. This may lead, unavoidably, to problems later if some supposedly irrelevant feature is questioned. For example, Heinrich Hertz did not report the size of the room used to test Maxwell's equations, which later turned out to account for a small deviation in the results. The problem is that parts of the theory itself need to be assumed in order to select and report the experimental conditions.

v. Conclusion:

You have asked questions and performed an experiment to confirm your hypothesis; your conclusion is the record of the final findings in your experiment. A conclusion is simply a summary of the experiment. The conclusion, plain and simple, is the answer to your question and it should be *clear, concise* and *stick to the point*. There are two possible outcomes to your experiment: either the experiment supported the hypothesis and considered true or the experiment disproved the hypothesis as false. If the hypothesis is false, the steps in the scientific method is repeated to make adjustment in your tested hypothesis but if the hypothesis corroborates with your conclusion then the experiment is certified true/correct.

If the hypothesis turns out to be false, there are some questions to ask to find out why:

1. What was wrong with the original hypothesis? 2. Did you make poor observations?

3. Was your experiment flawed?

Test Questions:

1. What are the problems with the classical conception of scientific methods?
2. How objective is scientific method? Can scientific method bring fourth objective knowledge?
3. Of what importance and relevance is control experiment to research methodology?
4. Do you agree with the postmodernist that the practice of science involves many pathways as against the classic linear process?
5. Of what importance is peer review to scientific research, particularly, to unscientific and pseudoscientific works or obvious errors in researches?
6. To what extent is documentation and replication guide against systemic error in experimentation?

WEEK 9

PROBLEMS OF SCIENTIFIC AND TECHNOLOGICAL DEVELOPMENT IN NIGERIA

What is mostly required here is applied knowledge. The main discussion points will center on science, technology, development and Nigeria. The issues discussed under the nature of science and its methods act as a guide for science.

Technology is taken as the applications and practice of science to the identification and solution of problems that are of value to humankind. Technological findings are tentative and subject to further scrutiny and modifications in the light of new developments and new discoveries.

Development implies progress, growth, advancement, expansion, and change, in any field of endeavor that takes place in a society as a result of the effort, support and participation of the people. Achieving development in any society (here the emphasis is on Nigeria) lies with the people – their skills and knowledge.

Nigeria what is required here is an appreciable knowledge of the social make up of the country, for example, the population, literacy distribution, colonial history, global position, and suchlike.

Test questions:

1. What are the set backs to the development of science and technology in Nigeria?

2. What are the problems created by the development of science and technology in Nigeria?

3. What are the objectives of technology?

4. What is technology transfer?

5. What are the problems associated with technology transfer?

6. Is technology transfer likely to hinder or promote the development of science and technology in Nigeria?

WEEK 10

SCIENCE AND SOCIETY

What is mostly required here is applied knowledge. Understanding of science as in topics 7 and 8 will act as crucial guides.

Society is a human setting in which scientific and technological enterprises operate. Core discussion points include: the interdependence between science and society; characteristics of science; characteristics of society; impacts of science on society; impacts of society on science.

Test questions:

1. To what extent can the characteristics of a society affect the type of science and technology it will develop?

2. Why is science a social activity?

3. Why is it necessary for science and society to work together to ensure that scientific knowledge is used in the best possible ways?

Conclusion: it is important to aim towards a healthful balance between science and society.