UNIVERSITY OF AGRICULTURE ABEOKUTA
Department of Communication and General Studies

GNS 204: Logic and History of Science

Course Facilitators: Uche S. Odozor
Emmanuel Akintona
MSC Okolo
OGF Nwaorgu

The Course

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 science and the problems confronting science with specific emphasis on Nigeria.

Texts:

1. A. G. A Bello (2000) *Introduction to Logic*, Ibadan: University Press PLC
2. Cohen, Morris & Nagel, Ernest (1978) *An Introduction to Logic and Scientific Methods*, London and Henley: Routledge & Kegan Paul.
3. Copi Irving M. *An Introduction to Logic*. New York: Macmillan.
4. Daniel Flage, (1995) *Understanding Logic*, Englewood Cliffs, New Jersey: Prentice-Hall inc.
5. D.N. Ucheaga, *Rudiments of Logic* (University of Calabar Press)
6. King, Peter & Shapiro, Stewart (1995), "The History of Logic," in *The Oxford Companion to Philosophy*, (OUP): 496–500.
7. Kreyche, Robert J. *Logic for Undergraduates.* Revised edition; New York: Holt, Rinehart and Winston.
8. Patrick Suppes, (1985) *Introduction to Logic*, New Delhi & Madras: Affiliated East-West Private Ltd.
9. Wesley. C Salmon, (1973) *Logic*, Englewood Cliffs, N. J: Prentice-Hall, Inc.
10. Samuel Ade-Ali & Ayo Fadahunsi (1995) *Introduction to Philosophy and Logic*, Ibadan: paper Back Publishers Ltd.
11. S. F. Baker (1965) *The Elements of Logic*, New York: McGraw-Hill Book Company.
12. Quine, W. V. O (1967) *Methods of Logic*, Revised ed. New York: Holt Rinehart & Winson.

GENERAL ELECTRONIC RESOURCES

- Routledge Encyclopedia of Philosophy
- Internet Encyclopaedia of Philosophy
- Philosopher's Index

Please Note:

- The texts given above are not exhaustive. You are expected to source for other useful books in the Library or elsewhere.
- Remember to adopt eclectic reading habit.
- Be aware that the part relating to science as it concerns Nigeria is mostly applied knowledge. You can get further information from magazines, newspapers, journals, science articles and fiction, science related news on TV, radio, etc.

Teaching
The course is taught by a weekly two-hour lecture.

Assessment
- This is a core module for second year undergraduates specializing in science and science related disciplines.
- It is a 2 unit course.
- Assessment is by e-examination (70%) and two CATs: debate/paper submission (15%) and written test (15%).

Outcome Assessment Strategies
- The primary goal of this course is to enable the student demonstrate critical thinking and creative ability.
- Logic, which is a branch of philosophy, is not about unreflective acceptance of facts; it is rather interested in the questions asked, the puzzles posed, the answers suggested and what counts as a good (correct) answer to the questions and puzzles.
- Lectures basically serve to introduce the rules and principles that help to distinguish good (correct) from bad (incorrect) reasoning.
- The lectures, therefore, act to establish and strengthen independent reasoning, help to evaluate findings and assist in giving accurate interpretation of reality.

WEEK 1

1. General Introduction: What Logic is

Issues:

- Definition of Logic.
- Brief History of Logic.
- Logic as both science and art.
- Why study Logic? The importance/uses of Logic.
- Basic concepts used in Logic.

Questions:

1. What is the distinction between ‘logic’ and ‘Logic’?
2. How did the discovery of Logic facilitate subsequent scientific developments?
3. In what sense is Logic both a science and an art?
4. Mention three reasons why the study of Logic can be considered a worthwhile exertion?

WEEK 2

NATURE OF ARGUMENTS

1. What are arguments?

Argument in philosophy is not about disagreement or fight among people; rather, it is about the relation that exists between premises and conclusion. Since human by nature is rational, it is expected of him to be reasonable in constructing his arguments. Arguments are platforms upon which reasoning are tested. Reasoning is a special kind of thinking from which inferences and deductions are made and problems solved. A good reasoning requires that a conclusion is deduced from the premises (evidence).Arguments are used to win people to ones' side. It is not just enough for people to make claims; claims are to be justified by providing evidence to back them up. Logic is that tool (methods and techniques) for testing the validity of arguments. For every argument to be valid, it is expected that the conclusion is derived from the premises.

An argument is simply defined 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" (Copi 1973:2). 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.

However, all arguments require that the premises provide grounds for the truth of the conclusion and to make an argument valid, the conclusion must necessarily be derived from the evidence provided by the premises.

2. 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: Logic deals with declarative statements, that is, statements capable of being true or false. 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).

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.

3. Types of arguments:

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

- **Inductive Argument:**

An argument is claimed to be inductive if its premise(s) only provide some support but do not guarantee its conclusion. Inductive argument is structured in such a way that from some set of factual propositions (premises), a conclusion is inferred. For example,

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 should be noticed 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.

The support offered by the premises to the conclusion in inductive arguments can either 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. **A**ll Nigerians are corrupt (may be 99%)
Abacha is a Nigeria.
Therefore Gen Abacha is corrupt

*** The premises here only offer high/strong degree of support to the conclusion.**

ii. 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.**

- **Types of Inductive Arguments:** There are two types of inductive arguments,

  i. those that move from **particular to general**. The premises are particular instances, while the conclusion is general. Example (ii) and (iii) suffice.
  ii. those that goes from particular to particular. Here, the premises and the conclusion are made up of particular instances. Examples (iii) and (iv) above suffice. Therefore, it is not the case that inductive inferences go only from particular to general.

- **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 or correct 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 mothers are women
Therefore, all mothers are human beings

All academician are educated
All scholars are academicians
Therefore, all scholars are educated

ii. All human beings are mortal
All UNAABites are human beings
Therefore, all UNAABites are mortal

All gutter boys are wayward
All Yahoo boys are gutter boys
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 □ q	(conditional statement)
Shade puts to bed	p	(antecedent affirmed)
Therefore, Shade is a mother	∴/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 □ 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

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 that 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. What is an argument?
2. Make distinctions between a proposition and a sentence.
3. Why does logic restrict its language to declarative statements alone?
4. Mention a few premise indicators and conclusion indicators.
5. Mention some of the general characteristics of inductive and deductive arguments? What are their differences?

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WEEK 3

VALIDITY OF ARGUMENTS

- **Valid argument:** A deductive argument is valid if its conclusion is necessarily and logically drawn from the premises. The premises of a deductive argument guarantee the conclusion: so, if the premises are true then the conclusion must be true. Validity of an argument is determined by the relation between the premises and the conclusion. In as much as the conclusion is drawn from the premises, the argument remains valid.

- **Invalid argument:** An invalid argument is that which the conclusion does not follow from the premises. In other words, the premises do not guarantee the conclusion.

Arguments are in different forms, as there is a single premise argument so we have two or more premises arguments. Examples of a single premise argument are:

i. Nigeria imports crude oil despite the fact the she is an oil producing nation. Therefore from all indications, she is worse off with high pump price.

ii. Ade beats his wife into coma last week. Therefore, Ade must be responsible for the death of his wife who passed on this morning.

iii. Although by definition, the unconscious patient cannot tell you whether he perceives pain, available data suggest that he may; therefore, you cannot know that he doesn't

Examples of two premises arguments are:

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

All metals conduct electricity
Iron is a metal
Therefore, iron conducts electricity (valid)

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

All criminals are lawbreakers
Some politicians are lawbreakers
Therefore, all politicians are criminals (invalid)

Note: The order of premises and conclusion is not rigid, anyone may come first.

SOUND AND UNSOUND ARGUMENTS

- **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 or invalid?
2. How do you determine a sound argument?
3. What are the differences between sound and unsound arguments?
4. Can arguments with the same form carry different validity status?

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WEEK 4

Language

Issues:

- What is Language?
- Logic and Language
- Functions of Language: Informative, Expressive, Directive
- Forms of Language: Declarative, Interrogative, Imperative, Exclamatory
- Language and Its Multiplicity of Uses: Motivational, Ceremonial, Performative
- Context and 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. Although language has a plethora of uses, below are the three major divisions into which these very many uses 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; in other words, it is used for carrying out effective communication. This is because language 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 can translate into an argument, e.g.,

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

LANGUAGE OF MULTIPLE FUNCTIONS

As should by now be evident, language is a very slippery and flexible tool, able to be manipulated by its user in a myriad of ways. Thus, although three types of language usage have been highlighted above, experience shows that in actual situations, speakers do not

necessarily restrict themselves within any single one of these three categories. Rather, one finds that a speaker may find herself combining two or all three of the above uses, and still carry out effective speech, achieving a number of desired effects, goals, or aims; and this is not as a result of any mistake.

A pastor may, in motivating his congregation to give generously to charity, start by giving them the historical perspective of a missionary activity the church has been doing in the past and how it has helped in converting souls, and benefited the poor in the community in a number of ways. At this level, the informative use of language is evident. He then proceeds to harness his scriptural knowledge in moving his congregation to become emotionally involved, thereby eliciting their emotional responses. This is the expressive level. Finally, when he has succeeded in getting them emotionally fixed with the appropriate emotive and expressive language, he then invites them to donate generously, which directly corresponds to the directive language use type. In all this, the three types have all been used together to achieve the desired result, because restricting oneself to only one of the three could not have achieve the desired aim. This type of complex or multiple function is an example of **motivational function** of language.

Another interesting case of complex use of language has been identified as **ceremonial**. For example, ceremonial greetings at social functions can serve to express sociability or goodwill (expressive usage), as well as an invitation to dinner (directive usage); the elaborate, ritualistic language of a wedding ceremony not only emphasizes the solemnity of the occasion (expressive), but also invites the newly weds to take their union seriously (directive). University seminars may also involve the three elements by offering knowledge, expressing attitudes and then enjoining on listeners to rethink their academic stands on a certain issue, although it is something the listeners may have heard again and again over the years. Thus, ceremonial language is mainly a ritualistic phenomenon; it is not primarily that the hearers have anything new to hear when they are uttered.

The third type of multiple language usage to be considered here is the **performative** type. A performative utterance is one which, when uttered in appropriate circumstances, actually becomes the performance of the act it appears to report or describe. They actually carry out actions that go on at the time of their utterance, because they involve performative verbs whose utterance actually constitutes the doing of the stated action. Examples include, "I *congratulate* you"; "We *are grateful* to you"; "I *promise*"; "I *accept* your offer"; "I *apologize*"; "We *greet* you"; "*Thank* you very much"; etc. Thus, typically accompanied by the first person singular or plural (I or We), performative language is also apparently a mixture of the three major functions previously established, and, thus, is tied specially to the circumstance in which it is uttered. For instance, congratulating a person implies the recognition of their achievement, success or accomplishment (informative); it also involves an expression of good will and happiness (expressive), and, perhaps, a suggestion of the expected behaviour or character that is appropriate to the newly acquired status, subsequent to the accomplishment (directive).

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 as well 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 a careful or thoughtful 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**.

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?

WEEK 5

5. DEFINITION

Issues:

- Defining Definition
- Elements of definition
- Purposes of definition
- Types of definition
- Rules of 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 by distinguishing within it those sensible notes or characteristics that make it the kind of thing it is and no other; and what we ordinarily define is some kind of species. Hence, the function of definition, in general, is to set limits to the meaning of the object to be defined in such a way as to narrow it down and then ease its comprehension. If I define 'paper' as *a material made from wood on which writing is usually done*, especially in these modern times, I automatically exclude other kinds of materials from the definition, such as sand, stone, cloth, plastic, glass, rubber, metal, etc. Even if this definition is made for a person who has not seen paper before, his mind will automatically exclude these other irrelevant types of materials and focus on the one that the definition has provided, in order to be able to form the concept of *paper*, and then attain an understanding of what is being defined. In the same way, the concept of 'animal' quickly excludes inanimate objects from the mind's eye. It is precisely this phenomenon or process of 'exclusion' of irrelevant notes and then 'narrowing down' on the essential ones that we mean by the phrase 'set limits to'; and it is this particular phenomenon that eases the attainment of knowledge and understanding.

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:

1. **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. It does not have to be a completely new word; it may be a word that seems confusing, or is now being used in a sense completely different from the sense with which we are familiar. Of course, our ability to command a language depends on how well we have mastered its vocabulary, which, in turn, depends on how versed we are with regard to the concepts of the language.

2. **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. Consider the concept, 'litter', in the following expressions:

   a) There is a litter of rubbish in the next room.
   b) The cat left a litter of kittens behind the kitchen door.
   c) It was customary for princes and princesses to travel in a litter in ancient times.
   d) Some birds retire to their litter early.

   Except the context is made clear as regards the sense of 'litter' meant, the tendency is to lead one's listeners or readers astray. Here then, the user of the expression needs to give the exact sense in which he or she is using it by choosing from the available options above: a) waste; b) baby cats (i.e. kittens, in this case); c) royal chair; d) roost.

   Further, the confusion in the argument below derives from the ambiguous use of the term, 'perfection'.

   The perfection of a thing is its ultimate end.
   The greatest virtue is perfection.
   → Therefore, the greatest virtue is a thing's ultimate end.

Recall the first rule of categorical syllogism which was discussed above (*fallacy of four terms*). This ambiguity is caused by the different senses in which 'perfection' has been used in the argument, one as an end-purpose, and the other as a moral attribute. There is need, therefore, to define the exact sense meant by the user and to maintain that sense throughout the argument.

3. **To reduce vagueness and set out limits in borderline cases:** Some expressions do not always have a clear-cut meaning. '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. Further, in the world of today, even in Africa, people are known to place almost any kind of governance under the democratic label, due to the appealing nature of that system of government. Yet even democracy itself has a very broad range of application, not because anything can pass for a democracy, but because there are different types of well-known democracies. Thus, the need arises for the person using the expression to clearly spell out, in a definition, the borderline demarcating the exact age of adulthood and childhood, as well as the precise type of vehicle referred to.

4. **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".

5. **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. E.g. the appropriation of public funds, which is common among African politicians, is sometimes typically described as "pen robbery". Also, travels, whether official or vocational, by Nigerian government officials are usually referred to as "working visits" to make it pleasant in the ears of the populace. The overarching aim is to influence the attitude of the citizens in the desired direction, while maintaining a good image of the public officials.

6. **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. Not only are ambiguity and vagueness avoided, differences are settled and common grounds are reached and knowledge is enhanced.

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:

I. **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. Authors do this all the time. For instance, until recently, the idea of development had been formerly restricted to material success, like strong economy, or scientific and technological advancement, such as is seen in places like North America, Europe, and some parts of Asia. Later, however, it became clear that besides material well-being, human development also legitimately extends to other things like a people's system of values, be it religious, ethical or even merely social. In another example, 'democracy', which was initially defined by a frontline American politician as "government of the people, by the people and *for* the people," has been redefined in recent literature as "the government of the people, by the people and *with* the people." However, the bottom line is that since the writer or speaker disagrees with the existing definition, he or she automatically faces the obligation to proffer a redefinition, although the extent to which the stipulated definition is accepted depends on how convincing the author is. On other occasions, a writer or speaker may simply stipulate a working definition in order to defend, prove, or sustain a particular point of view, about which he or she is thoroughly persuaded. Some of the reasons for which a stipulative definition may be offered include secrecy, convenience, or mere idiosyncrasy. A stipulative or nominal definition, therefore, is a proposal to change an already existing meaning to something rather new or different. In effecting this type of definition, the writer or speaker may give the etymology of the word to be defined, replace it with a synonym, or just break it down into its simpler equivalent through the process of translation.

II. **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. This is a formal type of definition used to convey the exact nature or essence of an object, idea, or phenomenon—as it actually is in itself—rather than as we perceive them or want others to view them. Thus, while stipulative definitions are not necessarily true or false—since they depend on the definer's subjective attitude or opinion—real or essential definitions are true or false, depending on whether they correctly capture the phenomenon they are meant to portray or explicate.

III. **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 rather hates to hear.

In this connection, one needs also recall that there is dictionaries are published for every area of human inquiry, like Medical Dictionary, Dictionary of Philosophy, Bible Dictionary, Dictionary of Psychology, Dictionary of Contemporary Linguistics, (and until recently, Dictionary of Terrorism), etc. In all these, one finds that a particular word would enjoy different meanings in different fields of knowledge, and so, is also defined accordingly across those various fields of inquiry. This explains why a term, such as 'stress', would be differently defined in the medical sciences and in other fields, like Physics or Linguistics.

IV. **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*. Also, it certainly helps the police better if a stolen item is reported as a car, van, bus or truck, rather than just a 'vehicle', even if all the other particulars, such as colour, model, registration number, etc., are supplied. In fact, things even get better if the type of car, as well as the company name, is mentioned. Although precising definitions may, sometimes, also serve the ulterior intention of influencing the attitude of an audience, they generally aim at minimizing confusion.

V. **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. Here again, the definition is also merely theoretical or operational since it is meant to push forward the scientist's theoretical insinuations. Typically, this definition type comes in form of mathematical symbols or scientific formulae. Example is any scientific formula, like that of Albert Einstein: $E = mc^2$.

VI. **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. For instance, a military-minded person can ridicule democracy, persuasively defining it as "the government of the people by the few privileged elite, where the public is taught to believe that their opinions and votes count, when, in fact, they do not". Persuasive definitions are commonly found in the sphere of politics, religion, advertisement and the media, etc.

VII. **Ostensive definition:** (From the Latin verb, *ostendere*, meaning "to show", "to reveal" 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. But it is mainly useful in leading the mind to follow the course a particular discourse,

especially if knowing the particular notes of the object referred to is crucial to the whole point of the discourse. 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

a. **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. Thus, the definiens and the definiendum must be equal and mutually co-extensive in meaning. For example, it is erroneous to define a university as a place where people go to learn how to teach or to act in theatrical performances, because a university is much more than that. On the other hand, it seems bogus to define *classroom* as a place where people go to learn *everything* they did not know before, because the concept of classroom is much less, in scope, than that.

b. A definition must not be expressed in negative sentences, except when absolutely necessary. For example, it is clearly ridiculous to define 'bicycle' by saying that it is not a car, or not a motorcycle; such a negative definition would simply leave the real issue of what a bicycle essentially is unaddressed. Thus, this rule simply means that a definition needs to tell what something positively is, rather than just what it is not.

c. 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 misleading because they leave one with little clue as to the actual meanings of the terms being defined, especially if one really does not know what they mean. This is why it would still be a legitimate question—after a circular definition has been rendered—to ask again for the meanings of 'a pot used for cooking' or 'a process by which things evolved'. This would only make the vicious circle to continue spiraling away into infinity, unless a proper definition is derived.

d. **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".

e. **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. Here, again, it seems better to define 'university' as *a place where people go to acquire higher education*, rather than just "a place where students go to do photocopy". The former definition says something about the essence of 'university'; but the latter only furnishes irrelevant details.

Questions:

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

2. Explain the relationship between the purposes and types of definition.
3. How do the rules of definition facilitate the attainment of knowledge?

WEEK 6

Fallacies

Issues:

- Definition of fallacy? Nature of Logical Fallacies
- Causes of fallacy
- Formal and Informal Fallacies
- Fallacies of Relevance and Fallacies of Ambiguity
- Avoiding fallacy

Categories of fallacies

There are many fallacies, depending on the context in which human beings find themselves in real life. But only two major categories have been traditionally identified in Logic to ease the understanding of the nature of these errors. Basically, there are **formal and informal fallacies**. Formal fallacies refer to include **fallacies of undistributed middle term, four terms, denying the antecedent**, **positing consequent, illicit minor term and illicit major**, etc. **Informal fallacies** are many and will be studied in detail hereafter. One fundamental difference between formal fallacies and informal fallacies is that the former are inherent in the logical form or structure of arguments, rather than in the meaning of the propositions that are asserted in the arguments. On the other hand, 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 on their logical structure as such. Thus, as the names apparently suggest, formal fallacies occur in the 'formal' structures of arguments, while informal fallacies occur under typically non-formal or informal circumstances. Here, we shall begin with the formal category of fallacies.

FORMAL FALLACIES

Formal fallacies general occur in the violation of any of the rules of constructing syllogisms and are, therefore, better understood in discussing these rules. Examples are drawn from categorical and hypothetical syllogisms below.

RULES OF CATEGORICAL SYLLOGISM

Here are the six rules that guide the construction of categorical syllogisms:

Rule 1: A valid standard-form categorical syllogism must have only three terms, each of which must appear twice, and used in exactly the same sense, throughout the syllogism. The basic requirement of this rule is that the three terms of a categorical syllogism must maintain their respective meanings throughout, as any shift in the meaning of any of the terms introduces a fourth term; e.g.:

Premise 1: Every **teacher** is responsible to his students.
Premise 2: Experience is a **teacher**.
Conclusion: Therefore, experience is responsible to its students.

This syllogism is invalid (and, in fact, nonsensical) because it involves two different senses of 'teacher': one as '*human* classroom instructor' and the other as '*nonhuman* life experience'. Such categorical syllogisms are, thus, said to commit the **fallacy of four terms**.

Rule 2: In a valid, standard-form categorical syllogism, the middle term must be distributed in at least one of the premises. To understand this second rule, it is important to refer to the distribution table above, and the definition of *distribution* given there, as well as the rules of distribution. For the middle term to perform its stated function of logically connecting premises with their conclusion in a categorical syllogism, it needs to be made universal—that is, by being distributed, or made to refer to *all* members of the class it designates—in at least one of the premises. If it fails to do this, the syllogism would be rendered invalid; and this would be the **fallacy of undistributed middle (term)**, as in the example below:

All shops are **buildings**.
Some **buildings** are houses.
Therefore, some houses are shops.

This categorical syllogism is, therefore, invalid because its middle term ('buildings') is not distributed in both premises. As predicate in the major premise, which is a universal affirmative proposition, it is particular. As the subject of a particular proposition (I) in the minor premise, it is also undistributed.

Rule 3: In a valid standard-form categorical syllogism, if a term is distributed in the conclusion, then it must be distributed in the premises. In other words, a term that is particular in the premises must not become universal in the conclusion, or a logically unacceptable situation known as **overextension** would take place with regard to the term in question. If it is the major term that is overextended in this way, it is called the **fallacy of illicit major**; but if it is the minor term, it is the **fallacy of illicit minor**. Here is an example of the former:

All dogs are **mammals**.
No snakes are dogs.
Therefore, no snakes are **mammals**.

The major term ('mammals') is particular in the premises, and yet is distributed or made universal in the conclusion, thus resulting in the fallacy of illicit major. Here is an example of fallacy of illicit minor:

Some pets are domesticated animals.
Some **snakes** are not pets.
Therefore, no **snake** is a domesticated animal.

Rule 4: No standard-form categorical syllogism is valid if both of its premises are negative propositions. For example:

***No** conservatives **are** radicals.*
*Some radicals **are not** liberals.*
Hence, some liberals are not conservatives.

Because the middle term 'radicals' does not unite the premises, but makes them exclusive of each other, it is impossible to infer a worthwhile conclusion from the premises, as in the above example. This results in the **fallacy of exclusive premises**.

Rule 5: If the conclusion of a valid, standard-form categorical syllogism is negative, then at least one of the premises must be negative; in other words, it is illegitimate to infer a negative conclusion from two affirmative premises. Otherwise, the **fallacy of inferring a negative conclusion from affirmative premises** would occur, as below:

All despots are dictators.
Some dictators are fundamentalists.
*Thus, some fundamentalists **are not** despots.*

Notice that this implies, on the other hand, that if any one of the premises of a valid categorical syllogism is negative, then the conclusion must be negative. Any failure in this regard would, accordingly, result in the corresponding **fallacy of drawing an affirmative conclusion from a negative premise**. For example,

***No** democrats **are** despots.*
Some liberals are democrats.
*Therefore, some liberals **are** despots.*

Rule 6: No valid standard-form categorical syllogism with a particular conclusion can have two universal premises. If both premises are universal, then the conclusion must be universal; or there would occur the **fallacy of existential import**, whereby the conclusion warrants the existence of entities the premises do not assert. It is fallacious for an argument to infer a particular proposition—which asserts the existence of objects of a specified kind—from universal premises, which do not assert the existence of anything at all. Here is an example of such a violation:

All artists are copycats of nature.
No mythical heroes are copycats of nature.
Therefore, some mythical heroes are not artists.

HYPOTHETICAL SYLLOGISM

As the name implies, a hypothetical syllogism is a syllogism made up of hypothetical propositions, or at least whose major premise is a hypothetical proposition. Here is an example of the former:

If Abeokuta is in Ogun State, then Abeokuta is in Nigeria.
If Abeokuta is in Nigeria, then Abeokuta is in Africa.
Therefore, if Abeokuta is in Ogun State, then Abeokuta is in Africa.

The above argument has the following form:

a implies *b*
b implies *c*
therefore, *a* implies *c*

It is the equivalent of the following mathematical expression:

a = *b*
b = *c*
therefore, *a* = *c*

But our focus is on mixed hypothetical syllogisms (i.e. those with hypothetical and categorical propositions). There are two types in this category which are recognized in Logic as the only deductively valid argument forms in hypothetical syllogism. These are called *modus ponens* and *modus tollens.* The former is exemplified as follows:

If Abuja is Nigeria's capital, then Abuja is in Nigeria.
Abuja is Nigeria's capital.
Therefore, Abuja is in Nigeria.

In the *modus ponens*, we **posit** the antecedent in the minor premise, and then **posit** the consequent in the conclusion. This gives us the following argument form:

If *p*, then *q*
p
therefore, *q*

NB: To *posit* a proposition means to use it *exactly* as it originally appears in the major premise of the hypothetical syllogism, i.e. whether affirmative or negative. For instance, in the example above, we moved the antecedent, "Abuja is Nigeria's capital," exactly as it is down into the position of the minor premise, and did the same with the consequent, "Abuja is in Nigeria," to form our conclusion. On the other hand, in the *modus tollens* argument form, we **sublate** the consequent in the minor premise and then sublate the antecedent in the conclusion. To *sublate* a proposition is to deny or negate it as it originally appears in the major premise, for example:

If Accra is Nigeria's capital, then Accra is in Nigeria.
Accra is not in Nigeria.
Therefore, Accra is not Nigeria's capital.

It has this form:

If *p*, then *q*
~*q*
Therefore, ~*p* (where ~ is the sign of negation)

The above example has an affirmative major premise. Here is another example which has a negative major premise:

If Efik is not a Nigerian ethnic group, then Efik is not a Nigerian culture.

Efik is a Nigerian culture.
Therefore, Efik is a Nigerian ethnic group.

Here again, the consequent is first denied (sublated) in the minor premise, and the antecedent denied in the conclusion. It is a fallacy to posit the consequent in the minor premise, in the case of the *modus ponens*—the **fallacy of positing (or affirming) the consequent**. It is also fallacious to deny the antecedent in the minor premise of the *modus tollens*—called the **fallacy of denying the antecedent**.

INFORMAL FALLACIES

Informal fallacies are then 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 conclusion. 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. Below are listed thirteen examples of fallacies of relevance, with their Latin names, as a matter of tradition.

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.

   The problem with the argument of the scientists is that it is illegitimate to conclude that something does not exist simply because it has not been discovered at present; after all, science should be an open-minded, on-going enterprise, not a closed, dogmatic pronouncement that could never be refuted in the future. Besides, many aspects of human knowledge which are taken for granted today were a complete mystery in earlier times. Nor is it legitimate for the natural scientist to dismiss the existence of God based on no other reason than that God cannot be seen physically. This is because not only are some of the claims in science not physically evident, but certain aspects of scientific research are based on speculations.

   On the hand, the problem of the theological argument is that it is wrong to conclude that God must, therefore, exist just because the scientists cannot legitimately argue in the way they did; after all, religious issues are fundamentally a matter of faith and belief, rather than of material evidence.

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.

Of course, adults are also prone to this fallacy: they often affirm or accept, without questioning, whatever their pastor tells them in a religious gathering. Yet, a renowned preacher is not necessarily an authority or an expert in several other areas of knowledge, say agriculture, engineering, or mechanics, etc.

This fallacy is also commonplace with advertising agencies and advertisements. Here, for instance, it is typical to find Austin Okocha, who is a football star, advertising *LG* products or *Pepsi*. Okocha, who is an authority in a completely irrelevant field—football—is posed as an expert in *LG* products, the knowledge of which lies in a completely different area, namely electricals or electronics. The fact that he is knowledgeable in professional football has been cleverly twisted to incorrectly establish the irrelevant conclusion that he is, therefore, an expert in electronics and electrical products or in beverages (as when he advertises for *Pepsi*). Although this fallacy is very persuasive, one need only ask oneself why we should patronize these electrical products or beverages simply because a professional footballer, who may not necessarily know much about the technicalities involved in their manufacture, says they are good for our homes.

However, it is pertinent to note that if Okocha, or any other sporting personality, is used in the advertisement of relevant sports items, like *Puma* or *Adidas* football boots, jerseys, pants, or shorts, then there would be no fallacy involved in that case, because then the advert would be appealing to an authority that is relevant.

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 Tuesday 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 ten thousand innocent people lost their lives?"

This seems like one question; but it actually has at least six other presuppositions: 1) that you travelled to Lagos; 2) that it was last week; 3) Tuesday, to be precise; 4) you threw banana peels out of your car window; 5) you did this intentionally; 6) you killed ten thousand people.

Now, clearly, the answer to the question is not simply in the affirmative or negative. If the defendant answers Yes or No, she would only further implicate herself with a tacit acceptance of these other presuppositions. Again, the defendant makes things even worse by answering that it was not banana peels that she threw out of the window; or that it was not Lagos she was travelling to; much more if she were to say simply that it was not last week Tuesday that the incident happened. In fact, she would even be in big trouble by replying that ten thousand was only an exaggeration of the number of victims involved. Other complex questions are: "Have you spent the money you robbed from the bank?" "Is that your senior wife cooking *our* dinner inside your kitchen?" "Is it next Monday that you will give me a car gift?"

d) **Appeal to personality** (*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 slur 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 argumentation is supposed to address issues, rather than persons or personalities.

Argumentum ad hominem is sometimes instantiated by the famous dictum, "Look who's talking," as when one rejects valid or legitimate points simply because they have come from somebody one does not like or has no affection for. For that reason alone, one contends that the proposal is bound to be bad simply because it has been made by a person one deems to be a radical or an extremist; instead of critically assessing the merits of such proposals with an open mind. Yet, if a proposal is good, then we must accept it, irrespective of who it is coming from, because what makes it good has to do with the proposal itself, rather than with the person who gives it.

Conversely, whatever is bad is bad, no matter who is condemning it—or upholding it. Finally, this fallacy can also be directed at people's circumstance(s). An example is arguing that a preacher must accept a given idea simply because its denial would be inconsistent or incompatible with the scriptures. Another example is that of hunters who, on being asked to stop the barbaric slaughter of wild animals, reply by pointing out that their critics eat the flesh of harmless cattle. The fact that the critics eat beef simply does not establish the conclusion that hunters are justified in exterminating already endangered wild animal species, just for the fun of it.

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. Thus, it would be naïve to aid the death of a person by giving them away to their attackers, simply because we want to remain true to the general principle of honesty being the best policy. Further, it is unreasonable to expect that because political office, at the federal level, is occupied by the president, the vice president, and the senate president, etc. therefore, government at the state level is also made up of the president, the vice president, and the senate president, etc. instead of governors, their deputies and the speakers.

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 stand side by side, or go simultaneously.

This fallacy is related to the **Problem of Induction**, in which philosophers (like David Hume and Bertrand Russell) have maintained that there is no logical basis

for making such a connection, simply because one is yet to observe a single instance in which the first incidence is not accompanied by the second.

People often attribute their having had such a bad day to waking up "from the wrong side of the bed"; or seeing a particular person or thing first thing in the morning. This seems ridiculous; but it is the way people sometimes view the world of reality. They contend, for instance, that because Smith was standing close to them during a gathering, that establishes conclusively that Smith must have stolen their missing purse. Yet, it is not the *modus operandi* of criminals to remain at the scene of their crimes to direct suspicion at themselves. Rather, they cook up alibis for themselves and, if possible, plant materials that will implicate other people who, in fact, are innocent.

Another classical example of this fallacy is the claim that mobile telephony in Nigeria owes its appearance and existence to the particular civilian administration that came to power in 1999. The fact of the matter is that the country was simply a ready market for telecommunications business at that point, such that mobile telephony would still have quite naturally started, as long as any other democratic government was in power.

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 yesterday 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. This fallacy typically takes place when a supposedly adequate explanation leaves issues or questions rather unresolved or unaddressed, even after all is said and done. Thus, in the above examples, the (legitimate) question still begging to be addressed remains, respectively:

1. Why is the holy book the word of God?
2. Why is the colour of your eyes the same as those of your parents?
3. How/why does the future (always) resemble the past?
4. Why is white normally the colour of snow?
5. How would a king not have a throne?
6. Why was I late to the meeting?

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.

This fallacy is perfectly captured in the catchy English phrase, "jumping the band wagon". Young people often fail to understand why their guardians would not permit them to do just about everything their peers are doing. Also, some parents would rather have their children study medicine, law, or such apparently 'more prestigious' courses in the university, with no consideration for the child's peculiar inclinations and natural endowments. Usually, they also want their child to be married into a family with a wealthy and influential background, as befits their status in the society. In fact, wedding ceremonies and marriages could become a complete bore, simply because intending couples must do things exactly as everyone else does, or has been doing, them. However, the principle of majority clearly does not always guarantee rightness or correctness. The fact that everybody is doing—or believing—a particular thing does not make it right; nor does it mean that it is right for me, and that I, myself, must also do it. A whole group of people can, of course, be totally misled.

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. This fallacy is, therefore, also commonplace in law court proceedings, especially when a defendant has eventually been found guilty, and the only option open to his counsel seems to be to appeal to the judge to tender justice with mercy.

In Chinua Achebe's novel, *No Longer at Ease*, and the novel, *Incorruptible Judge*, we find cases where people guilty of a charge are being pleaded for, on account of their having dependants, who would suffer if the defendant were sent to jail, let alone executed. Here, as in other fallacies of relevance, the sidelined issue—the only real issue—is whether the person has, indeed, committed the crime in question; and if he has, what does the law enjoin in that regard?

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) **Irrelevant conclusion** (*ignorantio elenchi*): This is the fallacy in which the argument misses the point by subtly shifting attention from a generally understood and expected conclusion to the establishment of a different conclusion, which serves the ulterior purpose of the speaker or writer, or which may be more appealing to the populace or listeners to a discourse. This is commonly seen in religious and political gatherings, where speakers appeal to the sensibilities of the audience in order to get them to give money or vote for a particular candidate—things the audience would rather not do ordinarily.

m) **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. In times of trials and tribulations, people often think their life has come to a certain or definite end, only for the troubles to evaporate the very next morning. The point here is that, in actual life, things do not always operate with the sort of mechanical or mathematical certainty we expect of them; there is often a probability—no matter how tiny—that things turn out rather differently from what we envisage.

This fallacy apparently results from failure to distinguish between *necessary* and *sufficient* conditions. A necessary condition is a condition that is required for something to happen, but which may not suffice in itself to make that thing happen; but a sufficient condition is one that, if we see it, then we can be sure that that thing has happened, or is about to happen. Thus, while rolling a ball down a slope is a necessary condition for sending it to the valley, that, in itself, may not be sufficient for achieving that purpose. But if the ball is rolled down and the sufficient condition (such as the absence of all impediments) obtains, then would it be reasonable to conclude that it will roll all the way down.

n) **Hasty conclusion**: As the name clearly implies, 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 could have some personal interest in the matter, even when completely in the dark about it. Sometimes, the individual knows that the conclusion may likely be false, and still insists on it due to some ulterior motive. In any case, the fallacy of hasty conclusion represents a disservice to truth and knowledge, both of which are the core targets of Logic.

Once the aim is defeated, the usefulness simply evaporates. This fallacy is rather common in journalism—the tendency, sometimes, to publish an unconfirmed report because of the dramatic impact it would have on the news-starved public. For instance, it is not uncommon to hear, in the news, of the death of some prominent Nigerian politician, only for the concerned politician to appear the next day and dispel the rumour. In another instance, a certain Nigerian professional footballer was murdered in his home in the United States. Before the police finished the investigation, the media were already awash with the conclusion that it was a case of suicide, even when there was no evidence, and the friends and family of the deceased, who had always known him, were insisting that there was no reason for him to have wanted to commit suicide.

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 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.

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 anything about.
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.

Questions:

4. What is fallacy?
5. What is distinction between fallacy and 'lie'?
6. Explain the major difference between formal and informal fallacies.
7. What is the difference between fallcies of relevance and those of ambiguity?
8. Mention three ways of avoiding fallacy.

WEEK 7

NATURE OF SCIENCE

Issues

1. What are the qualities that make science what it is?
2. What is its essence?
3. What differentiates science from other intellectual matters?

Further questions:

13. What is science?
14. What are we in search of?
15. Are we in search of knowledge or information?
16. How do we distinguish between genuine research and pseudo research?
17. What is the importance of science?

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

WEEK 8

METHODS OF SCIENCE

1. 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 empiricist, 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 change or not? Is it true that human has the capacity to perceive reality accurately when philosophy has made us know 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 UFO (Unidetified 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?

Thomas Samuel Kuhn, in *The Structure of Scientific Revolutions*, observed that scientific method is now taking a sociological dimension different from what it used to be. For this reason, much work was done by Imre Lakatos and Thomas Kuhn on the "theory laden" character of observation. Kuhn (1961) says, "the scientist generally has a theory in mind before designing and undertaking experiments so as to make empirical observations. He also claimed that the route from theory to measurement can almost never be traveled backward". This implies that the way in which theory is tested is dictated by the nature of the theory itself. This led Kuhn (1961: 166) to argue that "once it has been adopted by a profession ... no theory is recognized to be testable by any quantitative tests that it has not already passed".

On a similar note, Paul Feyerabend denied that science is genuinely a methodological process. In his book *Against Method*, he argues that scientific progress is *not* the result of applying any particular method. He argues that for any specific method or norm of science, one can find a historic episode where violating it has contributed to the progress of science. Thus, if believers in a scientific method wish to express a single universally valid rule, Feyerabend jokingly suggested, it should be "anything goes".

Michael Polanyi (1891–1976), a chemist and philosopher, in his book *Personal Knowledge*, also criticized the common view among the scientist community that the scientific method is purely objective and generates objective knowledge. He considered this view a misunderstanding of the scientific method and of the nature of scientific inquiry. He argued that scientists do and must follow personal passions in appraising facts and in determining which scientific questions to investigate. He concluded that a structure of liberty is essential for the advancement of science: that the freedom to pursue science for its own sake is a prerequisite for the production of knowledge through peer review and the scientific method.

For the postmodernist, it is “science wars”, resulting from conflicting values and assumptions between them and the realist camp. Whereas postmodernists assert that scientific knowledge is simply another discourse and not representation of any form of fundamental truth, the realists maintain that scientific knowledge reveals real and fundamental truths about reality/nature. However, many books have been written by scientists to challenge the postmodernist’s assertions and defend science as a legitimate method of deriving truth.

Even though, a highly controlled experiment allows researchers to catch their mistakes and make anomalies easier to see, about 33% to 50% of all scientific discoveries are estimated to have been *stumbled upon* rather than sought out. This may explain why scientists so often express that they were lucky. On this background, Louis Pasteur says, "Luck favours the prepared mind", but some psychologists have begun to study what it means to be 'prepared for luck' in the scientific context. The psychologist, Kevin Dunbar, corroborating this says, “the process of discovery often starts with researchers finding bugs in their experiments”. These unexpected results lead researchers to try and fix what they *think* is an error in their methodology. Eventually, the researcher decides the error is too persistent and systematic to be a coincidence. The highly controlled, cautious and curious aspects of the scientific method are thus what make it well suited for identifying such persistent systematic errors. At this point, the researcher will begin to think of theoretical explanations for the error, often seeking the help of colleagues across different domains of expertise.

Summarily, scientific methods were not seen as providing a universal and rigid method by which truths are discovered. They are not as objective as science portrayed them and they do not provide objective knowledge as always claimed by science and scientists.

2. 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). In this book, it was a remarkable that Alhazen based the conclusions of his work on experimental evidence rather than abstract reasoning: the first major publication to do so. Alhazen's contributions have proved so significant that his likeness was immortalized on the 2003 10,000-dinar note issued by Iraq.

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

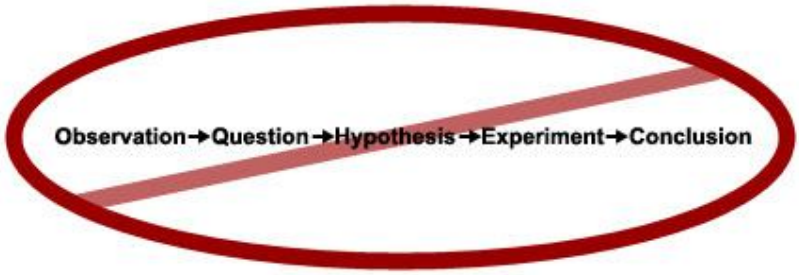
(2) There is no method for ascertaining the truth of a scientific hypothesis, i.e., no method of verification;

(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**.

3. 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.

4. 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; 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?

Recommended Texts:

Born, Max (1949), *Natural Philosophy of Cause and Chance*, Peter Smith, also published by Dover, 1964. From the Waynflete Lectures, 1948.

Brody, Thomas A (1993), *The Philosophy Behind Physics*, Springer Verlag, (Luis De La Peña and Peter E. Hodgson, eds.)

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

Gauch, Hugh G., Jr. (2003), *Scientific Method in Practice*, Cambridge University Press, http://books.google.com/?id=iVkugqNG9dAC 435 pages

Godfrey-Smith, Peter (2003), *Theory and Reality: An introduction to the philosophy of science*, University of Chicago Press.

Kuhn, Thomas S.(1962), *The Structure of Scientific Revolutions*, University of Chicago Press, Chicago, IL, 2nd edition 1970. 3rd edition 1996.

Popper, Karl R., *The Logic of Scientific Discovery*, 1934, 1959.

WEEK 9

PROBLEMS OF SCIENTIFIC AND TECHNOLOGICAL DEVELOPMENT IN NIGERIA

Issues

4. What science is
5. What technology is
6. What development is
7. What Nigeria is
8. Set backs to the development of science and technology in Nigeria
9. Problems created by the development of science and technology in Nigeria

Further questions:

1. What are the objectives of technology?
2. What is technology transfer?
3. What are the problems associated with technology transfer?
4. Is technology transfer likely to hinder or promote the development of science and technology in Nigeria?

WEEK 10

SCIENCE AND SOCIETY

Issues

10. What science is

11. What society is

12. Interdependence between science and society

13. Characteristics of science

14. Characteristics of society

15. Impact of science on society

16. Impact of society on science

Further 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?