ELEMENTARY LOGIC

(L.L.B.)

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PREFACE.....

The University of Bombay has recommended two of my books – (i) Introduction to Logic and (ii) Second Course in Logic – for Pre-Law students. But "Introduction to Logic" has been out of print for almost 20 years. Moreover, the style of question papers too is markedly different from what prevailed two decades back. Hence, this book has been especially written for the Pre-Law Syllabus. Of course, the basic material for the book is from my earlier books on Logic.

Knowledge of logic is useful to everyone; but it is of greater importance to a student of law. A lawyer has to be particularly alert to the weaknesses in his opponent's arguments. The new Five-Year degree course in Law has prescribed Logic as a subject for the first two years of Pre-Law course.

In spite of the great importance of Logic, there isn't much curiosity about it. So a writer on Logic has to do something to stimulate interest. I trust that "DO YOU KNOW QUESTIONS", *with which each Chapter begins, will arouse the reader's interest.*

In Logic, a major problem for the student is to determine whether he is going along the right track. So, the relatively more difficult test questions have been solved at the end of the book.

A large number of objective and short answer questions too have been framed. This will enable the reader to judge whether he has grasped the subject and whether he is clear about its central concepts.

I acknowledge my gratitude to Ms. Chhaya Date, Lecturer in Logic at the Govt. Law College, Bombay, for having volunteered to distribute the book directly to the students. This has helped my Publishers to make the book available at a fairly low price, in spite of small number of copies that have been printed.

K. T. BASANTANI

SYLLABUS .....

LOGIC - PAPER I – PRE-LAW 1ST YEAR

SECTION I : Deductive

I. **Nature of Logic** – (a) Definition of Logic; (b) Deductive and Inductive arguments; (c) Form and content of an argument; (d) Concept of logical form; (e) Logic as a formal science; (f) Truth and Validity; (g) Inference and Implication; (h) Utility of Logic.

II. **Propositions** – (a) What is a proposition? (b) Traditional analysis of a proposition; (c) Constituents and components; (d) Proposition and Fact; (e) Proposition and Sentence; (f) Proposition and Judgment.

III. **Terms** – (a) What is a Term? (b) Distinction between a word and a term; (c) Kinds of terms – Singular and General; Positive and Negative; Condrary and Contradictory; (d) Denotation and Connotation.

IV. **Traditional Classification of Propositions** – (a) Simple and Compound Propositions; (b) Categorical and Conditional propositions; (c) Quality of Propositions; (d) Quantity of propositions; (e) Four-fold classification of propositions; (f) Singular propositions; (g) Reduction of sentences to logical form; (h) Distribution of terms in a Categorical Proposition.

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VI. **Laws of Thought** – (a) Law of Identity; (b) Law of (Non) Contradiction; (c) Law of Excluded Middle; (d) Functions of the Laws of Thought.

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VIII. **Opposition of Propositions** – (a) Types of Opposition; (b) Inference by Opposition of Propositions; (c) Opposition of Singular Propositions.

IX. **Eductions** – Types of Eduction : (a) Converse; (b) Obverse; (c) Obverted Converse; (d) Contrapositive; (e) Inverse; (f) Other Immediate Inferences.

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XI. **Division** – (a) What is logical Division? (b) Rules of logical division; (c) Fallacies of Division.

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XIII. **Explanation** – (a) What is an Explanation? (b) Nature of scientific explanation; (c) Common sense and Scientific explanation; (d) Explanation of facts and law; (e) Types of Explanation; (f) Limits of Explanation.

Recommended Readings :

1. Introduction to Logic – K. T. Basantani.
2. An Introduction to Logic – Irving Copi.

LOGIC – PAPER II PRE-LAW (IIND YEAR)

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II. **Deductive Proof :** (a) Direct deductive proof; (b) Nine rules of Inference; (c) Formal proof of validity; (d) Rule of Replacement; (e) Rule of conditional proof; (f) Rule of Indirect proof; (g) Proof of Tautologies.

III. **Hypothetical and Disjunctive Arguments :** (a) Rules of Hypothetical–Categorical Argument and Fallacies; (b) Rules of Disjunctive–categorical argument and fallacies; (c) Dilemma – What is a dilemma? Types of Dilemma; Rebuttal of a dilemma; Refutation of a dilemma; Importance of dilemma.

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IX. **Mill's Experimental Methods :** (a) Method of Agreement; (b) Method of Difference; (c) Method of Agreement and Difference; (d) Method of Concomitant Variation; (e) Method of Residues; (f) Evaluation of Mill's methods.

Recommended Books for Pre-Law (IInd Year)

1. Second Course in Logic – K. T. Basantani
2. Modern Introduction to Logic – L.S. Stebbing

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CHAPTER – 1

NATURE OF LOGIC

DO YOU KNOW THAT ....

- *whether you are a mathematician, scientist, poet, actor, or lawyer, you are bound to follow rules of logic?*
- *we all use rules of logic – logic merely makes us aware of them ?*
- *your reasoning can be correct even when your conclusion is false ?*
- *an uneducated man may reason as well as a logician ?*
- *logic would help us to detect errors in reasoning ?*

1. INTRODUCING LOGIC

The essential feature which distinguishes man from other creatures is his ability to reason. This reasoning ability is revealed when men infer, argue or demand proofs.

Men sometimes reason well, and sometimes badly. We use various expressions to indicate this. The words 'correct', 'valid' and 'logical' stand for good reasoning, and the words 'incorrect', 'invalid' and 'illogical' stand for bad reasoning. The science which enables us to draw these distinctions is logic. *Logic furnishes principles and methods for distinguishing between correct and incorrect reasonings.*

We are familiar with the process of drawing conclusion from the data. The terms 'inference' and 'reasoning' are used for this process.[1] In an inference the thinker passes on from one or more given statements, accepted as true, to another statement, which follows from them. The given statements are called the *premises.* The statement which follows from them is called the *conclusion.* Let us take an example.

All honest men are trusted.

All good men are honest.

∴ All good men are trusted.

---

[1] We shall ignore the. distinction between inference and reasoning.

Here the statements *"All honest men are trusted "* and *"All good men are honest"* are the premises. The statement *"All good men are trusted "* is the conclusion.

2. INFERENCE AND IMPLICATION

In an inference the thinker proceeds from the premises to the conclusion. He does so, because he believes that there is a certain relationship between the premises and the conclusion. This relation is that of implication.

The relation of implication holds between two (or more) statements. These are called implicans and implicate. *Implicans* is the statement (or statements) which implies some other statement. *Implicate* is the statement which follows from the implicans. Let us take examples.

1. A is red implies A is coloured.
2. If A is a father, then he is a man.

In the first example, "A is red" is the implicans. It implies the statement "A is coloured." The statement "A is coloured" is the implicate. It follows from the statement "A is red." In the second example, "A is a father" is the implicans, while "He (A) is a man" is the implicate.

In the relation of implication, if the implicans is true, the implicate must be true.

If the relation between the premises and the conclusion of an inference[2] *is that of implication, then it could not be the case that the conclusion is false when the premises are true.* This means, when the premises are true, the conclusion must also be true.

In an inference the conclusion follows from the premises, because the thinker knows that the premises imply the conclusion. If the relation between the premises and the conclusion were not that of implication, the conclusion could not be drawn from the premises. This will be clear from the following examples:

1. This wall is white.

∴ This wall is not not-white.

In the above inference, the premise *"This wall is white"* implies the conclusion *"This wall is not not-white."* Due to this relation, it is impossible that the conclusion *"This wall is not not-white"* be false if the premise *"This wall is white" is* true. Such a relation between the premise and the conclusion is said to be that of implication. It is because of the relation of implication that the thinker is able to draw the conclusion from the premise. Now look to the following inference :

2. A is the brother of B.

∴ B is the brother of A.

In this inference the premise does not imply the conclusion. The conclusion may be false even if the premise is true.[3] *In fact, the premise implies that "B is either the brother or the sister of* A." Since it may be the case that B is the sister of A, the above conclusion cannot be drawn.

It is to be noted that implication is a logical relation between propositions as such. (A proposition is a statement which is either true or false.) It does not depend upon the thinker. The implications of a proposition are its logical consequences. These will remain the same whether the thinker knows them or not. Thus, the relation between implication and inference is one-sided. While every inference depends upon an implication, the relation of implication does not depend upon drawing the inference.

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[2] Here the reference is to deductive inference. The premises of an inductive inference do not imply the conclusion. (See Section 4 below.)

[3] "Brother of" is a non–symmetrical relation. (See Ch. 14.)

3. DEFINITION OF LOGIC

The science of logic has developed along two different, though related, lines. One line of development has been influenced by the doctrines of Aristotle. The other line of development was due to certain advances in mathematics. The logical doctrines of Aristotle, and those who followed him, are called *Traditional Logic,* while the doctrines of those logicians who were influenced by mathematics are called *Mathematical Logic.* As the mathematical logicians make greater use of symbols, their treatment is also called *Symbolic Logic.* Symbolic logic or mathematical logic developed in modern times. Therefore, it is commonly called *Modern Logic.* We should bear in mind that modern logic does not differ radically from traditional logic. It is a development and extension of the principles of traditional logic.

Traditionally, logic was defined as the science which investigates the general principles of valid thought.[4] It is a systematic inquiry into these principles. It provides principles which will enable a person to distinguish between correct and incorrect arguments.

The above definition regards thinking as the subject-matter of logic. The term 'thinking' is too wide. It applies to several mental processes. *These include not only reasoning, but also imagining, daydreaming and remembering.* All these processes cannot be the concern of the logician. Logic deals with reasonings alone. Its task is to study the difference between good reasoning and bad.

Moreover, thinking, being a mental process, is subjective. It is something that occurs in the mind of the thinker. We cannot consider this process from the point of view of its validity. For instance, how can we determine whether our daydreams are valid or invalid? These objections show that the above definition is unacceptable.

Cohen and Nagel hold that the central topic of logic is implication. *They define logic as "the Science of implication, or of valid inference (based on such implication)."*[5]

The above definition too is not acceptable. It applies to deductive arguments only. But logic includes inductive arguments too. In view of this, today logicians generally agree that logic deals with valid arguments. **So we may define logic as the study of the forms of valid arguments.**[6]

Valid argument : In an argument it is claimed that the conclusion follows from the premises. But do the premises provide evidence for the conclusion? And if they do, is the evidence adequate? Let us understand this with the help of examples.

1. All Hindus are men.
   All Brahmins are Hindus.
   ∴ All Brahmins are men.
2. Ram is older than Gopal.
   Gopal is older than Ashok.
   ∴ Ram is older than Ashok.
3. A, B and C are Jews.
   A, B and C are intelligent.
   ∴ All Jews are intelligent.

---

[4] J.N. Keynes, *Studies and Exercises in Formal Logic,* Fourth Edition, p. 1.

[5] Cohen and Nagel, *An Introduction to Logic and Scientific Method,* 1964, p.13.

[6] The words "inference", "reasoning" and "argument" are not used in exactly the same sense. But, in this elementary text, we shall ignore these minor differences. So, the words "inference" and "reasoning" appear, they shall have the same meaning as the word "argument".

In the first argument the class of Brahmins is included in the class of Hindus, and the class of Hindus is included in the class of men. So the conclusion asserts that the c]ass of Brahmins is included in the class of men. The premises of the second argument assert a certain relation between individuals. Ram has the relation of "being older than" to Gopal, and Gopal has this relation to Ashok. Thus, it is concluded that Ram has this relation to Ashok. In both these arguments the evidence is sufficient. That is, if the premises are true, the conclusion must be true. But this is not the case with the third argument. Its premises may be true, and yet the conclusion may be false. However, we do not come across such clear cases. Moreover, in real life, even about clear cases, people do have different feelings. To some men, a black cat crossing the way is sufficient to make them believe that it was the cause of their ill luck. To others, the reasoning sounds silly. Now logic cannot go by what we happen to feel about the evidence. *It must provide methods for determining whether an argument is valid (correct) or invalid (incorrect).*

The validity of an argument is determined by the nature of relationship between its premises and its conclusion. If the premises provide "good" evidence for the conclusion, the argument is valid.[7] If not, it is invalid. However, what is regarded as "good" evidence depends upon the type of argument. "Good evidence" in the case of inductive arguments differs from "good evidence" with regard to deductive arguments. For deductive arguments, evidence is considered to be "good" only if the relation between the premises and the conclusion is that of implication.

4. DEDUCTIVE AND INDUCTIVE ARGUMENTS

Arguments may be classified into deductive and inductive (non-deductive). The classification is based upon the nature of relationship between the premises and the conclusion. In a deductive argument the premises imply the conclusion. As such, the conclusion cannot be false, if the premises are true. The following argument is deductive:

All birds have feathers.

All crows are birds.

∴ All crows have feathers.

Since the premises of a deductive argument imply the conclusion, they provide sufficient evidence for it (the conclusion). That is, nothing more is required to demonstrate the conclusion.

We also come across arguments in which the premises do not provide sufficient evidence for the conclusion. Such arguments are said to be inductive. Consider the following inductive argument:

Socrates, Plato and other men (who have died so far) are mortal.

∴ All men are mortal.

The evidence for the conclusion consists of the cases of those men who have died in the past. Now it is possible that what has occurred in the past may not occur in future. This shows that the evidence is not sufficient.

It follows from the above that the conclusion of a deductive argument is certain, while that of an inductive argument is probable. To bring out the probable character of inductive arguments, Bennet and Baylis call them *"empirical probability arguments".*[8] This expression is used to show that sciences use inductive arguments.

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[7] This definition of "valid argument" covers both deductive and inductive (non-deductive) arguments. But, strictly speaking, only correct deductive arguments can be described as valid arguments.

[8] Bennett and Baylis, *Formal Logic*, p. 7.

Different inductive arguments have different degrees of probability. And the scientific value of an argument depends upon its degree of probability.

For testing the validity of deductive arguments, it is possible to find exact criteria. These criteria can be applied mechanically. But there are no such criteria for determining the scientific value of inductive arguments.[9]

We may bring out the difference between deductive and inductive arguments in another way too. Since in a deductive argument the premises imply the conclusion, the conclusion cannot go beyond the premises. On the other hand, the conclusion of an inductive argument goes beyond the premises. As a consequence, the premises of an inductive argument may be true, and yet its conclusion may be false. This cannot be the case with a deductive argument.

According to the modern logicians, logic is a science of deductive systems. So they do not include induction in the scope of logic. However, today logicians hold that logic must include inductive arguments too. Our definition of logic has taken this into consideration.

5. FORM AND CONTENT OF ARGUMENT

Each inference is about a certain subject matter. This is called its content. Apart from its content, it has certain other characteristics. These are said to be its form. Let us illustrate.

1. Pawar is a Maharashtrian.
   All Maharashtrians are Indians.
   ∴ Pawar is an Indian.
2. Sunil Dutt is an actor.
   All actors are artists.
   ∴ Sunil Dutt is an artist.

It is obvious that these two inferences differ in their content. However, they are very similar. They have the same form. In both of them an individual (Pawar, Sunil Dutt) is stated to be a member of a class. This class is included in a wider class. From these, it is concluded that the individual is a member of the wider class. The diagrams at Figs. 1.1 and 1.2 clearly bring out that their form is the same. Now take the following inference:

3. All Maharashtrians are Indians.
   All Indians are men.
   ∴ All Maharashtrians are men.

The third inference has a different form. (See Fig. 1.3.) It makes no reference to an individual. It expresses relations between three classes. One class (Maharashtrians) is included in another class (Indians). This class (Indians) is included in a still wider class (men). So it is concluded that the first class (Maharashtrians) is included in the third class (men).

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[9] Carney and Scheer (*Fundamentals of Logic, 1964*, p. 189) talk about the "correctness" of inductive arguments. I have substituted the expression "scientific value" for "correctness".

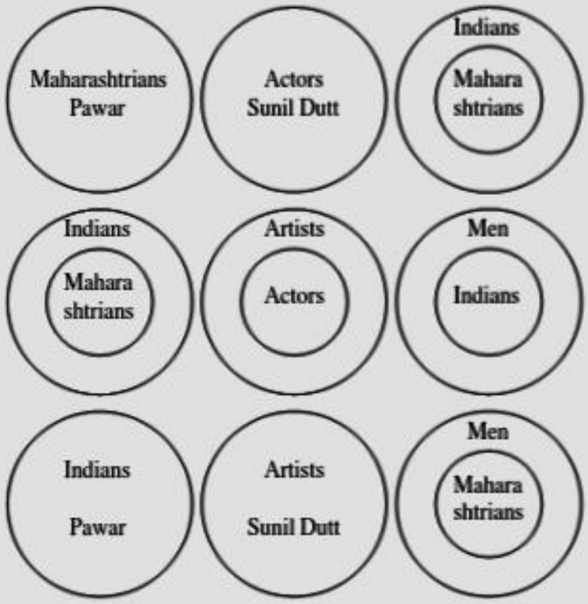

Fig. 1.1 **Fig. 1.2** **Fig. 1.3**

Logic, as we have said, studies the forms of valid inferences. To do so, the logician must find out which forms are valid, and which invalid. This would enable him to arrive at the principles by which the validity of inferences is to be determined.

In section 8, we shall see that there are **two different senses of validity.** In that Section, we shall see that deductive inferences are said to be formally valid, while correct non-deductive inferences can be properly described as "good arguments".

6. LOGIC AS A FORMAL SCIENCE

In the preceding section we have seen that arguments have a certain content and a certain form. Now we have to discuss whether logic is concerned with forms of arguments or with their contents.

The specific problem for logic is to distinguish between valid and invalid arguments. The validity (or correctness) of an argument depends upon its form. It is not affected by the content of the argument. This become clear from the following examples :

1. A is a table.

   ∴ A is not a chair.

2. If A is a table, A is not a chair.

   A is a table.

   ∴ A is not a chair.

The conclusions of both these arguments are clearly true. But they re true for different reasons. In the first argument the conclusion "A *is not a chair*" follows from the premise "A *is a table*", because we know the meanings of the words "table" and "chair". That is to say, the truth of the conclusion depends upon our knowing the content (or subject-matter) of the argument. On the other hand, the conclusion of the second argument will be true even if we did not know the meanings of the words 'table' and 'chair'. The correctness of this argument is independent of its content. This can be easily shown by replacing the content of the second argument with certain symbols. By using the symbol 'p' for *"it is a table"* and the symbol 'q' for *"it is a chair"*, the second argument would be :

If p, then not q

p

∴ not q

Let us supply some other content in place of 'p' and 'q', but keep the form of the argument same.

3. If I work hard, I shall not fail.

I work hard.

∴ I shall not fail.

Here "I *work hard"* is put in place of the symbol 'p'; *"I shall fail" is* put in place of the symbol 'q'. Like the argument (2) above, this argument (argument 3) is also correct. The contents of the two arguments are clearly different. Therefore, their correctness does not depend upon their content. Since the form is the same, the correctness of the arguments must be due to their form.

Since the validity of an argument depends upon its form, logic is said to be a formal science. Moreover, it would be impossible for logic to examine the contents of all the actual and possible arguments. That is why logic abstracts, from the context, forms of propositions and arguments and then finds out the valid argument forms. In this way, logic supplies methods and principles for distinguishing between valid and invalid arguments.

The formal nature of logic becomes clear from the fact that logic is concerned with necessary propositions.[10] On the other hand, all the other sciences (with the exception of mathematics) are concerned with contingent (or empirical) propositions. Let us see what necessary and contingent propositions are. A *necessary proposition* is one whose truth does not depend upon experience. Its truth can be known by examining the proposition itself. On the other hand, a *contingent proposition* is one whose truth depends upon experience. Let us understand the nature of necessary and contingent propositions with the help of the following two sets of propositions :

Set I

1. If trains are late, railway stations are crowded.
2. Signal lights are either red or green.

Set II

1. If it is green, then it is not not-green.
2. Either America won the war in Viet Nam or it did not.

The propositions of the first set are contingent, while those of the second set are necessary. We can determine the truth of the propositions of the first set by appealing to experience. But the propositions of the second set are true, irrespective of experience. They are true on account of their form.

The propositions of logic are true in virtue of their form. No matter what the word "green" means, the proposition "If *it is green, then it is not not-green"* will be true. Its truth can be known by examining the proposition itself.

7. THE NOTION OF LOGICAL FORM

Common sense distinguishes between the matter and the form of a thing. A ten-paise coin has a certain form or shape; and it is made of a certain kind of material. Similarly, the statue of a person may be made of marble, bronze, silver or gold; yet it may have the same form. For the common man, the form of a thing is its shape. This is not the correct notion of form. *The notion of form is wider than that of shape.* Shape

[10] Ambrose and Lazerowitz, *Fundamentals of Symbolic Logic*, pp. 18-19.

is physical, while form may not be physical. Non-physical things, like music and poetry, also have form. Music may be in different rā gas. Rā ga is the form of music. We are also familiar with the forms of poetry like *'ghazal'*, *'nazm'* and *'rabā i'*.

Susanne Langer explains the notion of form by comparing it with structure.[11] The structure of a thing is the way it is constructed. It is the organization of parts having certain mutual relations. To take an example, the structure of a chair is the arrangement of its legs, arms, seat and back. Similarly, the structure of a proposition is its various elements. The proposition *'Ashok is handsome' is* composed of the subject Ashok', the predicate 'handsome' and the sign of relationship 'is'.

The structure of the different kinds of propositions is different; Let us consider the following propositions :

1. Indira Gandhi is the daughter of Jawaharlal Nehru.
2. Indira Gandhi is tall.

The first proposition asserts a relation between two individuals, viz. Indira Gandhi and Jawaharlal Nehru. The second proposition asserts that the attribute of tallness is possessed by the individual 'Indira Gandhi'.

Not only propositions, but arguments also, may differ in their structure and, thus, in their form.

In Section 5, we have seen that the first two arguments differ in their structure from the third argument. All the three propositions of the third argument assert that one class is included in another class. But only the first proposition of the first and the second argument asserts this relation. The other two propositions express that an individual is a member of a class.

The notion of logical form can be further clarified (a) by comparing logical form of a proposition with the grammatical form of a sentence, (b) by means of blanks, and (c) by referring to the use of constants and variables.

Form of proposition and form of sentence: Grammar classifies sentences into indicative, interrogative, exclamatory, optative, etc. Now, the form of an interrogative sentence differs from that of an exclamatory sentence. But all interrogative sentences, whatever their contents, have the same form.

1. Where were you yesterday ?
2. Why did you leave the classroom?
3. What is your name ?

All these sentences ask for information. Therefore, they have the same form. Propositions may also have the same form, though they may differ in their contents. Consider the following propositions :

1. Ram is honest.
2. Socrates was wise.
3. Taj Mahal is beautiful.

In all these propositions the subject is an individual, while the predicate is an attribute. The propositions state that an attribute is possessed by an individual.

Form as revealed by blanks: Max Black explains the notion of form by the use of blanks.[12] We fill forms in which blanks (.......) are provided. These blanks are to be filled in with the required information. Different persons filling the same form would supply different information. To clarify the idea of blanks, some columns from a college admission form are given below :

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[11] Susanne Langet, *Introduction to Symbolic Logic*, pp. 11-16.

[12] Max Black, *Critical Thinking*, Second Edition, pp. 48-50.

Name..............................

Religion ....

Age .... Date of birth............

Different persons seeking admission will supply different information in these blanks, but the pattern of the admission form, with its columns, will remain the same.

Constants and variables : The notion of form is further clarified by the use of symbols. Modern logic uses two kinds of symbols. These are constants and variables. The meanings of 'constant' and 'variable' in logic are similar to their meanings in common use. In common use constant means that which remains the same, and variable means that which changes.

Variables are those symbols which do not have any fixed meaning They may be given any value. In this respect, variables are similar to blanks in a form. As a blank may be filled in with any information, a variable may be replaced by any content. We shall examine the following propositions and see what constants and variables they involve :

1. If it rains, then roads will be wet.
2. If the day is hot, then we perspire.
3. Ram is either intelligent or hardworking.
4. He is either a poet or a philosopher.

The first two propositions state a condition and a consequence that follows from it. The expression "if-then" expresses this. The last two propositions state alternatives. The expression "either-or" asserts relation between alternatives. However, the first two propositions differ in their contents, and so do the last two. Suppose we leave blanks in place of the contents, the form of the first two propositions will be "If .... then ....", while that of the last two propositions will be "either .... or ....". Now, instead of leaving blanks, we may place certain symbols (which are letters of the English alphabet). These symbols will be called variables.[13] If we place variables, the above propositions would be:

1. If p, then q.
2. If p, then q.
3. Either p or q.
4. Either p or q.

In the first two, 'p' stands for the condition and 'q' for the consequence. In the last two, 'p' and 'q' stand for the two alternatives. The symbols 'p' and 'q' are variables.

In the above propositions the expressions "if-then" and "either-or" are called constants.[14] These constants have always the same meaning. In fact, the form of the first two propositions is the same, because the same constant occurs in them. Similar is the case with the last two propositions. This shows that the form of a proposition depends on the constants.[15] However, it (the form) is revealed by variables. Variables show that the content of a proposition makes no difference to its form.

8. TRUTH AND VALIDITY

The validity of an argument is sometimes confused with the truth of its conclusion. However, validity and truth are two separate aspects of an argument.

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[13] The reference is to propositional variables.

[14] Reference is to logical constants, and not to individual constants or predicate constants.

[15] The reference is to the form of a compound proposition.

Truth is the property of a proposition. A true proposition represents facts, while a false proposition does not. Consider the following propositions :

1. The earth is round.
2. Gold is heavier than silver.
3. There are golden mountains in India.
4. Man can live without oxygen.

Obviously, the first two propositions here are true, while the last two are false. This is because the first two propositions represent fact, but the last two do not.

When we talk about the truth and falsity of an argument, we are really referring to the truth and falsity of the conclusion of the argument. Now the conclusion depends upon the premises. Therefore, we shall see later, how the truth and falsity of the conclusion is related to the truth and falsity of the premises.

Validity of an argument depends upon the nature of relationship between its premises and its conclusion. *An argument is valid, when its conclusion is a logical consequence of its premises.* To put it differently, when the premises of an argument imply its conclusion, the argument is valid.

A valid argument makes no claim regarding the truth or falsity of either the premises or the conclusion. However, careful thinkers would like their arguments to be both valid and true. Such arguments may be called **'sound arguments'.**[16] As we have already seen, when the premises of a valid argument are true, its conclusion is also true. Therefore, a sound argument will have true conclusion.

In a valid argument the relation between the premises and the conclusion is that of implication. *The relation of implication guarantees only this. It is impossible for the conclusion to be false when the premises are true.* Thus, an argument will be invalid only when the premises are true, but the conclusion is false.

It may seem surprising that even when the premises and the conclusion are false, the argument may be valid. Really, there is nothing surprising about this, because truth and validity are two separate aspects of an argument. Let us take an argument in which the premises as well as the conclusion are false, and yet the argument is valid.

All men are immortal.

All monkeys are men.

∴ All monkeys are immortal.

This argument is valid, because its conclusion follows from the premises.

Now we are in a position to discuss whether logic is concerned with truth or with validity. Arguments have a content and a form. We determine the truth or falsity of an argument by examining its content. We determine its validity by examining the nature of relationship between the premises and the conclusion. The pattern of relationship between the premises and the conclusion is the form of argument. *Since logic* is a *formal science, it is concerned with validity, and not with truth.*

There are other reasons too why logic is not concerned with the factual problem of truth. Arguments in all the branches of knowledge fall within the scope of logic. It would be impossible for the logician to find out the truth or falsity of propositions in all spheres of knowledge. Moreover, the subject-matter of logic is merely the forms of arguments, and not any particular argument or its content. This also shows that logic is concerned with validity only.

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[16] Albert E. Blumberg in *Encyclopaedia of Philosophy* (Collier Macmillan, 1967), Vol. V, p. 13.

Validity of inductive inferences : Logicians usually reserve the term "valid inference" for correct deductive inferences. So, for the sake of clearness, we shall use the expression "good argument" for a correct inductive (non-deductive) inference, and "bad argument" for an incorrect one.

We cannot determine the "validity" of inductive inferences in the same way in which we determine the validity of deductive inferences. The premises of an inductive inference do not imply its conclusion. So we cannot say that, in a good argument, if the premises are true, the conclusion must be true. Rather, we can say that *if the evidence in the premises (of an inductive inference) makes it reasonable to believe the conclusion, the argument is good*. If not, it is bad.

To determine whether an inductive inference is "good" or "bad", we have to consider the content of its premises. That is why some logicians say that a correct inductive inference is "materially valid". Thus, the "validity" of an inductive inference is determined by the amount of evidence in the premises. So, if there is change in the evidence, the reliability of the argument will be affected. Take the following three cases :

a) Mr. 'A' is 25. So he will be alive next year. (This is a good argument. Its conclusion is quite likely to be true. The available evidence shows that very few people who are 25 years old die before the age of 26.)

b) Mr. 'A', a truck driver, is 25. He loves fast driving, and has had many accidents in the past. When he was driving at high speed, his truck hit another one. From these facts, it is concluded that he will be alive next year. (This argument is bad. On the basis of the evidence in the premises, it is not reasonable to believe the conclusion.)

c) While 'D' was on his way to keep an important appointment, a black cat crossed his path. This made him conclude that he will meet with bad luck. (Here the premise is irrelevant to the conclusion. As such, it cannot be regarded as the evidence for the conclusion. So the argument is a bad one.)

We may further add that an argument may become a bad one if too much is claimed in the conclusion. Suppose we know that "P" is a Jain. From this we may infer that he is likely to be a vegetarian. Since we know that most Jains are vegetarians, it is reasonable to accept the conclusion. So the argument is good. Now suppose we say "He is a Jain, and so he is sure to be a vegetarian", the argument would become a bad one.

An argument is judged to be good or bad on the basis of the available evidence. So even if the conclusion turns out to be false, the argument may be good. Let us suppose that it has been raining every evening for the last ten days. Newspaper reports say that this is due to an area of depression in the Indian Ocean. From this evidence we infer that it is likely to rain that evening too. But if it does not rain that evening, the conclusion would be false. Yet at the time we inferred the conclusion, we had good reasons for doing so. Therefore, the argument is a good one.

We cannot determine whether an inductive inference is good or bad by applying the rules of formal logic. About common sense inferences, such as the above ones, there is no particular difficulty. But we find inductive inferences in all fields of knowledge. Here only an expert can judge whether an argument is good or bad. A botanist can examine arguments in Botany, an economist those in Economics, and so on.

Truth and validity of inductive inferences : As in the case of deductive inferences, so also in the case of inductive inferences, truth and validity are two separate aspects. An inference may be a bad one even when its premises and conclusion happen to be true. To illustrate, take the example of a black cat crossing

D's path. Now suppose, shortly afterwards, 'D' meets with bad luck. Let us say, he is arrested for hoarding rice. Then the conclusion would be true. However, the argument would still be bad; because the premise is irrelevant to the conclusion.

9. UTILITY OF LOGIC

The primary concern of logic is to find out the general principles which are exhibited in valid arguments. Logic is not interested in the practical application of these principles. It does not matter to the logician whether these principles are useful for determining the validity of arguments. Still we cannot say that logic has no utility. One benefits by knowing the principles of logic.

Logic has theoretical as well as practical value. The *theoretical value* of logic consists in giving us knowledge of valid argument forms. As Mansel has observed, to justify the study of logic, it is sufficient to show that what it teaches is true.

Apart from this theoretical value, logic has *practical utility*. Men often hold contradictory beliefs. They do not realize that if they accept one of the contradictory beliefs, they must reject the other. We hold such beliefs as "All good men are honest" and "Some good men are not honest", without knowing that they are inconsistent. To say that the latter belief indicates exceptions to the general rule is not a satisfactory explanation. Logic makes a person conscious of inconsistencies in his beliefs. Also, logic shows why a particular belief is inconsistent.

It is sometimes pointed out that we can find out inconsistencies in our beliefs and judge the correctness and incorrectness of reasoning, without knowing the principles of logic. We don't deny this. Logic only makes us conscious of the reasons for the correctness or incorrectness of arguments. With the help of logic, we can find out why a particular reasoning is incorrect and can name the fallacy it commits. Moreover, a person who knows the principles of logic is more likely to reason correctly.

Logic is especially helpful to the scientist. No doubt, a scientist can judge the weight of evidence in support of a particular theory better than a logician can. But a scientist will be in a better position to do so, if he knows the general conditions which determine the probability of the different types of inference. And logic provides this knowledge.

Lastly, the value of logic as a *general intellectual discipline is* also to be remembered. The study of logic cultivates the power of abstract thought, and this is helpful in all spheres of life.

SUMMARY

Inference and implication : In an inference (i.e. deductive inference) the thinker passes on from the premises to the conclusion. This is because the premises imply the conclusion. Implication is a logical relation between propositions.

Definition of logic : The traditional definitions of logic laid emphasis on thinking. Cohen and Nagel define logic as "the science of implication, or of valid inference (based on such implication)." This definition too is not suitable. Today logic is generally defined as the study of the forms of valid inference.

Deductive and inductive arguments : In a deductive argument the premises imply the conclusion. As such, they provide sufficient evidence for the conclusion. But in an inductive argument the evidence is not sufficient. However, inductive arguments differ in their degrees of probability.

Form and content of argument : Every argument is regarding a certain subject-matter. This is its content. It has also a certain form. The form of an argument consists of those logical characteristics which are independent of its content.

Notion of form : Form is not the same as shape. Shape is physical; but even non-physical things have form. Susanne Langer explains the notion of form by comparing it with structure. The notion of logical form is also clarified by *(a)* comparing logical form of a proposition with the grammatical form of a sentence, (b) by means of blanks and (c) by referring to the use of constants and variables.

Logic as a formal science : The validity of an argument depends upon its form, rather than upon its content. Moreover, like mathematics, logic is concerned with necessary propositions. And the truth of a necessary proposition is not determined with reference to facts. In view of these, logic is said to be a formal science.

Truth and validity : Propositions are either true or false; arguments are either valid or invalid. An argument is valid when its conclusion is implied by its premises. When an argument is valid and its conclusion is true, it is said to be a *sound argument.*

Validity of an argument depends upon its form, and its truth upon its content. Since logic is a formal science, it is concerned with validity, and not with truth.

Utility of logic : Though logic is not an art, it has a certain utility. It makes us conscious of inconsistencies in our beliefs. A scientist will be benefited, if he knows the general conditions which determine the probability of the different types of inferences. Moreover, logic has value as a general intellectual discipline.

TEST QUESTIONS

1. Define Logic and bring out its nature.
2. Take examples of deductive and inductive arguments and show why inductive arguments are probable.
3. "Logic is the science of valid thought." Does this definition indicate the real nature of logic?
4. Distinguish between inference and implication. Discuss the view that logical implication is formal.
5. Distinguish between form and matter (content). Give examples.
6. Explain the notion of form.
7. What is meant by saying that logic is a formal science ?
8. Explain the terms 'truth' and 'validity'. When is an argument said to be true?
9. It is said that logic deals with validity, and not with truth. Why?
10. What is the utility of logic?
11. Define the following terms :
    - i) Logic
    - ii) Inference
    - iii) Premise
    - iv) Conclusion
    - v) Deductive inference
    - vi) Inductive inference
    - vii) Formal validity
    - viii) Good inductive argument
12. Distinguish between the following :
    - i) Deductive and inductive arguments.
    - ii) Truth and validity.
13. Give reasons for the following in one or two sentences :
    - i) Why is it said that the premises of a valid deductive inference imply its conclusion?
    - ii) Why is it said that the conclusion of a valid deductive inference can be false?

iii) Why are deductive inferences said to have formal validity?

iv) Why do inductive inferences not have formal validity?

14. Answer the following in one or two sentences :

   i) On what basis are inferences classified into deductive and inductive?

   ii) When is an inference said to be deductive?

   iii) When is a deductive inference said to be valid?

   iv) When is an inductive inference said to be a good argument?

15. Give technical terms used in logic for the following groups of words :

   i) The field of knowledge whose main task is to study the difference between good reasoning and bad.

   ii) A statement which forms evidence for the conclusion.

   iii) A statement which follows from the premises.

   iv) An inference in which the premises claim to provide sufficient evidence for the conclusion.

   v) An inference in which the premises imply the conclusion.

   vi) The relation between the premises and the conclusion such that the conclusion cannot be false if the premises are true.

16. State whether the following statements are true or false :

   i) When the relation between the premise and the conclusion is that of implication, then if the premise is false, the conclusion must be false.

   ii) When the relation between the premise and the conclusion is that of implication, then if the premise is true, the conclusion must be true.

   iii) The conclusion of a sound argument is true.

   iv) The form of an argument has nothing to do with its subject matter.

   v) The conclusion of a valid argument can be false.

   vi) All inductive arguments are equally probable.

17. Fill in the blanks with the suitable alternative :

   i) A proposition whose truth is known by examining its content is called a ______ proposition. (necessary/contingent/verbal/real)

   ii) ______ (All/Some) necessary propositions are ______ (true/false)

   iii) ______ (All/Some) contingent propositions are ______ (true/false)

   iv) ______ determine the form of a proposition. (Constants/Variables)

   v) Logic is a ______ science. (formal/empirical/normative/applied)

   vi) Form is ______ shape. (the same as /different from)

CHAPTER – 2

PROPOSITION

DO YOU KNOW THAT ....

- *while every proposition is a sentence, every sentence is not a proposition?*
- *a proposition cannot be both true and false?*
- *some questions give information?*
- *even exclamations may express propositions?*
- *while judgments are not propositions, propositions are products of judgments?*

1. WHAT IS A PROPOSITION?

Logic deals with validity of arguments. The validity of an argument depends upon the nature of relation between its premises and its conclusion. The premises and the conclusion of an argument are propositions. Thus, the basic unit of logic is proposition. Let us take an argument and consider the propositions it contains.

All boys are tall.

Ashok is a boy.

∴ Ashok is tall.

Now, what is it that strikes us about the propositions in the above argument? We notice two things. Firstly, these propositions express either true or false statements. The first statement is false, the second statement is true, and the third one may be either true or false. Secondly, all the propositions are expressed in words. They are, what grammar calls, sentences. Thus, we have to consider two problems. These are : (1) What is a proposition? (2) Is proposition the same as grammatical sentence?

The thinker is concerned with the truth and falsity of propositions. He draws inferences on the assumption that the given propositions (premises) are true. Since the verbal expression (of a proposition) does not affect the validity of an argument, the thinker is not concerned with it. Thus, truth or falsity is the essence of a proposition. **So, we may define proposition as a statement which is either true or false**. Let us take examples.

1. Tagore was a great poet.
2. Mickey Mouse appears in Walt Disney's cartoons.
3. Dogs do not dance.
4. If Panchatantra contains fables, it is interesting to read.
5. Either Bangladesh or Burma has an atom bomb.

The following are the main **characteristics** of a proposition.

i) Every proposition is either true or false. *It cannot be both true and false.*

Let us illustrate. The proposition "India has Congress government" appears to be true for some years, and false for some other years. However, this wrong impression is created, because the proposition has not been expressed fully. A proposition is asserted with reference to a given date. And with reference to that date, it cannot be both true and false. The above proposition would be fully expressed thus : "India has Congress government in July 1995." If it is so expressed, it cannot be both true and false.

ii) *The truth or falsity of a proposition is definite.* It always remains the same; it cannot change. Of course, we may not know whether a given statement is true or false. For example, today we cannot say whether the statement "There are living beings on the Planet Mars" is true. Further, we may even hold wrong belief about its truth or falsity. But neither absence of knowledge nor wrong belief affects the truth or falsity of a statement. A true statement will continue to remain true; and a false statement will always be false.

There are some statements which look like propositions, but which are not propositions. Consider the following statements :

1. A foot consists of twelve inches.
2. A kilogram consists of one thousand grams.

These sentences appear to express propositions. Really, they do not. While asserting these statements, we are not raising the question of their truth or falsity. We are merely saying that the words "foot" and "kilogram" are to be used in these ways. Of course, the answer to the question "Do we use these words in the above senses" may be true or false. But *such propositions are about the use of words*, and not about the objects for which the words stand.[1]

2. PROPOSITION AND FACT

What determines the truth or falsity of a proposition? It is the facts. If a proposition represents the facts as they are, it is true. If it does not, it is false. "*Butter melts in heat*" is a true proposition, while "*A horse has two legs*" is a false proposition.

Though a proposition claims to represent a fact, it is different from a fact. If it were not so, there would be no possibility of error. We walk across a street, and see something long and dark. We say that it is a snake. Really, it is a rope. This shows that we made a mistake. This mistake would not have been possible, if the proposition "*This is a snake*" were not different from the fact. *A proposition claims to represent facts*. This claim may or may not be justified. If it is justified, the proposition is true; otherwise, it is false.

3. PROPOSITION AND JUDGMENT

Propositions are often confused with the mental act of judging. In fact, some logicians call propositions judgments. This confusion is due to ambiguity in the use of the term 'judgment'. Sometimes the term 'judgment' is used in the sense of the mental

[1] Cohen and Negel, *An Introduction to Logic and Scientific Method*, 1964, p. 29.

act of judging, and sometimes in the sense of what is judged. However, the two are different. The mental act of judging is different from the result of this act (e.g. what is judged). While propositions are a result of thinking (the mental act of judging), they are not to be identified with this thinking activity. Logic is concerned with what is judged. It is only this that can be considered to be either true or false. Of course, the thinker arrives at the proposition "*Ram is taller than Gopal* ", by comparing Ram and Gopal in respect of their height. But what is true or false is the judgment "*Ram is taller than Gopal* ", and not the mental act by which this judgment is passed.

If the term 'judgment' is understood in the sense of a product of judgment (or what is judged), the logician is concerned with it. But he is concerned with the product of judgment only when it has assumed a fixed and definite form. We find that a judgment assumes a fixed and definite form, when it is expressed in language. When a judgment is expressed in language, it is called a proposition. Thus, to avoid misunderstanding, it is better to say that logic deals with propositions.

4. PROPOSITION AND SENTENCE

Some logicians use the terms "proposition", "statement" and "sentence" in the same way. But, to maintain the usual meaning of "sentence", we shall use "proposition" and "statement" in a narrower sense than the term "sentence". However, for us, there will be no distinction between "proposition" and "statement".

A proposition is expressed in the form of a sentence. But it is not the same as a sentence. The same proposition may be expressed by different sentences. Let us illustrate. For the English expression "calling a spade a spade", the French people use the expression "calling a cat a cat". Similarly, a sentence in English and one in Hindi may differ as sentences. Yet they may express the same proposition. This is because proposition (statement) is what a sentence states, and not the words in which the statement is made.

As we have stated in Section, a proposition is either true or false. But the question of truth or falsity arises only with regard to what declarative (or indicative) sentences say. Therefore, in a direct, or straightforward, way declarative (or indicative) sentences alone express propositions. Other kinds of sentences, e.g. those expressing questions, feelings, wishes, commands, requests, etc. cannot be used to make statements. For example, the following sentences do not express propositions :

1. Why do people believe in astrologers?
2. Hurrah! We won the match.
3. I wish man had wings.
4. Shoot!
5. Please give me your pen.

Sometimes we come across sentences which are in the form of a question or exclamation, but which are really declarative sentences. Let us consider two such sentences :

a) What thief would trust a thief?
b) Thief!

Obviously, the first sentence is not a real question. It does not demand information; it gives information. It states that no thief would trust a thief. The second sentence too gives information. The speaker is pointing to a thief. Since these sentences give information, they express propositions. Thus, we see that *every sentence does not express a proposition, but every proposition is in the form of a sentence.*

A sentence has physical existence. When spoken, it is sound waves; when written, it is marks or signs on a surface. On the other hand, a proposition is what a sentence says. The statement has no physical existence. It can be easily seen that sentences have physical existence. The fact that we can talk about their length shows so. But we cannot say that a given proposition is either long or short. This is because a proposition does not have physical existence.

The form of a sentence is not a proper guide to the form of a proposition. The logical form of a proposition depends upon the statement that a proposition expresses. The grammatical form of a sentence is determined by various considerations. Some of these have nothing to do with giving information. To illustrate, often proverbs and idiomatic expressions have a force which is not a part of their logical meaning. Consider the expression "United we stand, divided we fall." This expression emphasizes the fact that unity is strength, and disunity is a weakness.

Distinction between proposition and sentence in traditional logic : If we accept the traditional view of proposition, we would find certain further differences between proposition and sentence. These are:

1. *A proposition contains a single statement*, but a grammatical sentence may contain more than one statement. When a grammatical sentence is reduced to the logical form of proposition, every statement that a sentence contains is expressed by a separate proposition. Thus, the sentence "India is a secular State, where people of all religions are treated equally" contains two statements. Therefore, it will be reduced to two propositions. These are :

a) India is a secular State.

b) People of all religions are treated equally in India.

2. *The grammatical order of subject and predicate is often different from the logical subject and predicate*. In the sentence "Blessed are the poor", the logical subject is 'the poor', while the grammatical subject is 'blessed'.

Thus, we see that there are important differences between proposition and sentence. Yet there is an intimate connection between the two. Logic deals with propositions only when they have a definite and fixed form. This definite form is not possible, till a proposition is expressed in language. Thus, only when a proposition is expressed by a sentence, its form becomes definite.

5. CONSTITUENTS AND COMPONENTS

Though proposition is the basic unit of logic, it can be analyzed into its elements. However, the elements into which a proposition is analyzed have no existence apart from the proposition.

The elements into which a proposition can be analyzed are called its constituents. The constituents of a proposition are what the proposition is about. The proposition "Brutus killed Caesar" is about "Brutus", "Caesar" and "killing".

A constituent is any element of a proposition. It may or may not be its subject. In the proposition "Sheela is honest", the constituent 'Sheela' is the subject of the proposition, but the constituent 'being honest' is not the subject.

In every proposition there is one element which combines the other elements. *This combining element is called component*. In the proposition "Ram loved Sita", the constituent 'loved' is a component. Without this combining element, there would be no proposition. "Ram-Sita" is not a proposition. The component "is" is required to make it a proposition.

Component and other constituents : A component and other constituents differ in the following respects :

1. A *component is universal, while the constituents it combines can be particulars*. That is why, the constituents it combines may be changed, and yet the proposition would be meaningful. We shall change the individuals combined by the component 'loved', and see what happens.

1. Majnu loved Laila.
2. Yusuf loved Zulekha.
3. Farhad loved Shereen.

In these propositions the combining element 'loved' has remained the same, even though the other constituents have changed. Now, this combining element 'loved' cannot be replaced by an individual. Thus, we may say that a particular can occur as a constituent, but it cannot be a component.

2. Every proposition is about a certain content (or subject-matter). The constituents are what the proposition is about. So, the constituents indicate the content of a proposition. Since *the contents of propositions differ, their constituents too differ*. However, even though propositions differ in their constituents, they may have the same form. Consider the following propositions:

1. Ram is honest.
2. Savitri is clever.
3. This mango is ripe.

All the above propositions assert that an individual possesses a quality. Thus, we see that though the above propositions have different constituents, the relation between the constituents is the same. To put it differently, in all the above propositions the component is the same. This component is predication (that is, assertion of a quality about an individual).

3. *The form of a proposition depends upon the way the constituents are combined.* That is to say, it depends upon the component. However, a component is not to be identified with the words through which it is expressed. The following propositions have different components, though in all of them the component is expressed by the same word, namely "is":

1. John is intelligent.
2. Lata Mangeshkar is a singer.
3. A peacock is a bird.

In the first proposition, the component *is predication*. The attribute of intelligence is affirmed of John. In the second proposition, the component is *membership of a class*. Lata Mangeshkar is a member of the class of singers. In the last proposition, the component is *class-inclusion*. The class of peacocks is included in the class of birds. As *the components in these propositions are different, these propositions are of different forms*.

6. TRADITIONAL ANALYSIS OF PROPOSITION

The traditional logicians maintained that every proposition has two constituents. These were called the subject and the predicate of the proposition. The *subject is* that about which something is said. The *predicate is* that which is affirmed or denied of the subject. In the proposition "This paper is white", 'this paper' is the subject and 'white' is the predicate. **The subject and the predicate of a proposition are called terms**.

A proposition consists of only two terms. These terms stand in a certain relation to one another. The relationship is that of affirmation or negation. This relationship is expressed by the copula. *Thus, copula is that element which expresses affirmation or denial*. When the predicate is affirmed of the subject, the copula is affirmative; when it is denied of the subject, the copula is negative. Let us see the copula in the following propositions :

1. All kings are men.
2. John is a Christian.
3. No men are perfect.
4. Peter is not reliable.

The first two propositions express agreement between the subject and the predicate. Therefore, the copula is affirmative. The last two propositions express disagreement between the two terms. Therefore, the copula is negative.

In the third proposition above, it may appear as if the copula is not negative. This is because the word 'no', which is a part of the copula, occurs before the subject. While dealing with the traditional classification of propositions (in Chapter 4), we shall see why the sign of negation is placed before the subject.

Copula is not to be considered a link between the subject and the predicate. It is only a sign of predication (that is, asserting a quality). It shows that the predicate is either affirmed or denied of the subject.

The traditional logicians maintained that the copula must be in the present tense of the verb 'to be'. That is, it must be 'is', *'am'* or *'are'*. However, the real copula is not the word 'is' or 'am'. It is predication. That means, it is the act of affirming or denying the predicate of the subject. In the proposition " *What cannot be cured must be endured* ", the verb 'is' or 'are' does not occur. Yet there is a copula. This copula is the relationship between the subject *'things that cannot be cured'* and the predicate *'things that must be endured'*. The traditional logicians would bring this proposition to its logical form thus: *"All things that cannot be cured are those which must be endured.*

The function of the copula is the same as that of the component. In fact, copula is a component. It is that element which unites the terms. However, the traditional logicians did not realize that there are various ways in which the copula unites the terms. Some of these are:

1. predication (that is, asserting an attribute of an individual); e.g. "This table is polished."
2. membership of a class; e.g. "John is a Christian."
3. inclusion of one class in another class; e.g. "All kings are men"; "Some teachers are respected."

The traditional logicians believed that there is only one kind of relation between terms, namely predication. That is why their classification of propositions is defective. We shall see how this is so in Chapter 5.

SUMMARY

Proposition is a statement which is either true or false. But its truth or falsity may not be known. A proposition is true when it represents a fact; it is false when it does not. Some statements took like propositions; but they aren't propositions.

Proposition and sentence : A proposition cannot be identified with sentence. Only indicative sentences express propositions, because they give information. A sentence has physical existence, but we cannot say so about a proposition. Further, the form of a sentence is not a proper guide to the form of a proposition.

The traditional logicians maintained that a sentence is to be reduced to as many propositions as there are statements in it. Also, the grammatical subject and predicate are sometimes different from the logical subject and predicate.

Constituents and components : According to the modern logicians, a proposition can be analyzed into its constituents. The constituent which unites the other constituents is called component. A component is universal, while the other constituents can be particulars. Constituents indicate the content of a proposition; the component its form.

The traditional logicians analyzed a proposition into subject, copula and predicate. Subject and predicate are called terms. The function of the copula is the same as that of the component. Copula expresses agreement or disagreement between the two terms.

TEST QUESTIONS

1. What is a proposition?
2. What determines the truth or falsity of a proposition? Can the same proposition be both true and false?
3. How does a proposition differ from a fact and a judgment?
4. Distinguish between a proposition and a grammatical sentence.
5. A proposition is expressed in the form of an indicative sentence. Why is it so ?
6. What is a constituent? Take two propositions and point out their constituents.
7. Distinguish between a constituent and a component. Is copula a component?
8. What is the copula? What is its function?
9. Define the following terms :

   (1) Proposition (2) Constituent (3) Component (4) Copula.
10. State whether the following statements are true or false :
    1. The sentences "Two is twelve" and "Unity is strength" express the same proposition.
    2. "Mahatma Gandhi was an American" is a proposition.
    3. If we do not know the truth or falsity of a statement, the statement is not a proposition.
    4. A false statement is not a proposition.
    5. A proposition is identical with an indicative sentence.
    6. Copula is a link between the subject and the predicate.
    7. Every proposition has two constituents and a component.
11. Fill in the blanks with appropriate alternatives:
    1. The truth or falsity of a proposition depends upon _____. (our knowledge/our feelings/facts)
    2. _____ interrogative sentences express propositions. (All/ Some/No)
    3. A proposition _____ physical existence. (has/does not/have)
    4. The _____ unites the other elements in a proposition.

       (constituent/component/existential quantifier/universal quantifier)
    5. A component is _____ universal. (always/never/sometimes)
    6. A constituent is _____. (always particular/never particular/sometimes particular)
    7. Copula is _____. (a component/a constituent/either a component or a constituent/neither a component nor a constituent)

8. Copula expresses _____ between the subject and the predicate.

(agreement/disagreement/either agreement or disagreement/neither agreement nor disagreement)

12. State, with reasons, whether the following sentences express propositions :

(This exercise is based on the distinction between proposition and sentence. Only indicative sentences express propositions. However, if a question or an exclamation gives information, it expresses a proposition. It is preferable to solve this exercise after going through both the modern and the traditional classification of propositions.)

1. Joso Meiffret rode a bicycle at 116 miles per hour in 1961.
2. Alas ! Russell is dead.
3. What a beautiful rose !
4. Jose Meiffret wished he were able to ride a bicycle at 200 miles an hour.
5. If whale has warm blood, it is not a fish.
6. Isn't love blind ?
7. Run!
8. Pirates!
9. May God rest his soul in peace!
10. I disbelieve what you say.
11. Musicians are generally moody.
12. It is false that pain and death are avoidable.
13. Why do people consult palmists?
14. Perhaps black magic is practised even today.

CHAPTER – 3

TERMS

DO YOU KNOW THAT ......
* *a term may be negative even when it contains no sign of negation?*
* *a term always has a definite meaning?*
* *terms do not have independent existence?*
* *even with help, some words cannot become terms?*

1. WHAT IS A TERM ?

In the preceding chapter we have seen that the subject and the predicate of a proposition are called terms. We have also seen that a proposition is expressed in the form of a sentence. A sentence consists of words. As such, the subject and the predicate of a proposition are words. Now, a term may consist of a single word or a group of words. *Therefore, a term may be defined as a word, or a group of words, which stands as the subject or the predicate of a logical proposition.* In the proposition "Himalaya is the highest mountain", the subject term 'Himalaya' is a single word, but the predicate term 'the highest mountain' is a group of words.

2. TERM AND WORD

Though every term is a word (or a combination of words), every word is not a term. A word becomes a term when it stands as subject or predicate in a proposition.

Some words can become terms independently. Some of them have to be combined with some other word (or words) to become terms. There is also a third kind of words. These words cannot become terms. The above three kinds of words are called *categorematic* words, *syncategorematic* words, and *acategorematic* words.

Categorematic words are those which can stand as terms without the support of other words. 'Man', 'building', 'honest', 'virtue', etc. are categorematic words. *Syncategorematic* words are those which cannot become terms by themselves. They can become terms only when they are joined with one or more categorematic words. Words like 'a', 'an', 'of', 'in' and 'very' are syncategorematic words. *Acategorematic words can never become terms.* The signs of exclamation like 'ah!', 'alas!' and 'hurrah!' are acategorematic words. These exclamatory signs cannot be combined with any other word. In the sentence "Hurrah! We won the match", the word 'hurrah' stands separately. It is not a part of the statement "We won the match."

The meaning of a term depends upon its being an element in a proposition. Words have an independent meaning. However, when words are considered by themselves, they may have more than one meaning. For example, the words 'sound' and 'pound' have more than one meaning. Sound may mean "that which is heard" or it may mean "free from defect". But when a word is the subject or the predicate of a proposition, its meaning becomes definite.

Lastly, terms can express only information, thoughts or reasonings. They cannot express feelings, questions, wishes, requests, commands, etc. On the other hand, words may express not only information, thoughts or reasonings, but also feelings, questions, wishes, requests, commands, etc. This is because while terms are concerned with the informative use of language, words are not restricted to the informative use.

Now we shall deal with some classifications of terms.

3. SINGULAR AND GENERAL TERMS

A general term is that which can be applied, in the same sense, to each of an indefinite number of objects, having certain common qualities. Both the terms in the following propositions are general terms:

1. All Brahmins are Hindus.
2. Some scholars are respected.

In the first proposition the subject term 'Brahmin' applies to every Brahmin; and the predicate term 'Hindu' applies to every Hindu. Same is the case with the terms in the second proposition.

A singular term is that which can be applied to one definite object. In the following propositions the subject term is singular:

1. This man is not trustworthy.
2. Dilip is an actor.

Singular terms are of two kinds. These are proper names and designations.

A proper name (also called a non-significant singular term) *is a mark which distinguishes an individual person or thing from others.* It does not indicate the possession of any attribute. Such names are mostly those of persons, places, and pet animals. Sometimes they are given to inanimate objects too. For instance, children give names to dolls out of affection. Ram, Bombay, Qutab Minar and Taj Mahal are proper names.

A designation (also called a uniquely descriptive name or a significant singular term) *indicates one definite object by stating an attribute which only that object possesses.* 'This man', and 'the author of the Discovery of India' are designations. Designations resemble general terms in indicating attributes. But, like proper names, they apply to one definite object. However, there is a difference between proper names and designations. A proper name indicates an object directly, but a designation does so by referring to an attribute (or a group of attributes).

The distinction between singular and general terms can be explained in another way too. A general term is the name of a class which can be divided into its members. That is why when the subject of a proposition is a general term, we may assert something either about the subject as a whole or about a part of the subject. In the proposition "All colleges are educational institutions", the assertion is about the whole class of colleges. On the other hand, in the proposition "Some colleges have Students' Parliament", the assertion is about a part of the class. Now, the question of the membership of a singular term does not arise. That is why, we cannot use words like "all", "some" and "no" before singular terms.

4. POSITIVE AND NEGATIVE TERMS

Strictly speaking, affirmation and negation have meaning only in the case of propositions. A term has meaning only. It cannot, by itself, be either affirmed or denied. However, a term may indicate the presence or absence of an attribute. On this basis, terms are divided into positive and negative.

Positive terms imply the presence of attributes, while negative terms imply their absence. Thus, 'desk', 'boy', 'sweet' and 'honest' are positive terms. They imply the presence of some attribute. On the other hand, 'non-desk', 'non-boy', 'non-sweet' and 'non-honest' are negative terms. They indicate absence.

A negative term can be formed by prefixing "non" (or "not") to a positive term. Thus, from the positive term 'Indian', we get the negative term 'non-Indian'. *However, whether a term is positive or negative depends meaning.* For instance, the terms 'foreigner' and 'doubt' do not have the prefix 'not' before them. Yet they are negative terms. The term "foreigner" means one who does not belong to the country; the term "doubt" means absence of belief and disbelief.

Does a negative term apply to any object whatsoever, or is it limited in its application? Let us understand this with the help of the term 'not-white'. If we accept the first interpretation, the term 'not-white' would apply not only to red, blue, yellow, green and other not-white colours, but also to charity, justice, God, etc. In this sense, the term 'not-white' would apply to anything in which the attribute of whiteness is absent. When a term is understood in this sense, it is called **infinite or indefinite negative term.**

Let us now take the second sense. In this sense, the term 'not-white' would apply only to those coloured things which are not white. When a negative term is understood in this way, it is not indefinite or infinite. There are limits to its application. The limits to the application of a term constitute its **'universe of discourse'.** The universe of discourse of the term 'white' is 'colour', and that of the term 'square' is 'figure'. If negative terms are interpreted in this sense (as logicians like Joseph do), no term would be purely negative. Because the universe of discourse would indicate the type of things to which a negative term would apply. Thus, the term 'not-white' would apply to colours only.

In practice, we apply a negative term to a definite group of objects. We apply the term 'not-white' or 'non-red' to colours; the term 'not-big' to size. But the meaning of a negative term can be understood without this limitation. A negative term merely indicates that a certain attribute is absent. It does not indicate the type of things to which the term can be applied. In view of this, it is better to interpret a negative term as an infinite negative one. In fact, logic, being a formal science, is really concerned with this interpretation of negative terms. That is to say, logic is concerned with infinite negative terms.

5. CONTRARY AND CONTRADICTORY TERMS

Terms may imply attributes that cannot co-exist. When they do so, they are called *incompatible terms*. Thus, 'white' and 'not-white', as well as 'white' and 'black', are incompatible. A thing which is white cannot be not-white. Similarly, a thing which is white cannot be black.

Incompatible terms are mutually exclusive. Two incompatible terms cannot be affirmed together. If one of them is affirmed, the other will have to be denied. This is what is meant by saying that they are mutually exclusive. There are two kinds of mutually exclusive terms. These are contradictory terms and contrary terms.

Contradictory terms are mutually exclusive and collectively exhaustive. Because they are mutually exclusive, two contradictory terms cannot be affirmed of anything at the same time. Also, taken together, they exhaust the entire universe to which reference is made. 'White' and 'not-white' (or 'non-white'), 'moral' and 'non-moral', 'pleasant' and 'not-pleasant' are pairs of contradictory terms. White and not-white are mutually exclusive. A thing which is white cannot be not-white. Similarly, a thing which is not-white cannot be white. Taken together, these terms exhaust all colours. ('Colour' is the universe of discourse of 'white' and 'not-white'.)

Since contradictory terms are collectively exhaustive, they exhaust all possibilities. White and not-white would exhaust all colours. But there are mutually exclusive terms which leave open a third possibility. Such terms are said to be contrary.

Contrary terms are those which express the greatest degree of difference in the same universe of discourse. They stand at the opposite ends in the universe to which reference is made. In the universe of colour, the terms 'white' and 'black' stand at the opposite ends. They have the maximum difference. Therefore, they are called contrary terms. Similarly, the terms 'good' and 'bad', and the terms 'pleasant' and 'painful' are contrary terms.

Let us distinguish between contradictory and contrary terms. Contradictory terms exhaust all possibilities. On the other hand, contrary terms leave open a third possibility. From this, it follows that two contraries cannot both be true of anything, but they may both be false. A thing cannot be both white and black, but it may be neither white nor black. On the other hand, two contradictories can neither be true together nor false together. Nothing can be both white and not-white; but everything must be either white or not-white.

6. DENOTATION AND CONNOTATION

There are two ways in which we can know the meaning of a term. We may know its meaning by considering the objects to which it applies, or we may know its meaning by considering the attributes which these objects possess. The former is called denotation; the latter is called connotation. Let us explain this with the help of general terms.

A general term like 'city' is applicable, in the same sense, to all cities. For instance, it is applicable to Bombay, Calcutta, Madras, Ahmedabad, Delhi, London, Paris, New York, etc. This reference of a term to the individual objects to which it can be applied is called its denotation. *Thus, the denotation of a term consists of all the individual objects to which it can be applied.* It consists of all the objects that exist now, have existed in the past, or will exist in the future. For example, the denotation of the term 'man' is all men—living, dead, and yet to be born.

We can understand the meaning of a term in another way too. The objects to which a term is applied possess some common attributes. *The common attributes possessed by all the objects to which a term is applied form its connotation.* The term 'man' implies the attributes of 'rationality' and 'animality'. These are its connotation. In a similar way, the connotation of the term 'triangle' is the attributes of 'being a plane figure bounded by three straight lines'.

Three senses of connotation : There are three senses in which the term 'connotation' (or intension) is used. Keynes calls them subjective intension, objective intension and conventional intension.

Subjective intension consists of those attributes which the use of a term calls up in the mind of a person. This will include the qualities by which an individual recognizes that an object belongs to a certain class. The subjective intension would differ from person to person. Even for the same person, it would differ from time to time. Thus, the subjective intension of the term *'tall building'* for a villager (who has not known about tall buildings in a city) would be different from its subjective intension for a city-dweller. For a villager, a three-storied building would be a tall one. This would not be so for a person living in a city.

The objective intension consists of all the attributes possessed in common by the members of a class. It would be impossible to know all the common qualities. Therefore, the objective intension would include known as well as unknown attributes. The objective intension of the term 'man' would be all the attributes—known and unknown common to men.

Conventional intension consists of those qualities which are essential to the class. These are the qualities which are implied by a term. If any of these qualities is absent in an individual, that individual would not be a member of the class.

The conventional intension constitutes the definition of a term. This kind of intension is called conventional intension, because the attributes implied by a term are settled by convention (that is, by use in society). The conventional intension of 'man' consists of the qualities of 'rationality' and 'animality'.

Now, we cannot understand the terms we use and communicate with one another, if the connotation of a term is not more or less fixed. The subjective intension may differ from person to person. Even with the same person, it may differ from time to time. The objective intension cannot be completely known. Therefore, for the purpose of communication, we require conventional intension. That is why we shall mean by the connotation of a term its 'conventional intension'. In fact, Keynes uses the term 'connotation' for conventional intension, and the term 'comprehension' for objective intension.

In the above sense of the term 'connotation', proper names do not have connotation. Proper names merely suggest attributes; they have only subjective intension. They do not imply attributes; so they do not enable us to decide the objects to which these names can be applied.

As regards denotation, there are certain names which are meaningful, but which have no denotation. These are terms which refer to **imaginary objects.** Such terms have connotation, but not denotation. For *example, the term "man with blue skin and ten heads" has* connotation. We can understand what such a being would be. But there are no such men. Therefore, such a term would not denote anything. Other examples of such terms are *'glass mountain', 'unicorn'* and *'centaur'.* Sometimes the terms which have no denotation are said to have an *'empty '* or *'null'* (i.e. nil) extension.

SUMMARY

Term is a word or a group of words which stands as the subject or the predicate of a logical proposition. Categorematic words can stand as terms independently, syncategorematic words when they are combined with categorematic words, while acategorematic words can never stand as terms. The meaning of a term depends upon its being an element in a proposition. Terms can express only information, thoughts or reasonings; but words may also express feelings, questions, wishes, commands, etc.

Classification of terms : Terms are classified as singular and general, on the basis of the number of objects to which they can be applied. Singular terms may be proper names or designations. The classification of terms into positive and negative depends upon whether they indicate the presence or the absence of an attribute. Negative terms are to be interpreted as infinite negative terms. Incompatible terms may be contrary or contradictory. *Contradictory* terms are exclusive as well as collectively exhaustive, while *contrary terms* are merely exclusive. Contrary terms express the greatest degree of difference in the same universe of discourse.

Denotation and connotation : A term denotes things and connotes attributes. There are three senses of connotation. These are subjective intension, objective intension and conventional intension. Connotation of a term is its conventional intension. In this sense, proper names have no connotation. Also, there are certain meaningful names which do not have denotation.

TEST QUESTIONS

1. What is a term? Can every word become a term?
2. Distinguish a term from a word.
3. Explain the distinction between singular and general terms.
4. Explain positive and negative terms. Do negative terms have limited application ?
5. Distinguish between contrary and contradictory terms.
6. Explain the denotation and connotation of terms. What are the different senses of connotation?
7. Define the following terms :

i) Term	ii) Singular term
iii) General term	iv) Positive term
v) Negative term	vi) Contrary terms
vii) Contradictory term	viii) Conventional intension
ix) Denotation of a term	x) Connotation of a term

8. Give technical term used in logic for the following groups of words :
   i) A word which stands as the subject or the predicate of a proposition.
   ii) A term which can be applied to each of an indefinite number of objects, having certain common qualities.
   iii) A singular term which indicates an object by stating an attribute.
   iv) A negative term which has no limitations.
   v) Two terms which are mutually exclusive and collectively exhaustive.
   vi) Two terms which cannot both be true, but which can both be false.
9. State whether the following statements are true or false :
   i) The meaning of a term is independent of the proposition in which it occurs.
   ii) Like a general term, a designation implies attributes.
   iii) Like a proper name, a designation denotes one definite object.
   iv) When the subject of a proposition is a general term, the proposition must be universal.
   v) When we say "Not-green means any colour other than green", the term 'not-green' is taken as an infinite negative term.
   vi) Every meaningful name must have denotation.
10. Fill in the blanks with appropriate alternatives :
    i) A general term can be applied to _____ number of objects. (a definite/ an indefinite)
    ii) Designations are _____ terms. (singular/general/negative)
    iii) Whether a term is positive or negative depends upon _____. (meaning/prefix like 'not').

iv) Both _____ terms can be denied together, but both _____ terms cannot be denied together. (contradictory/contrary)

v) _____ terms are mutually exclusive. (Only contrary/Only contradictory/ Both contrary and contradictory/Neither contrary nor contradictory)

iv) _____ terms are collectively exhaustive. (Contrary/Contradictory)

vii) Both the _____ terms cannot be affirmed of an object, but both of them can be denied. (positive/contrary/contradictory)

viii) Denotation of a term consists of _____ while its connotation consists of _____ (individual objects/qualities/both individual objects and qualities)

CHAPTER – 4

TRADITIONAL CLASSIFICATION OF PROPOSITIONS

DO YOU KNOW THAT ......

- *what traditional logic calls "simple proposition" may not really be so?*
- *hypothetical proposition is the same as implicative proposition?*
- *disjunctive propositions are never negative?*
- *traditional logicians recognized only four kinds of propositions?*
- *singular propositions are universal?*
- *the word "some" does not preclude the possibility of "all"?*

1. SIMPLE AND COMPOUND PROPOSITIONS

The traditional logicians recognized the distinction between simple and compound propositions. But the distinction is not clear. Moreover, the terms "simple proposition" and "compound proposition" are not used in the sense in which modern logic uses these expressions.

Simple proposition : A simple proposition is one which affirms or denies a predicate of a subject. That is, in a simple proposition, the predicate is asserted of the subject. All the following propositions will be regarded as simple propositions by the traditional logicians :

1. All fairies are beautiful.
2. Everything changes.
3. No dogs whistle.
4. There are no ghosts.
5. Some singers are handsome.
6. Some actresses are not beautiful.
7. Sai Baba is a saint.
8. Samson is not weak.

From the above examples we see that the so-called simple propositions may be about an individual, or about classes. The subject term of some simple propositions is an individual. Propositions (7) and (8) are of this type. On the other hand, the subject and the predicate term of (1), (3), (5) and (6) are classes. As for propositions (2) and (4), we do not find two terms. But, while reducing the above sentences to the logical form of a proposition, even these propositions would be shown as expressing a relation between two terms which are united by the copula.

Compound propositions : When a proposition makes on asser-tion under certain conditions, it is called a compound proposition. The following are examples of compound propositions in the traditional logic :

1. If ghosts frighten, they are dangerous.
2. If dogs cannot whistle, they can bark.
3. Either Meena or Mohini is intelligent.
4. Either monkeys do not sing or tigers do not dance.

The propositions in which the predicate is affirmed or denied of the subject absolutely (i.e. without any condition) were called categorical propositions by the traditional logicians. So, simple propositions are categorical propositions. As distinguished from these propositions, compound propositions make the assertion under certain conditions. So, they are called conditional propositions. In the next section, we shall deal with "categorical" and "conditional" propositions.

2. CATEGORICAL AND CONDITIONAL PROPOSITONS

Under the head of relation, Kant classified propositions into categorical, hypothetical and disjunctive. The last two are generally grouped under the head of conditional propositions. This was done to distinguish categorical propositions from them.

Categorical proposition : A *categorical proposition affirms or denies a predicate of a subject absolutely*. It does not include any condition in its expression. "Congress is a political party" and "All rats are colour-blind" are categorical propositions. In both of them the predicate is asserted without any expressed condition.

Conditional proposition : A *conditional proposition* is *one in which the assertion is made subject to some expressed condition*. In the proposition "If petrol is brought near fire, it will explode", the occurrence of explosion depends upon the condition of petrol being brought near fire.

Conditional propositions are of two kinds. These are hypothetical and disjunctive propositions.

Hypothetical proposition : A *hypothetical proposition is one which presents a condition together with some consequence which follows from it.* The example of conditional proposition taken above is that of hypothetical proposition. It :states the condition "petrol being brought near fire" and the consequence of this condition, viz. "petrol will explode". The proposition does not refer to any actual instance of petrol being brought near fire. It only states that if the condition is fulfilled, the consequence will follow.

In a hypothetical proposition there are two propositions. These are (i) the proposition which states the condition and (ii) the proposition which expresses the consequence. The proposition which states the condition is called *antecedent*; that which expresses the consequence is called *consequent*.

In the strict logical form of hypothetical proposition, the antecedent is placed before the consequent. Moreover, the condition is introduced by the word *'if'*, and the consequence by the word *'then'*. *However, in most hypothetical propositions the word 'then' does not occur.* But it is understood to be there.

Disjunctive proposition : A *disjunctive proposition is one which states alternatives*. This proposition asserts that at least one of the alternatives is true. The following propositions are disjunctive:

1. Bertrand Russell was either a mathematician or a philosopher.
2. A line is either straight or curved.

Let us look to the alternatives in the above propositions. In the first two propositions the alternatives are such that, by affirming one of them, we cannot deny the other. For instance, by affirming the alternative "Russell was a mathematician", we cannot deny that he was a philosopher, and vice-versa. This shows that the alternatives in the first proposition are not mutually exclusive. On the other hand, in the second proposition, the alternatives are mutually exclusive. If we affirm that a line is straight, we can deny that it is curved; and vice versa.

Now the question arises : Are the alternatives in a disjunctive proposition to be taken as exclusive ? This question has to be answered negatively. To determine whether the alternatives are exclusive, we have to examine the content (or subject-matter) of a proposition. But logic is a formal science; as such it is concerned with the form of a proposition, and not with its content. From the form of a disjunctive proposition, we cannot know whether the alternatives are exclusive. In view of this, Keynes maintains that the alternatives of a disjunctive proposition are to be interpreted as non-exclusive. That is to say, a disjunctive proposition asserts that at least one of the alternatives is true. It does not exclude the possibility that both the alternatives may be true.

3. QUALITY OF PROPOSITIONS

The predicate may be affirmed or denied of the subject. When the predicate is affirmed of the subject, the proposition is said to be affirmative. When it is denied of the subject, it is said to be negative. *The classification of propositions into affirmative and negative is said to be on the basis of quality.* Consider the following propositions :

1. All monkeys are mischievous.
2. Some snakes are poisonous.
3. Japan is a rich country.
4. No mermaid is beautiful.
5. Some politicians are not honest.
6. Einstein is not a magician.

The first three propositions are affirmative, while the last three are negative. In the first three propositions the predicate is affirmed of the subject, while in the last three it is denied.

Let us look to the copula in the above propositions. In the first three propositions the copula does not contain the sign of negation 'not', while in the last three the copula is negative. (In the fourth proposition *"No mermaid is beautiful"*), the sign of negation comes before the subject; but, really, it is a part of the copula. (We shall see this while dealing with the fourfold classification of propositions.) **This shows that the quality of a proposition is determined by the copula.**

The definitions of affirmative and negative propositions given above apply to categorical propositions only. This is because only categorical propositions can be analyzed into subject and predicate. However, according to some logicians, e.g. Keynes, hypothetical propositions may also be classified into affirmative and negative. A hypothetical proposition is affirmative, if the consequent follows from the antecedent. It is negative, if the consequent does not follow from the antecedent. On this view, *the quality of a hypothetical proposition is determined by its consequent.*

Thus, "If taxes hinder economic progress, they are not progressive" is a negative hypothetical proposition.

There are no distinctions of quality among disjunctive propositions. A disjunctive proposition merely asserts that at least one of the alternatives is true. Even if the alternatives are negative, the nature of disjunction will not be affected. That is why all disjunctive propositions are taken to be affirmative. A *proposition containing the expression "neither nor" may appear to be the negation of disjunctive proposition; but it is not.* It is a conjunctive proposition, which makes two negative assertions. For instance, the proposition "Neither India nor Pakistan is a loser by the Simla Pact" is not a disjunctive proposition. It does not assert alternatives. Rather, it denies the predicate 'being a loser by the Simla Pact', of two subjects ('India' and 'Pakistan'). Therefore, it is the conjunction of two negative categorical propositions. Now, according to the traditional logicians, every proposition has one subject and one predicate. Since this proposition has two subjects, it will be brought to the logical form of two propositions. These propositions are :

1. India is not a loser by the Simla Pact.
2. Pakistan is not a loser-by the Simla Pact.

4. QUANTITY OF PROPOSITIONS

The predicate may be affirmed or denied either of the whole subject or of a part of the subject. When the predicate is affirmed or denied of the whole subject, the proposition is said to be universal. When it is affirmed or denied of a part of the subject, it is said to be particular. The distinction between universal and particular propositions is said to the distinction of quantity. Let us take examples.

1. All lions are ferocious.
2. No great leaders are selfish.
3. Some professors are absent-minded.
4. Some flowers are not fragrant.

Here the first two propositions are universal, and the last two are particular.

Logic recognizes only two signs of quantity. These are "all" and "some". These words, placed before the subject, indicate the quantity of a proposition. The quantity sign "all", placed before the subject, indicates that the proposition is universal. The word "some", before the subject, shows that the proposition is particular. Of course, in everyday speech, we use various words to indicate quantity. But when a sentence is brought to the logical form of proposition, its quantity has to be expressed by the words "all" and "some" only. However, when we wish to deny the whole subject, we use the word "no" before the subject. Here the word "no" is a sign of both quantity and quality. It expresses that the proposition is universal negative. It combines the quantity sign "all" and the quality sign "not".

When a proposition is universal negative, we have to express quality and quantity by the word "no", so as to avoid ambiguity. Because if we use the expression "not all", we cannot decide whether the predicate is denied of the whole subject or of a part of the subject. Let us clarify this by considering the proposition "Not all great leaders are selfish." This proposition would be commonly understood to express that "Some great leaders are not selfish." Therefore, to avoid ambiguity, when we wish to deny the predicate of the whole subject, we have to express the denial with the word 'no', placed before the subject.

Meaning of Some : At this stage it is necessary to explain the meaning of the word "some", as understood in logic. When a common man uses the word "some", he means "some only, but not all". This is not what logic means by the word "some". *In logic, the word "some" stands for any indefinite quantity.* It does not exclude the possibility that the assertion may be about "all" (i.e. the whole subject). In fact, a proposition is taken to be universal, only when we are certain that the predicate applies to the whole subject. But when we are not certain whether the predicate applies to the whole subject or to a part of it, the proposition is taken as particular. That is, for logic, "some" means "some at least"; it does not exclude the possibility of "all".

When the assertion is about a part of the subject, the word "some" is used. It makes no difference to logic whether the part is small or large. The word "some" is used for any quantity whatsoever. The quantity may be I out of 100, or 99 out of 100. Thus, the second sense of "some" is "at least one". *Thus , the word "some" in logic means "at least one; may be all".*

Quantity of hypothetical and disjunctive propositions : Hypothetical and disjunctive propositions are also classified on the basis of quantity. The form of hypothetical proposition is always universal. But when a hypothetical proposition contains a sign of particularity, e.g. the word 'sometimes', it is to be considered as particular. The proposition "Sometimes if there is change in government, people suffer" is a particular proposition.

A disjunctive proposition asserts alternatives. Alternatives lose their force if they are particular. Therefore, disjunctive propositions are usually universal. *However, disjunctive propositions can be particular.* If in a disjunctive proposition the alternatives are applicable to some of the members of a class, the proposition is particular. Thus, the proposition "Some men are either born good or born wicked" is a particular proposition.

5. FOURFOLD CLASSIFICATION OF PROPOSITIONS

We have seen that according to quality propositions are classified into affirmative and negative. According to quantity they are classified into universal and particular. On the basis of these two principles (of quality and quantity), there *are four kinds* of propositions. This is called the *fourfold classification* of propositions. It is also called the *traditional scheme* (or traditional schedule) of propositions. The four kinds of propositions included in the traditional scheme are the following :

1. **Universal Affirmative :** In this kind of proposition the predicate is denied of the whole subject. *"All fairies are beautiful"* and *"All Brahmins are Hindus"* are universal affirmative propositions.
2. **Universal Negative :** In this kind of proposition the predicate is denied of the whole subject. *"No thieves are moral "* and *"No fool is a good friend "* are propositions this kind.
3. **Particular Affirmative :** In this kind of proposition the predicate is affirmed of a part of the subject. *"Some singers are rich"* and *"Some boys are clever"* are propositions of this kind.
4. **Particular Negative :** In this kind of proposition the predicate is denied of a part of the subject. *"Some modern men are not religious-minded"* and *"Some magicians are not rich"* are particular negative propositions.

These four types of propositions are symbolised by the vowels A, E, I and O. These vowels are taken from the Latin words *affirmo* (meaning 'I affirm') and *nego* (meaning 'I deny'). 'A' and 'I' are the first two vowels of the word "affirmo", 'E' and 'O' are the two vowels of the word "nego".

Using the symbol "S" for the subject and the symbol "P" for the predicate, the above four kinds of propositions may be represented thus :

Universal Affirmative	(A) All S is P.
Universal Negative	(E) No S is P.

Particular Affirmative	(I) Some S is P.
Particular Negative	(O) Some S is not P.

When we come to immediate inferences, we shall find it more convenient to indicate the quality and quantity by the small letters *'a', 'e', 'i'* and 'o'. The letter 'S' (standing for the subject) will be placed to the left, the letter 'P' (standing for the predicate) to the right, and the small letters *'a', 'e',* 'i' and 'o' in the middle. Thus, *'A' 'E', 'I'* and 'O' propositions may also be represented thus:

A	SaP
E	SeP
I	SiP
O	SoP

6. SINGULAR PROPOSITIONS

In addition to universal and particular propositions, Kant added a third sub-class of propositions under the head of quantity. This is singular proposition. *A singular proposition is one in which the predicate is affirmed or denied of a single definite individual.* That is to say, the subject of a singular proposition is a singular term. Thus, the propositions "Brutus is an honourable man" and "This man is not learned" are singular.

The traditional logicians considered singular propositions to be universal. This is because, in a singular proposition, the affirmation or denial is of the whole subject. The denotation of a singular term is one definite individual. Since the subject term of a singular proposition is this definite individual, it is taken in its entire denotation. And when the subject term is taken in its entire denotation, the proposition is universal. Therefore, singular propositions are universal.

7. REDUCTION OF SENTENCES TO LOGICAL FORM

The traditional logicians recognized only four kinds of categorical propositions. Every sentence has to be reduced to one of these four kinds.

Order of the constituents of proposition : In a categorical proposition, the predicate is affirmed or denied of the subject. The affirmation or denial is expressed by the copula. The traditional logicians insist that the subject, the predicate and the copula be clearly stated. The quantity of a proposition is expressed by the word "all", "some" or "no", placed before the subject. Of course, in singular propositions the subject term is one definite individual. Therefore, in their case the subject term is not prefixed by these signs of quantity. *The order of the constituents of proposition is :*

(Sign of quantity) Subject-Copula-Predicate

In everyday expressions we do not maintain this order. Sometimes, for the sake of literary effect, the predicate is placed before the subject. When a sentence is reduced to the logical form of proposition, the order indicated above has to be maintained. Thus, the sentence *"Sweet are the uses of adversity"* will be reduced to logical form as *"The uses of adversity are sweet."* (Here the subject term 'uses of adversity' is taken as a single whole; therefore, the proposition is singular. It is 'A' proposition.)

In ordinary expressions the different elements of a proposition (i.e. subject, copula and predicate) are not separated. But when a sentence is brought to the logical form of proposition, different elements have to be distinguished. This has to be done without changing the meaning of the expression.

Copula : According to the traditional logicians, the copula must be in the present tense of the verb "to be". Any reference to time must be shown by the predicate. Thus, the sentence *"Ramanujam was a great mathematician"* will be reduced to logical form thus: *"Ramnujam is a person who was a great mathematician."*

Qualifying clauses : A clause which qualifies the subject term is a part of the subject. Similarly, a clause which qualifies the predicate term is a part of the predicate. Sometimes the qualifying clause does not occur along with the relevant term. To take examples :

a) No revolutionary will be followed unless he is courageous. The clause "unless he is courageous" qualifies the subject term 'revolutionary'. Therefore, it is a part of the subject. Logical form: *No revolutionary if he is not courageous is one who will be followed. (E)*]

b) With determination all problems can be solved. The phrase "with determination' qualifies the predicate. Logical form: *All problems are those which can be solved with determination. (A)* }

Logic recognizes only two signs of quantity . These are "all" and "some". Sentences contain many signs of quantity. But, as stated earlier, every sentence is to be reduced to the form of 'A', 'E', 'I', or 'O' proposition. *To determine the kind of proposition, we have to understand the intention of the thinker.* However, if we know meanings of some **key words,** this will become much easier. These key words are :

1. All-Every-Each-Any : Affirmative sentences containing these words are to be brought to the form of 'A' proposition. To take examples :

a) Every man is responsible for his actions. (LF: *All men are responsible for their actions.*)

b) Any man can lift this weight. (LF: All *men are persons who can lift this weight.*)

c) He who understands his own nature becomes humble. ('He who' means 'anyone'. Therefore, it is 'A' proposition. Logical form: *All persons who understand their own nature are those who become humble.*)

Negative sentences in which the subject term is qualified by the above quantity signs are to be brought to the logical form of 'O' proposition. This is because the expressions "all not", "every not", etc. mean "some not". To take examples :

a) All that glitters is not gold. (LF : *Some things that glitter are not golden.*)

b) Every military general does not have a sound plan for defence. (LF: *Some military generals are not those who have a sound plan for defence.*)

2. Collective and distributive uses of the subject term : Sometimes the quantity sign "all" applies to the subject term, considered as a single whole; and sometimes it applies to each member of the subject class, separately. In the former case, the subject is used collectively; in the latter case, it is used distributively. Let us define the collective and the distributive use of terms. *A term is said to be collectively used when an attribute applies to all members of the class, taken together, and not to each of them separately. It is said to distributively used when an attribute applies to each member of the class, separately.* Thus, in the proposition "Not all the doctors in the world can cure him", the subject term is used collectively. The predicate is denied of all the doctors in the world, taken together. On the other hand, in the proposition "All great leaders are not liked", the predicate is denied of each great leader, separately. Now when the subject term is taken collectively, the predicate is affirmed or denied of the whole class. Therefore, the proposition is universal. But when the subject term is used distributively, the predicate is affirmed or denied of each member of the class, separately. In such cases, when the predicate is affirmed of the subject, the proposition is universal affirmative; and when it is denied of the subject, the proposition is particular negative. (This is because "all not" means "some not".) let us take some examples.

a) Not all the perfumes of Arabia can sweeten this little hand. (The subject term is used collectively. Therefore, it is 'E' proposition. Logical form: *No perfume of Arabia is that which can sweeten this little hand.*)

b) Not all the perfumes of Arabia have good fragrance. (The subject term is used distributively. The denial is about each perfume, separately. Therefore, it is 'O' proposition. Logical form : *Some perfumes of Arabia are not things that have good fragrance.*)

c) All my days are a burden to me. (Here the subject term "all my days" is taken collectively. It means "the whole of my life", which is a singular term. Therefore, this is a singular proposition. Singular propositions are universal, and so it is 'A' proposition. Logical form: *The whole of my life is a burden to me.)*

d) All great leaders care for national good. [Here the subject term 'great leaders' is used distributively. The predicate is affirmed of each great leader, separately. It is 'A' proposition. (We have already seen that the word "all" without negation indicates 'A' proposition.) Logical form: *All great leaders are those who care for national good.*]

3. Articles 'a' and 'an' when they 'mean any': Sometimes these articles are used before the subject term to indicate quantity. When they are used in the sense of "any" or "all", the proposition is to be reduced to the form of 'A' proposition if the sentence is affirmative. When it is negative, it is to be reduced to the form of 'O' proposition. To take examples:

a) An ant is an insect. (Here "an ant" means "any ant". Therefore, it is 'A' proposition. Logical form : *All ants are insects.*)

b) A selfish person is not a good friend. (Here "a selfish person" means "any selfish person". Since the sentence is negative, it is 'O' proposition. Logical form: *Some selfish persons are not good friends.*)

4. When the articles 'a' and 'an' mean one thing, the proposition is taken as singular. As such, it will be universal. If the sentence is affirmative, it will be 'A' proposition. If it is negative, it will be 'E' proposition. Example :

A Victoria Cross was sold for ₹ 36,000 (Here the article 'a' means 'one'. The number is definite. Therefore, it is 'A' proposition. Logical form : *The thing which was sold for ₹ 36,000 is a Victoria Cross .*)

5. The quantity signs **"always", "whenever", "wherever',' "whatever", "invariably", necessarily" and "absolutely"** are *similar to the quantify sign "all".* When these occur in an affirmative sentence, the proposition will be 'A', and when they occur in a negative sentence, the proposition will be 'O'. Examples :

a) Whatever goes up must come down. ('Whatever' stands for anything. Therefore, it is 'A' proposition. Logical form: *All things that go up are those that must come down.*)

b) Men are not necessarily bad. ('Necessarily' with negation means 'some not'. It is 'O' proposition. Logical form : *Some men are not bad.*)

6. Sentences which contain expressions like **"no" "never', "not at all" and "not a single"** are to be reduced to the form of 'E' proposition. This is because they express that the predicate is denied of the whole subject. To take examples :

a) Not a single member of the crew was saved. Logical form: *No member of the crew is one who was saved.*)

b) Not even one mango in the basket was rotten. (The expression 'not one' indicates 'E' proposition. *The word "even" makes the assertion emphatic.* While reducing the sentence to the logical form of proposition, the word 'even' will be ignored. Logical form: *No mango in the basket is that which was rotten.)*

c) Judges are not at an partial. (The expression 'not at all' indicates 'E' proposition. Logical form : *No judges are partial.*)

7. The quantity signs **'most', 'many', 'a few', 'certain', 'almost all', 'all but one' and 'several'** indicate *particular* proposition. When they occur in an affirmative sentence, the sentence will be reduced to 'I' proposition. To take examples :

a) Most houses in Japan are built from light material. (Logical form : *Some houses in Japan are buildings which are built from light material.*)

b) Almost all the passengers were insured. (Loigcal form: *Some passengers are those who were insured.*)

Negative sentences containing the above words are to be reduced to the form of 'O' proposition. Examples :

a) A few philanthropists did not help the victims of famine in Bihar. ('A few' occurring in a negative sentence means 'some not'. It is 'O' proposition. Logical form: *Some philanthropists are not those who helped the victims of famine in Bihar.*)

b) All but one members of the picnic party did not return safe. ['All but one' in a negative sentence meanse 'some not'. It is 'O' proposition. (Logical form: *Some mernbers of the picnic party are not those who returned safe* .)

8. The quantity signs **'mostly', 'generally', 'frequently', 'often', 'perhaps', 'nearly always', 'sometimes' and 'occasionally'** indicate *particular* proposition. When these occur in an affirmative sentence, the proposition is 'I'. Examples :

a) Eno's fruit salt generally gives relief from stomach discomfort. ('Generally' indicates particular proposition. It is 'I' proposition. Logical form: *Some occasions of taking Eno's fruit salt are occasions of getting relief from stomach discomfort.)*

b) Central Railway trains frequently run late. (Logical form: *Some Central Railway trains are those which run late.*)

c) Every one is occasionally wrong. [In this proposition the quantity sign 'occasionally' is secondary quantification. (We shall deal with secondary quantification later on in the section.) It applies to the predicate. 'Every one' indicates universal affirmative proposition. Logical form: *All persons are those who are sometimes wrong.]*

When these words occur in a negative sentence, the proposition will be 'O'. To take examples :

a) Perhaps modern men do not care for religion. ('Perhaps' indicates absence of certainty. As it is accompanied by the sign of negation, it is 'O' proposition. Logical form : *Some modern men are not those who care for religion.)*

b) It is false that intelligent persons nearly always prosper. ('Nearly always' indicates particular proposition. The expression "it *is false*" shows denial. Therefore, the proposition is 'O'. Logical form : *Some intelligent persons are not those who prosper.)*

9. The word **"few" has negative significance.** It means "some not". When this word occurs in an affirmative sentence, the sentence will be reduced to the form of 'O' proposition. To take examples :

a) Few men are free from vanity. (Logical form: *Some men are not persons who are free from vanity.*)

b) Few have peace of mind who prosper by cheating. ('Few' means 'some not'. Therefore, it is 'O' proposition. The subject term is "persons who prosper by cheating"; the predicate term is "having peace of mind". Logical form: *Some persons who prosper by cheating are not those who have peace of mind.*)

When the word **"few" occurs in a negative sentence,** the sentence will be reduced to the form of 'I' proposition. Examples :

a) Few nations do not wish to avoid the Third World War. ('Few' means 'some not'. But with the sign of negation, it means 'some'. Therefore, it is 'I' proposition. Logical form: *Some nations are those which wish to avoid the Third World War.*)

b) Few great men are not considerate. (Logical form: *Some great men are considerate.*)

The quantity sign "a few" is to be distinguished from "few". While "few" has negative significance, *"a few"* has positive force. Therefore, when the expression "a few" occurs in an affirmative sentence, it is to be reduced to the form of 'I' proposition. When it occurs in a negative sentence, it is to be reduced to the form of 'O' proposition. We have already dealt with sentences which contain the quantity sign *"a few"*.

10. The words **'seldom', 'hardly', 'scarcely' and 'rarely'** also have negative significance. *They are similar to the word 'few'.* When any of these words occurs in an affirmative sentence, the sentence will be reduced to the form of 'O' proposition. To take an example : "Politicians are rarely punctual in keeping their appointments." ('Rarely' means 'some not'. It is 'O' proposition. Logical form : *Some politicians are not punctual in keeping their appointments.*)

When the above words occur in a **negative sentence,** the sentence will be reduced to the form of 'I' proposition. Example : "Magnanimity in politics is not seldom the truest wisdom." ('Seldom' occurring in a negative sentence has positive force. It is 'I' proposition. Logical form: *Some cases of magnanimity in politics are cases of the truest wisdom.*)

11. Numerically definite propositions : Numerically definite propositions are those in which the predicate is affirmed or denied of some definite proportion of the subject. The expressions like "half ", "two-thirds" and "30 per cent" indicate a numerically definite proposition. Such propositions can be interpreted in two ways. These expressions may mean that the assertion is exactly about the stated proposition; or they may mean that the assertion is about the stated proportion at least. Following Keynes, we accept the first interpretation. That is, we accept the view that these propositions give information about the exact proportion. Therefore, numerically definite propositions would be brought to the logical form of *two* propositions. Let us take examples.

a) Two-thirds of the members left the meeting.

b) Seventy per cent of the candidates did not pass the test.

The first proposition means (i) two-thirds of the members left the meeting; and (ii) one-third of the members did not leave the meeting. Similar interpretation will be given to the second proposition. Thus, the above propositions will be brought to their logical form as under :

a) i) The proportion of members who left the meeting is two-thirds of the total. (A)

ii) The proportion of members who did not leave the meeting is one-third of the total. (A)

b) i) The percentage of candidates who did not pass the test is seventy. (A)

ii) The percentage of candidates who passed the test is thirty. (A)

12. Indefinite propositions : An indefinite proposition is one in which the quantity is not definite. The proposition does not contain words that express quantity; e.g. "some", "all", "most" and "many". In such cases the logical form of the proposition depends upon the intention of the thinker. On the basis of the information provided in the proposition, we have to decide whether the proposition is universal or particular. Where we are not able to do so, the proposition is to be taken as particular. The following are indefinite propositions :

a) Planets revolve round the sun.

b) Muslims are not idol-worshippers.

c) South Indians are black.

From our knowledge of the contents of the propositions, we can judge that the first two proposition are universal, while the last one is particular. These propositions will be reduced to the logical form thus :

a) All planets are those that revolve round the sun. (A)

b) No Muslim is idol-worshipper. (E)

c) Some South Indians are black. (I)

13. Proverbs are also indefinite propositions : But they have universal force. So they are generally reduced to the form of universal proposition. Examples :

a) Something is better than nothing. (This means, having some thing is better than having nothing. Logical form : All *cases of having something are better than cases of having nothing.*)

b) Handsome is that handsome does. (This proverb means that a person who does good deeds is good. Logical form: *All persons who do good deeds are good persons.*)

14. Multiple quantification : Sometimes the predicate is affirmed or denied of the subject under certain limitations. The limitation is by reference to time or place. This limitation leads to a secondary quantification of the proposition. While stating the proposition in its strict logical form, the secondary quantification will form part of the predicate. Examples :

a) All men sometimes lose their temper. (Here the quantity sign "all" qualifies the subject. Therefore, it is 'A' proposition. The word 'sometimes' limits the assertion with reference to time. This is secondary quantification. Therefore, this word will be a part of the predicate. Logical form : *All men are those who lose their temper sometimes.*)

b) She always orders the most expensive item in the menu. (The word "she" shows that the proposition is singular. 'Always' expresses secondary quantification. Logical form : *She is a person who always orders the most expensive item in the menu.*)

15. Exclusive propositions : An exclusive proposition is one which limits the application of the predicate to the subject only. These propositions are indicated by expressions like "only", "alone", "none but" and "nothing else but". *"Only experts can judge scientific matters"* is a proposition of this kind. Exclusive propositions are to be reduced to the form of 'A' and 'E' propositions. While reducing to the form of 'A' proposition, the subject and the predicate change places. In the case of 'E' proposition, the contradictory of the original subject becomes the subject. To take examples :

a) Only experts can judge scientific matters.

  i) All those who can judge scientific matters are experts. (A)

  ii) No non-experts are those who can judge scientific matters. (E)

b) None but graduates can vote.

i) All persons who can vote are graduates. (A)

ii) No non-graduates are those who can vote. (E)

It may be stated here that *when the words like "only" qualify the subject, the proposition is exclusive. But if they qualify merely the quantity sign, the proposition is not exclusive.* For instance, "Only a few thieves are kind-hearted" is not an exclusive proposition. Here the word "only" qualifies "a few". The proposition makes an assertion about (only) a few thieves. This sentence means that a majority of thieves are not kind-hearted. Therefore, this proposition is to be brought to the logical form in the same way as a numerically definite proposition. (The use of the expression "a few" in this proposition is different from its normal use. Normally, it means "some at least, may be all".) This proposition will be reduced to the following two propositions :

i) The number of kind thieves is small. (A)

ii) The number of non-kind thieves is not small. (E)

16. Exceptive propositions : In these propositions exception is made about a part of the subject. The exception is generally indicated by words like "except", "but" and "other than".

The exception may be qualitative or quantitative. In the proposition "All metals except Mercury are solid", the exception is qualitative. That is, the exception is about some definite object (or objects). On the other hand, in the proposition "All metals except one are solid", the exception is quantitative.

Qualitative exception : The exceptive proposition "All metals except Mercury are solid" will be reduced to the following two propositions :

i) All metals other than Mercury are solid. (A)

ii) Mercury is not a solid metal. (E)

In the above exceptive proposition, the exception is qualitative. So, in one proposition the subject will be the class, which in the other proposition the subject will be the exception.

Quantitative exception : The proposition "All metals except one are solid" will be reduced to the following two propositions :

i) Some metals are solid. (I)

ii) The number of metals which are not solid is one. (A)

When the exception is quantitative, one of the propositions will be particular. The other proposition will be singular, and the quantity will become its predicate.

17. Interrogative sentences : We have seen in Chapter 2 that questions do not express propositions. However, some questions are statements; but they are expressed in the form of questions for the purpose of greater emphasis. Such questions can be brought to the logical form of proposition. However, we have to bring the statement that the question contains (and not the question itself) to the logical form. In other words, we have to reduce the answer (which is, really, the statement the question implies) to the logical form of proposition. Now it will be observed that an affirmative question will imply a negative statement. Therefore, an affirmative question will be brought to the form of negative proposition. On the other hand, a negative question will imply an affirmative statement. As such, a negative question will be reduced to the form of affirmative proposition. To take examples :

a) What thief would trust a thief? (This question implies that no thief would trust a thief. It is reduced to 'E' proposition thus : *No thief is a person who would trust a thief.*)

b) Are not some facts stranger than fiction? (This question, implies that some facts are stranger than fiction. The quantity sign 'some' indicates that it is 'I' proposition. Logical form : *Some facts are stranger than fiction.*)

18. Subjectless propositions : Subjectless propositions may be exclamatory or impersonal. The traditional logic attempts to reduce these to the form of categorical propositions. As we have seen, these propositions do not have clear subject. Therefore, we have to understand the intention of the speaker, and reduce them to their logical form. To take examples :

a) It is hot. (Here the speaker is clearly referring to a definite day. It is, therefore, a *singular proposition*. It is brought to the logical form of 'A' proposition thus : *The day is hot.*)

b) Thieves! (Now, in the exclamation the speaker may be pointing to some persons and saying (about them) that they are thieves. On this interpretation, it will be brought to the form of 'A' proposition thus : *The persons I see there are thieves.*)

19. Compound proposition : The traditional logic recognizes that every proposition consists of a single statement. If a proposition contains more than one statement, it is to be reduced to as many propositions as there are statements.

We have to note that we are referring to propositions in which we find conjunctions like "and", "though", "yet", "still" and "neither nor". Hypothetical and disjunctive propositions are not to be analyzed into other propositions. In a hypothetical proposition the consequent depends upon the antecedent. As such, the antecedent and the consequent are not independent propositions. Similarly, the alternatives of a disjunctive proposition are not independent propositions.

We have to note that *the quality and quantity of the different statements in a compound proposition may not be the same.* We shall take some compound propositions and reduce them to their logical form.

a) Neither bad news nor good advice is well-received. (This is a compound proposition. The expression "neither nor" indicates that the predicate is denied of two things. Thus, the given proposition consists of two negative propositions. Both of them are 'E' propositions. These are: (i) *No bad news is well-received. (ii) No good advice is well-received.*)

b) No batsman can get runs unless he is venturesome, and not always then. This proposition consists of two negative propositions. One of them is 'E', and the other is 'O'. These are:

   i) No batsman if he is not venturesome is a person who can get runs.

   ii) Some venturesome batsmen are not those who can get runs. (The expression "not always" indicates that the second proposition is 'O'.)]

The expressions "not only" and "even" also indicate compound propositions. This will be clear from the following examples :

a) Not only poisonous snakes are dangerous. [(This proposition means that all poisonous snakes are dangerous and some beings other than poisonous snakes are dangerous. Logical form :

   i) All poisonous snakes are dangerous. (A)

   ii) Some beings other them poisonous snakes are dangerous.

b) Even bats are mammals. [(This proposition means that all bats are mammals and some non-bats (i.e. creatures other than bats) are mammals. Logical form:

   i) All bats are mammals. (A)

   ii) Some non-bats are mammals. (I)

20. Irregular sentences : It is not possible to show how each and every sentence is to be reduced to the logical form of proposition. Some sentences will not be covered by the types (l) to (19) above. For instance, requests, commands and warnings do not fall within the above types. Yet every sentence which gives information can be brought to the logical form of proposition. This is to be done by considering the intention of the speaker. We shall take an example.

Now is the time. [The proposition means that the present moment is the proper time. Logical form : *The present moment is the proper time.* (Here the subject term is singular. It is 'A' proposition.)]

21. Hypothetical propositions : Some hypothetical propositions express the relation between a condition and its consequence. These are to be brought to the logical form of hypothetical proposition. However, sometimes a hypothetical proposition can be reduced to the form of categorical proposition without changing its meaning. In such cases, either the hypothetical or the categorical form will serve the purpose. To take an examples :

When filled with hydrogen, a balloon rises in the air. (This proposition can be reduced either to the form of categorical proposition or to the form of hypothetical proposition. Logical form :

i) All balloons when filled with hydrogen are those which rise in the air. (This is 'A' proposition. The phrase "when filled with hydrogen" qualifies balloons.)

OR

ii) If a balloon is filled with hydrogen, it rises in the air.

b) Animals can never cry out, if frightened. [Logical Form :

i) If animals are frightened, they cannot cry out. (E)

OR

ii) No animal if frightened is one which can cry out. (In this categorical proposition, "if frightened" is taken as qualifying the subject term.)

22. Disjunctive propositions : We have seen in Section 2 above that a disjunctive proposition asserts alternatives. We have also seen that the form of disjunctive proposition is universal, though a disjunctive proposition can be particular. However, all disjunctive propositions are affirmative. Thus, disjunctive propositions can be either 'A' or 'I' propositions.

It may again be emphasized that the propositions with the expression "neither nor" are not disjunctive. They are compound propositions which are to be reduced to two negative propositions.

A	Affirmative sentences with "all", "every", "each", "any", "always", "whatever", "invariably", "necessarily", or "absolutely".
E	Sentences with "no", "never", "none", "not at all", "not a single", or "not even one".
I	**Affirmative sentences** with "most", "many", "a few", "certain", "almost all", "all but one", "several" "mostly", "generally", "frequently", "often", "perhaps", "Nearly always", "sometimes", "occasionally". **Negative sentences** with "few", "seldom", "hardly", "scarcely", or "rarely".
O	When 'A' is denied, we get 'O'; when affirmative sentences which contain words indicating "I" are denied, we get O. In addition affirmative sentences with the word "few", "seldom", "hardly", "scarcely", or "rarely" are 'O' propositions. (The words "few", "seldom" etc. have negative significance.)

The above table summarizes common expressions which indicate the kind of proposition.

8. DISTRIBUTION OF TERMS IN A CATEGORICAL PROPOSITION

A categorical proposition asserts relationship between the subject term and the predicate term. The assertion may be with regard to the entire denotation or to the partial denotation of these terms. The doctrine of distribution of terms deals with this.

A term is said to be distributed when the reference is to all the individuals denoted by the term. It is said that to be undistributed when the reference is to a part of the denotation of the term.

Even when the denotation is not definite, the term is taken to be undistributed. This means, only when there is explicit reference to the entire denotation, a term is said to be distributed.

There is no difficulty in deciding whether the subject term of a proposition is distributed. The quantity sign "all" or "some", before the subject, clearly indicates this. In a universal proposition the reference is to the entire denotation of the subject. Thus, in the 'A' proposition "All judges are fair-minded", the assertion is about the entire denotation of 'judges'. Similarly, in the 'E' proposition "No lemons are sweet", the subject is taken in its entire denotation. The word "no", before the subject, indicates that the predicate is denied of the entire denotation of the subject.

The traditional logicians considered singular propositions to be universal. Therefore, in singular propositions too, the subject term is distributed.

Let us now come to the distribution of the predicate term. Whether the predicate term is distributed or not depends upon the quality of the proposition. The predicate of an affirmative proposition is not distributed; because in an affirmative proposition there is no explicit reference to the denotation of the predicate. Let us understand this with the help of examples. The universal affirmative proposition "All judges are impartial" does not state whether all impartial persons are judges or not. Therefore, the predicate term is taken as undistributed. Similar is the case of particular affirmative proposition. We do not know whether the reference is to the entire denotation of the predicate or to a part of its denotation. The particular affirmative proposition "Some students are clever" does not tell us whether the whole class of clever persons is covered by some students. There may be clever persons who are not students. Thus, in a particular affirmative proposition also, the predicate term is taken to be undistributed.

There is one exception to the distribution of predicate in affirmative propositions. In 'A' proposition when the denotation of the subject and the predicate is the same, the predicate term also is distributed. In the proposition "All triangles are plane figures enclosed by three straight lines", both the terms are distributed.

In negative propositions the predicate term is denied of the subject. That is to say, all things denoted by the predicate are excluded from the subject. Therefore, negative propositions distribute predicate. Let us take examples of 'E' and 'O' propositions. In the 'E' proposition "No lemons are sweet", the whole class of lemons (subject) is excluded from the class of sweet things (predicate). Not only this, the entire denotation of the predicate term is excluded from that of the subject. Similarly, in 'O' proposition, a part of the denotation of the subject term is excluded from the entire denotation of the predicate. In the proposition "Some shopkeepers are not honest", a part of the class of shopkeepers is excluded from the entire denotation of honest beings.

Thus, we see that the subject of a universal proposition is distributed, but the subject term of a particular proposition is not. On the other hand, the predicate of a *negative proposition is distributed, but the predicate of an affirmative proposition is not.* **This shows that the quantity of a proposition determines the distribution of the subject term, while the quality of a proposition determines the distribution of the predicate term.** Let us state these results.

A proposition – subject distributed; predicate undistributed.

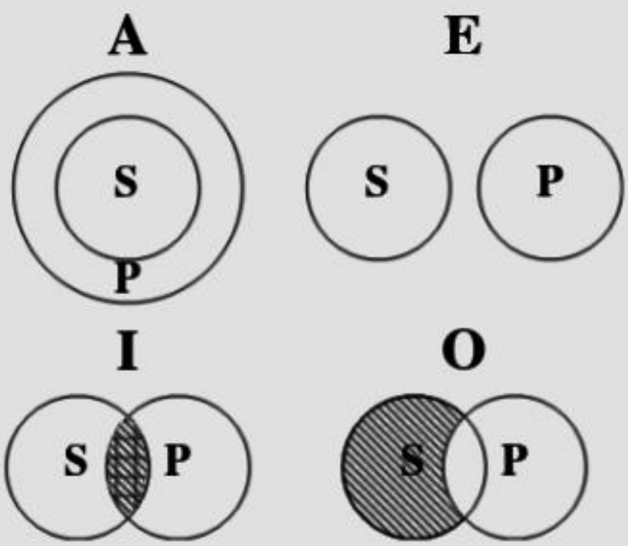
E proposition – subject distributed, predicate distributed.

I proposition – subject undistributed; predicate undistributed.

O proposition – subject undistributed; predicate distributed.

As an aid to memory, the word **'Asebinop'** may be remembered for the distribution of terms. In this word vowels stand for the four propositions. The consonants 's', 'b' 'n' and 'p' occur after the four vowels. These consonants indicate the distribution of terms. The consonant 's' indicates that only the *subject* term is distributed. The consonant 'b' indicates that *both* the subject and the predicate are distributed. The consonant 'n' indicates that *neither* of the terms is distributed. The consonant 'p' indicates that the *predicate* is distributed.

The distribution of terms in the 'A' ,'E', 'I' and 'O' propositions can be easily seen from the following diagrams :



In these diagrams the broken circle indicates the term that is undistributed. The diagram for 'A' proposition shows that the class represented by the subject term is included in the class represented by the predicate term; but the subject class does not cover the entire predicate class. This indicates that the subject term is distributed, but the predicate is not. The diagram for 'E' proposition shows that both the classes are completely separate. They exclude each other. Therefore, both the terms are distributed. The diagram for 'I' proposition shows that some members of the subject class (the shaded part) and some members of the predicate class (the shaded part) are the same. But neither term is taken as a whole. The diagram for 'O' proposition differs from the diagram for 'I proposition in the shaded part. 'O' proposition is about that part of the subject which is shaded. This part of the subject (the shaded part) is excluded from the whole of the predicate class. From this we see that 'O' proposition does not distribute the subject, but it distributes the predicate.

SUMMARY

The traditional logicians distinguished between *simple and compound propositions.* In a simple proposition there is a simple assertion; in a compound proposition the assertion is under certain conditions. In this sense, categorical propositions are simple, while hypothetical and disjunctive propositions are compound.

Categorical proposition is to be distinguished from hypothetical and disjunctive propositions. A categorical proposition merely affirms or denies a predicate of a subject. Hypothetical proposition in the traditional classification is the same as implicative proposition in the modern classification. Disjunctive proposition in the traditional classification is the same as disjunctive proposition in the modern classification.

Fourfold classification : On the basis of quality and quantity, the traditional logicians recognized four kinds of propositions. The classification of propositions into four kinds is called the fourfold classification of propositions. The four kinds of propositions are: (i) Universal Affirmative – 'A', (ii) Universal Negative - 'E', (iii) Particular Affirmative - 'I' and (iv) Particular Negative - 'O'. Singular propositions are treated as universal.

Reduction to logical form : While reducing sentences to the logical form of proposition, we must remember that logic recognizes only two quantifiers. These are "all" and "some". In logic, "some" means "at least some; may be all". Every sentence is to be reduced to one of the four forms - 'A', 'E', 'I' or 'O'. While doing so, we have to consider the intention of the thinker. However, if we know the meanings of certain key words, this will become much easier.

Distribution of terms : A term is said to be distributed, when the reference is to its entire denotation. It is said to be undistributed, either when the reference is to a part of its denotation or when its denotation is not definite. Now, universal propositions distribute subject, but particular propositions do not. Negative propositions distribute predicate, while the affirmative propositions do not. Thus, 'A' distributes subject; 'E' distributes both the terms; 'I' distributes neither term; and 'O' distributes predicate. However, when the denotation of the subject and the predicate is the same, 'A' proposition distributes both the terms.

TEST QUESTIONS

1. Explain the fourfold classification of propositions. Why are singular propositions considered to be universal?
2. Explain the collective and distributive uses of "all".
3. Explain the classification of propositions into categorical, hypothetical and disjunctive. Does the fourfold classification of propositions apply to hypothetical and disjunctive propositions?
4. Explain the distribution of terms in categorical propositions. What are the exceptions to the distribution of terms in 'A' proposition ?
5. Define the following terms :

(1) Categorical proposition
(2) Conditional proposition
(3) Hypothetical proposition
(4) Disjunctive proposition
(5) Collective use of a term
(6) Distributive use of a term
(7) Quality of proposition
(8) Quantity of proposition
(9) Affirmative proposition
(10) Negative proposition

(11) Universal proposition (12) particular proposition

(13) Singular proposition

6. Fill in the blanks with appropriate alternatives :

 1. _____ categorical propositions are general propositions. (All/Some/No)
 2. In 'E' proposition the copula is _____. (affirmative/negative)
 3. According to the traditional logicians, _____ disjunctive propositions are negative. (all/some/no)
 4. All singular propositions are _____(universal /particular/affirmative/negative)
 5. A term is said to be used _____ when an attribute applies to each member of the class, separately; it is said to be used _____ when an attribute applies to all members of the class to together, but not to each of them separately. (distributively/collectively)
 6. Universal propositions _____ distribute predicate, while particular propositions distribute subject. (always/sometimes/never)
 7. Particular propositions _____ distribute predicate, while universal propositions distribute subject. (always/sometimes/never)
 8. _____ affirmative propositions distribute predicate; and _____ negative propositions distribute subject. (All/Some/No)
 9. _____ negative propositions distribute predicate; and _____ affirmative propositions distribute subject. (All/Some/No)
 10. _____ of a proposition determines the distribution of the subject term; and _____ of a proposition determines the distribution of the predicate term. (Denotation / Connotation/Quality/Quantity)

7. Express the following sentences in the strict logical form of proposition in the traditional way, giving reasons :

 (First ten examples have been solved for guidance.)

 1. A great statesman was present. [Here 'a' stands for 'one', and not for 'any'. Since we do not know which one, the quantity sign 'some' will be used. However, here "some" does not indicate particular proposition. The number is definite. Therefore, even though the word "some" is used, the proposition is taken as 'A' proposition. Logical form : Some *great statesman is one who was present.*]
 2. Nothing is a tree unless it is a plant. [The expression 'unless it is a plant' goes with 'nothing'. When it is so expressed, it is: "Nothing unless it *is* a plant is a tree." This clearly shows that it is an exceptive proposition. It will be brought to the logical form of 'E' proposition: *"No non-plant (ie. no thing unless it is a plant is a tree."*]
 3. Those in the play are rehearsing. (The expression 'those in the play' clearly applies to all persons in the play, taken together. Thus, the subject term is used collectively. It is 'A' proposition. Logical form: *All persons acting in the play are rehearsing.*)
 4. Few artists are exempt from vanity. [The expression 'exempt from vanity' means 'not vain'. Since 'few' has negative force and the sentence itself is negative, it will be reduced to the form of 'I' proposition. Its logical form *is : "Some artists are not vain."* But if 'exempt from vanity' is taken as the predicate, the proposition will be 'O'. In that case, it will be brought to the logical form thus: *"Some artists are not those who are exempt from vain*ity) However, bringing this proposition to the form of 'I' proposition is to be preferred.)]

5. In all countries all foreigners are sometimes unpopular. [This proposition is about " all countries". But there are two other signs of quantity in it. These are secondary, and will not affect the form of the proposition These secondary signs of quantity will be placed in the predicate. Logical form: ***All countries are those in which all foreigners are sometimes unpopular. (A)***]
6. It is 859 miles from Bombay Central to Delhi. (The proposition can be taken as referring to the distance from Bombay Central to Delhi. In that case, its logical form will be: *"The distance from Bombay Central to Delhi is* 859 *miles."* On the other hand, if the subject of the proposition is taken as 'Delhi', the proposition will be reduced to the logical form thus : *"Delhi is a place 859 miles from Bombay Central."* In either case, it is a singular affirmative proposition. Therefore, it is 'A' proposition.)
7. Most planets are either too hot or too cold for living beings like ourselves. [This is a disjunctive proposition. The sign of quantity 'most' indicates that it is a particular proposition. It will be reduced to the form of 'I' proposition thus: *Some planets are either too hot or too cold for living beings like ourselves (i.e. men)*.]
8. Ducklings do not grow into swans. (This is an *indefinite proposition*. The quantity of the subject term is not indicated. Since the implication of the proposition is universal, it is reduced to the form of 'E' proposition thus: *No ducklings when they grow are those that become swans*.]
9. Brothers sometimes quarrel with each other. ['Sometimes" occurring in an affirmative sentence indicates that it will be reduced to 'I' proposition. Logical form : *Some brothers are those who quarrel with one other*.]
10. A few distinguished men have undistinguished sons. ("A few" in an affirmative sentence indicates 'I' proposition. Logical form : *Some distinguished men are these who have undistinguished sons.*)
11. Many a man has lived to regret a misspent youth.
12. Elephants never forget.
13. More than half people who go to movies on weekday afternoons are college students.
14. Grapes come from Nasik.
15. Hardly any man is infallible.
16. A budget which imposes heavy taxes does not always lead to inflation.
17. Women are jealous.
18. The machines in this factory all work.
19. No one likes to be wrong.
20. No child ever fails to be troublesome, if ill-taught and spoilt.
21. Only those who are registered are permitted to vote.
22. Congress has a majority in the Parliament.
23. There is nothing wrong with depriving people of their liberties.
24. Seven States have non-Congress governments.
25. People who like Shyam also like Mina.
26. A few statesmen have won Nobel Prize.
27. Few children do not love the circus.
28. Everyone has certain minimum food requirements.
29. No cat has nine tails.

30. Any boy is younger than his father.
31. It is not the case that great men are free from shortcomings.
32. Not only the English are brave.
33. Men of violent minds are not all lacking in tenderness.
34. He who preaches chastity to others should himself be chaste.
35. Books on history sometimes throw light more on their authors than on their subject-matter.
36. Two straight lines cannot enclose a space.
37. Old men are not necessarily wise.
38. Not all your endeavours will succeed.
39. What is not practicable is not desirable.
40. Improbable events happen almost every day.
41. Human nature never changes.
42. Several film stars are frivolous.
43. Gases at high pressure become liquids.
44. At least two of the judges did not condemn the prisoner.
45. None but gold will silence him.
46. An injection of adrenalin makes the blood clot more rapidly.
47. All fishers are kind to children except sharks.
48. A minority of newspapers did not go on strike.
49. In Fiji men wear skirts.
50. Japanese are imitative.
51. The giraffe has a long neck.
52. A large number of vain persons are showy.
53. Successful men are usually ambitious.
54. Not every tasty dish is nutritious.
55. Who is not affected by flattery ?
56. Never can the rights be separated from duties.
57. An Englishman maintains self-control in all situations.
58. Not a single ingredient of Ayurvedic medicines is harmful.
59. An old man may not be orthodox.
60. It is not the case that wasps dance.
61. The rose is a beautiful flower.
62. Creative thinkers seldom care for others' opinions.
63. Each and every millionaire is not born rich.
64. The whale is not a fish.
65. It is rare to find gamblers who are reliable.
66. Automobiles are usually expensive.
67. What politician can oppose people?
68. There are times when bravery is folly.
69. Romans celebrated the feast of Saturnalia.
70. Brokerage houses often fail.

CHAPTER – 5

MODERN CLASSIFICATION OF PROPOSITIONS

DO YOU KNOW THAT ......

- *even when a part of a statement containing the word "and" in true, the whole of the statement is false?*
- *when you offer someone "either tea or coffee", you are inviting him to have both if he so likes?*
- *because moon is not made of cheese, you can say, "If moon is made of cheese, a circle can be squarred"?*
- *you should never say, "If and only if you win a lottery, you will travel Europe" - who knows you may win a scholarship?*

1. THE TRADITIONAL CLASSIFICATION : ITS BASIS AND DEFECTS

The science of logic began with Aristotle. Aristotle conceived the form of proposition, and considered that deduction depends upon forms of propositions. His followers studied, in detail, only a few forms of propositions. They tried to express all propositions in these forms.

According to Aristotle, every proposition either affirms or denies something of something else. That is, every proposition (every categorical proposition) is of the subject-predicate form. But, as we shall see in the later sections of this chapter, very few propositions recognized by the traditional logicians are subject-predicate propositions.

The four kinds of propositions in the traditional classification (with the exception of singular propositions) are about classes. And propositions about classes are general propositions. Further, only some of the singular propositions are of the subject-predicate form.

We shall see that the logical structure of general propositions is different from that of subject-predicate propositions. Moreover, singular propositions in the traditional classification may be subject-predicate propositions, class-membership propositions or relational propositions. The traditional logicians did not realize this. They called all of them singular propositions.

From the above discussion, it is clear that the traditional classification of propositions is defective. It is a result of insufficient analysis. It ignores fundamental differences in the logical structures of propositions.

The emphasis of the traditional logicians is on propositions whose subject term is a class. The traditional logicians failed to distinguish singular propositions from propositions whose subject term is a class. Modern logic distinguishes between them. In this chapter we shall see that the propositions about classes are general propositions. On the other hand, singular propositions, except negative propositions, are simple propositions. However, we must not confuse the simple proposition, as understood by modern logic, with what traditional logicians call simple propositions. As we shall see, the modern view of simple propositions is quite different.

2. AIM AND BASIS OF MODERN CLASSIFICATION

The number of propositions which may stand as the premises or as the conclusion of an argument is unlimited. It is the function of logic to introduce order into this unlimited variety. Modern logic does this by classifying propositions, and finding out their standard forms. Determining the standard forms of propositions helps the logicians to find out similarities and differences among propositions.

There are *two different classifications of propositions*. These are the traditional classification and the modern classification. We have seen that the traditional logicians did not recognize many important distinctions between propositions. The modern classification is more scientific.

The easiest method of classifying propositions is to separate those propositions which do not contain another proposition (or propositions) as a component from those propositions which do so. The former are called simple propositions, and the latter compound propositions. Thus, the proposition "America landed a man on the Moon" is a simple proposition, while the proposition "Either America or Russia landed a man on the Moon" is a compound proposition.

In addition to simple and compound propositions, modern logicians also recognize **general propositions**. Propositions like "All musicians are artists" and "Some snakes are poisonous" are general propositions. General propositions are different from simple as well as compound propositions. Like a simple proposition, a general proposition does not contain another proposition as a component. But the kind of statement it contains is different from the statements contained by simple propositions. We shall deal with general propositions in Section 7.

3. SIMPLE AND COMPOUND PROPOSITIONS

Some propositions do not contain another proposition (or propositions) as a component, while others do. The former are called simple propositions, and the latter compound propositions. **Thus, we may define a simple proposition as one which does not contain any other proposition as a component.**

The following are simple propositions :

1. Shivaji was a hero.
2. Taj Mahal is beautiful.
3. Sunita likes classical music.

On the other hand, the following propositions have another proposition (or propositions) as a component :

1. Ptolemy believed that the Sun revolves round the Earth.
2. Romeo did not hate Juliet.
3. Today is Sunday and the College is closed.

4. He will take either coffee or ice cream.
5. If war is declared, then prices will rise.
6. If and only if it rains, the match will be cancelled.

As for the last four propositions, it is obvious that they have other propositions as components. But, really, even the case of the first two propositions is similar. They too have another proposition as a component. This becomes clear when we place the component proposition, or propositions, within brackets.

1. Ptolemy believed that (the Sun revolves round the Earth).
2. It is not the case that (Romeo hated Juliet).
3. (Today is Sunday) and (the College is closed).
4. Either (he will take coffee) or (he will take ice cream).
5. If (war is declared), then (prices will rise).
6. If and only if (it rains), (the match will be cancelled).

The proposition which contains another proposition (or propositions) as a component is called compound proposition (or compound statement). Thus, the above six propositions are compound. Of these, the first two contain one component proposition, while the other four have two component propositions.

A simple proposition cannot be analyzed into other propositions. That is to say, its constituents are not propositions. Moreover, *a simple proposition makes an assertion about an individual (or individuals)* An individual is anything that can possess attributes. It may be a person, a building, a city or a country. Thus, 'Ram', 'Taj Mahal', 'Bombay' and 'India' are individuals. They can possess (in fact, they do possess) attributes. All the above examples of individuals are proper names; but an individual may not be a proper name. 'This man', 'that building', 'the city I visited last month' and 'my native country' are also individuals. We can predicate a property of them. This shows that an individual is always a singular term.

4. KINDS OF SIMPLE PROPOSITIONS

There are four kinds of simple propositions. These are :

1. Subjectless proposition : The simplest kind of proposition is the subjectless proposition. Here the thinker asserts something, but the statement is not fully expressed. Subjectless propositions are either exclamatory or impersonal propositions. Let us take examples.

1. Fire !
2. It rains.

The first proposition is an **exclamatory proposition.** While distinguishing propositions from grammatical sentences (in Chapter 2), we pointed out that exclamatory sentences do not express propositions. However, a proposition gives information. Therefore, if an exclamation gives information, it is a proposition. The first sentence gives information about fire. So it expresses a proposition.

The second subjectless proposition is *impersonal proposition*. An impersonal proposition has a grammatical subject, but not a logical subject. The word 'it' is not a logical subject.

Subjectless proposition makes an assertion, but the subject of the assertion is not clear. Therefore, to understand the proposition, we have to know the situation in which the assertion is made. The proposition 'Fire!' obviously means that something is on fire. If the thinker points to a ship and utters this expression, it would mean: "That ship is burning." *Thus, subjectless propositions do not express the intention of the* *speaker clearly. Therefore, they are primitive propositions.* However, they give information. That is why they are propositions.

2. Subject-predicate proposition : A *subject-predicate proposition states that an individual possesses a quality (or attribute).* An individual is a singular term. Therefore, the subject of this kind of proposition is a singular term. To take examples :

1. Savitri was pure.
2. Solomon was wise.
3. The man who wrote to me today thinks clearly.

All these propositions assert an attribute about an individual. In the first two propositions the subject is a proper name; in the third one it is a uniquely descriptive phrase.

The *form of subject-predicate proposition* is symbolically represented as: S-P. Here 'S' stands for the subject; and 'P' stands for the predicate, which is an attribute.

3. Relational proposition : A relational proposition asserts a relation between two or more constituents. The constituents between which a relation is asserted are called *terms of relation.* These terms of relation cannot be called subject and predicate. All of them are subjects of relation. Thus, the relational proposition *"Ram loved Sita"* expresses relation between two subjects *'Ram'* and *'Sita'*. Of course, a relational proposition may express relation between three, four, or even more subjects.

There are various words which express relations. We are familiar with relations like 'wife of', 'brother of', 'father of' and 'cousin of'. We are also familiar with relations expressed by transitive verbs like 'love', 'hate', 'give', 'take' and 'drink'. Words expressing equality and inequality in any respect and words expressing similarity and difference also stand for relations. Thus, the expressions 'bigger than', 'smaller than', 'taller than', 'same as', 'different from' and 'equal to' stand for relations.

In a relational proposition the relation proceeds from something to something else. This is called the **sense or direction of relation.** The term from which the relation proceeds is called *referent.* The term to which the relation proceeds is called *relatum.*

The sense or direction of relation may be indicated by an arrow. In the relational proposition "Ram *defeated Ravana"*, the relation of defeating proceeds from 'Ram' to 'Ravana'. We may express the direction of relation thus:

$\text{Ram} \xrightarrow{\text{defeating}} \text{Ravana}$

Let us take some more examples.

1. Calcutta is bigger than Bombay.
2. Jan Sangh hates Communist party.
3. The man who wrote to me yesterday likes my brother.

All these propositions express relation between two subjects. Let us indicate these propositions by writing first the referent, then showing the direction with an arrow (the relation being written above the arrow), and then the relatum.

1. $\text{Calcutta} \xrightarrow{\text{bigger than}} \text{Bombay}$
2. $\text{Jan Sangh} \xrightarrow{\text{hates}} \text{Communist party}$
3. $\text{The man who wrote to me yesterday} \xrightarrow{\text{likes}} \text{my brother.}$

All these propositions have different referents and different relata (relata is the plural of relatum); they express different relations. Still they are of the same form. We may express these propositions with the help of symbols. We may use the symbol '*x*' for referent, 'y' for relatum, and 'R' for relation. The letters 'x' and 'y' will be small letters. The letter 'R' will be a capital letter. Thus the symbolic expression of relational proposition will be :

$$x\,R\,y$$

It can also be written as :

$$R\,(x, y)$$

The direction or sense of relation is indicated by the order in which the small letters 'x', 'y', etc. occur. The letter which occurs first is the referent; that which stands next is the relatum.

4. Class-membership proposition: A class-membership proposition asserts that an individual is a member of a class. Let us take some examples.

1. Shivaji was a hero.
2. Arjun was a warrior.
3. The drama we staged is a comedy.

Obviously, all the above propositions are class-membership propositions. The individual 'Shivaji' is included in the class of heros, 'Arjun' in the class of warriors, and 'the drama we staged' in the class of comedies'.

Class-membership proposition is symbolized as :

$$a \in F$$

Here the letter 'a' stands for any individual, and the letter 'F' for any class. The sign ' $\in$ ' (called epsilon) stands for class-membership. The letter which stands for the individual is a small letter (small 'a' is used above.) The letter which stands for class is a capital letter (capital 'F' is used above.) In the symbolic representation of class-membership proposition, *epsilon* ($\in$) *is a component.* Even when the individual and the class (which are constituents) change, the relationship of 'class-membership' (which is represented by epsilon '$\in$') remains the same.

The distinction between class-membership proposition and relational proposition is obvious. A relational proposition asserts relation between two or more terms of relation. In refers neither to the classes nor to the attributes implied by them. But the difference between a subject-predicate proposition and a relational proposition may not be so clear. Let us distinguish between subject-predicate and class-membership propositions. A subject-predicate proposition, as well as a class-membership proposition, asserts something about an individual. But while a subject-predicate proposition asserts a quality, a class-membership proposition asserts membership of a class. No doubt, members of a class possess certain common qualities. However, when we assert that an individual is a member of a certain class, we are emphasizing the denotative aspect of the class. On the other hand, when we state that an individual possesses a certain quality, we emphasize the connotative aspect. This is how the subject-predicate proposition "Ram is human" and the class-membership proposition "Ram is a man" differ.

We have taken examples of affirmative propositions. But any proposition can be denied. However, denial of a simple proposition gives us a compound proposition. So, it will not be dealt with here.

5. COMPOUND PROPOSITIONS

We have stated in Section 3 that a compound proposition is one which contains another proposition (or propositions) as a component. There are five propositional connectives. In Section 3, we have placed component propositions within brackets. What we finds outside the brackets are expressions which connect the component proposition (or propositions). In the compound propositions (2) to (6)[1] (in Section 3), these expressions are :

not

and

or

if then

if and only if

Before dealing with the different kinds of compound propositions, we must point out that it is convenient to use '*p*', '*q*' and '*r*' as symbols for the propositions which are combined. The letter '*p*' will stand for the first proposition, the letter '*q*' for the second proposition, and the letter '*r*' for the third proposition.[2]

On the basis of the above five propositional connectives, we get five kinds of compound propositions. These are negative, conjunctive, disjunctive, implicative and equivalent propositions.

1. Negative proposition : *When any proposition is negated (or denied), we get a negative proposition.* Negation is commonly expressed in English language by the word "not". However, expressions like "it is not the case", "it is not so", "it is not true" and "it is false" also stand for negation. The following propositions are negative :

a) St. Luke was not proud.

b) It is false that Russia is richer than America.

c) It is not the case that Einstein was a magician.

In all these cases only one proposition is negated. But a negative proposition may express negation of two (or more) propositions.

In logic, we use symbols for propositional connectives as well as propositions. For the connective "negation" (or the word "not"), the symbol "~" is used. This symbol is called "tilde" or "curl". Using the symbol "~" for negation and the propositional variable "p" for any pro-position whatsoever, the form of all the above five negative propositions will be :

$$\sim p$$

This is read as "not p".

In this Chapter, we shall symbolize merely the forms of propositions. So we shall use propositional variables, and not propositional constants.

A negative proposition is false, if its component is true. It is true when its component is false. The proposition "A monkey has a tail" is true. So, the negative proposition "A monkey does not have a tail" is false. On the other hand, the proposition "Man has wings" is false. Therefore, the negative proposition "Man does not have wings" is true.

2. Conjunctive proposition : *A conjunctive proposition is a compound proposition formed by combining any two propositions with the (truth-functional) connective "and".* What the conjunction "and" does is to form a single proposition by combining two propositions. The compound proposition "Today is Sunday and the

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[1] Compound proposition (1) in Section 3 is not a truth-functionally compound proposition. So, it does not have a truth-functional connective. It is beyond the scope of this book to bring out the notion of truth-functional connective.

[2] Small letters, '*p*', '*q*', '*r*' etc. are propositional variables. they stand for any (simple) proposition whatsoever. When we wish to symbolize a specific (simple) proposition, we use capital letters. Such capital letters are called propositional constants. When we wish to symbolize the form of proposition, we use propositional variables. Here we will be doing so.

college is closed" is conjunctive. We find two propositions in it. These are (i) "Today is Sunday", (ii) "The college is closed." These are connected by the word "and". Let us take some more examples :

a) Bertrand Russell is dead and the world has lost a great thinker.

b) The Prime Minister of India belongs to the Congress Party and Sai Baba is a saint.

A conjunctive proposition may be formed by the conjunction of any two propositions. The propositions which are combined by the connective "and" may be unrelated. In the second example above, the two component propositions have no relation.

The components of a conjunctive proposition are called **conjuncts**.

The propositional connective "conjunction" (or the word "and") is symbolized as ".". This symbol is called 'dot'. Using propositional variables and the symbol " . ", the form of conjunctive proposition will be :

$$p \cdot q$$

This is to be read as "p and q".

The word 'but', 'though', 'although', 'yet', 'while', 'still', etc. are also used to join two propositions. When these words are used in the conjunctive sense, the proposition is conjunctive.

A conjunctive proposition is true if and only if both the conjuncts are true. If one of the conjuncts (or both of them) is false, it is false.

3. Disjunctive proposition : *A disjunctive proposition is a com-pound proposition in which the word "or' (or the longer expression "either.....or") combines two propositions.* To take examples :

a) Either Lata or Asha sings well.

b) Lions laugh or tigers dance.

The components of a disjunctive proposition are called *disjuncts (or alternatives).*

Inclusive (weak) and exclusive (strong) uses of 'or' : Disjunction may be used in the inclusive (weak) sense or in the exclusive (strong) sense. When both the disjuncts can be true, the word "or" is said to be used in the inclusive sense. But when one disjunct is true and the other false, the disjuncts (or alternatives) are taken to be exclusive. In the statement "Kishore is either a singer or a dancer", the word 'or' is used in the inclusive sense. On the other hand, in the statement "Kishore is either handsome or ugly", the disjuncts are exclusive.

To find out whether the alternatives are exclusive, we must consider the content of the propositions. But logic is not concerned with the content of propositions. Now what is common to the inclusive and the exclusive sense of "or' is this : At least one alternative is true. *So, for logic, a disjunctive proposition is interpreted in the inclusive sense.*

In a true disjunctive proposition, at least one of the alternatives is true. From this it follows that *a disjunctive proposition will be false if and only if both the alternatives are false.*

For the inclusive (or weak) sense of "or", we shall use the symbol "v". This symbol is called "wedge". Using propositional variables and the symbol "v", the form of disjunctive proposition will be :

$$p \vee q$$

This is to be read as "p or q".

4. Implicative (or conditional) proposition : *An implicative proposition is a compound proposition in which two propositions are combined by the words "if.....then.....".* When any other expression which has the same meaning as "if.......then......." is used, then too the proposition is implicative. The proposition "If war is declared, then the prices will go up" is an implicative one.

In an implicative proposition, the component proposition between the word 'if' and the word 'then' is called the *antecedent* (or the *implicans*). The component which follows the word 'then' is called the *consequent* (or the *implicate*). In the above proposition, "War is declared" is the antecedent; and "Price will go up" is the consequent (or implicate). The following are further examples of implicative propositions :

a) If Radha was the wife of Krishna, then Krishna was a male.

b) If a book is banned, everybody wants to read it.

It will be noticed that, in the second example, the word 'then' does not appear before the consequent. This is because, in ordinary English usage, the word 'then' is omitted. However, logically speaking, it (the word 'then') is understood to be there.

The propositional connective "implication" (or the words "if...then...") is symbolized as '⊃'. This symbol is called "horse shoe". It is also symbolized as "→". This symbol is called "arrow". Using propositional variables and the symbol "⊃", the form of an implicative (or conditional) proposition will be :

$$p \supset q$$

This is to be read as "if p, then q". It is also read as "p (materially) implies q". Here the propositional variable to the left of the horse shoe (p) is the antecedent (or implicans); that to the right of the horse shoe (q) is the consequent (or implicate).

An implicative proposition does not assert either that the antecedent is true, or that the consequent is true. Logicians use the propositional connective "if.....then....." in a special sense. This is quite different from the everyday usage of these words.

In everyday life, we consider "if p, then q" to be true, when both 'p' and 'q' are true. And if 'p' is true but 'q' is false, we would say that "if p, then q" is false. The logician agrees with these usages. However, the common man does not consider those cases in which the antecedent is false. Thus, the common man would not consider propositions like "If lions laugh, then tigers dance." He would say that if the antecedent is false, the truth or falsity of the consequent does not matter. But the logician does not ignore such cases. In logic, when the antecedent is false, the implicative proposition is taken to be true. Taking all these into account, we arrive at the following :

"An implicative proposition is false if and only if the antecedent is true, and the consequent is false."

From this it follows that an implicative proposition is true either when the antecedent is false, or when the consequent is true.

5. Equivalent (or biconditional) proposition : Sometimes we wish to assert "if p, then q" (p ⊃ q), as also "if q, then p" (q ⊃ p). When we do so, we write (p ⊃ q) . (q É p).

Logic has a name for a compound proposition which is formed by the conjunction of two statements in the above way. It is called equivalent (or materially equivalent) proposition. *Thus, an equivalent proposition is a compound proposition in which two component propositions materially imply each other.* In ordinary English, the two component propositions of an equivalent proposition are connected by the expression 'if and only if'. The following propositions are equivalent :

a) If and only if an animal is a mammal, then it breastfeeds its young ones.

b) A triangle is equiangular if and only if it is equilateral.

The propositional connective "material equivalence" (or the words "if and only if") is symbolized as "≡". This symbol is called "triple bar". The symbol "↔" (two-head arrow) is also used for equivalence. Using propositional variables and the symbol "≡", the form of an equivalent proposition will be

$$p \equiv q$$

This is read as "if and only if p, then q" (or "q if and only if p"). It is also read as "p is materially equivalent to q".

We have stated that in an equivalent proposition two implicative propositions imply each other. *So, an equivalent proposition is true if both the components have the same truth value.* That is, it is true either when both the components are true; or when both of them are false. If one of the components is true and the other is false, the equivalent proposition is false.

6. SYMBOLIZING FURTHER COMPOUND PROPOSITIONS

So far we have taken compound propositions whose components are simple propositions. But one or both the components of a compound proposition may themselves be compound propositions. Consider the following propositions :

1. Lata is not both a good singer and a good actress.

This is a negative proposition. It is the negation of a conjunctive proposition. By using brackets, let us show this : "It is not the case that [(Lata is a good singer) and (Lata is good actress)]." By using propositional variables, the form of this proposition is : "~(p . q)". Hence negation applies to "p" and "q", taken together.

2. The question is easy, but not the answer.

This is a conjunctive proposition. Its second conjunct is a negative proposition. It is a practice in logic to use "~" before whatever is negated. Since only the second proposition is negated, this symbol will be placed before the second proposition. The symbolic form of this proposition is "p . ~q".

3. Neither Caltex nor Burmah Shell is an Indian company.

The expression "neither nor" means none of them. It stands for the negation of the first proposition and that of the second proposition, separately. So the above proposition is conjunctive. Its symbolic form is "~p . ~q".

4. It is not the case that Jawaharlal Nehru was either a scientist or a saint.

This is a negative proposition. It is the negation of a disjunctive proposition. So, in the symbolic form we have to place the symbols for disjunctive proposition within brackets, and negation before the brackets. Its symbolic form is : "~(p v q)".

5. In case an Australian is fond of reading, he has to hide that weakness.

The expression "in case" has the same meaning as "if". So this is an implicative proposition. Its symbolic form is "p ⊃ q".

6. Unless he has good practice, he will lose the race.

The word "unless" means "if not". Thus, the statement says, "If he does not have good practice, he will lose the race." This is an implicative proposition. Its antecedent is a negative proposition. The symbolic form of the proposition is "~p ⊃ q".

7. If the light does not come on, then either the fuse is blown out or something is wrong with the bulb.

This is an implicative proposition. Its antecedent is a negative proposition; its consequent is a disjunctive proposition. We see that there are two (different) propositions in the consequent. So two propositional variables will appear in the consequent. Thus, the symbolic form of the proposition is "$\sim p \supset (q \vee r)$".

8. It is false that if and only if Ranjit is a great musician he will be a great singer.

The expression "it is false" stands for negation. This expression occurs at the beginning of the statement. So it applies to the proposition as a whole. Thus, the proposition is negative. It is the negation of an equivalent proposition. Its symbolic form is "$\sim(p \equiv q)$".

7. GENERAL PROPOSITIONS

Apart from simple and compound propositions, modern logic recognizes general propositions. These propositions can best be understood by comparing them to singular propositions.

Singular propositions are about an individual. They state that an individual does or does not possess a certain properly. As distinguished from such propositions, *a general proposition makes an assertion about a class or classes.* The following propositions are general propositions :

1. Everything is impermanent.
2. There are no ghosts.
3. All fairies are beautiful.
5. Some singers are actors.
6. Some actresses are not fashionable.

The first two propositions are about one class, ("impermanent things" in the first proposition; and "ghosts" in the second proposition). The last four propositions are about two classes.

The traditional logicians were interested in propositions of the type illustered by the last four examples above. These propositions were called 'A', 'E', 'I' and 'O' propositions. As for these propositions, they express the relation of inclusion or exclusion between classes. Since members of a class have certain properties in common, we may say that *these propositions only show connection between two properties*. That is, they consider properties (characteristics) apart from the individual things which have these properties. That is why the proposition ('A' proposition) "All fairies are beautiful" would be true even if there were no fairies. On the other hand, the proposition ('I' proposition) "Some singers are actors" asserts that there is (i.e. there exists) at least one individual who possesses the property of being a singer and being an actor. From this it is clear that a universal proposition does not imply existence, but a particular proposition does.

As we shall see in the next chapter, 'A' and 'E' propositions assert the relation of implication between two properties. However, these propositions differ from an implicative proposition. An implicative proposition is a compound proposition. Its antecedent and consequent are themselves propositions. On the other hand, the antecedent and the consequent of 'A' and 'E' propositions are not propositions. They are propositional functions. As we shall see in the next chapter, propositional functions cannot be considered to be either true or false.

A general proposition is to be distinguished from a class-membership proposition. In a class-membership proposition, an individual is asserted to be a member of a certain class. This shows that one of the constituents of a class-membership proposition is an individual, while the other constituent is a class. On the other hand, all the constituents of a general proposition are classes. In existential propositions and purely general propositions, the reference is to one class (or one property). Other general propositions assert relations between two classes. Thus, general propositions are about properties as such, and not about the individuals which possess these properties.

We have already distinguished general propositions from class-membership propositions and implicative propositions. *Let us now distinguish general propositions from simple propositions and compound propositions* (without referring to any particular kind of proposition). Simple propositions contain a particular as a constituent. That is, one of the constituents of a simple proposition is an individual. Consider the following simple propositions :

1. This building is tall.
2. Vinoba Bhave is a Hindu.
3. Shivaji defeated Shayista Khan.

On the other hand, all the constituents of a general proposition are universals. Thus, in the general proposition "All politicians are ambitious", the constituents 'politician' and 'ambitious' are universals.

Now, while dealing with simple propositions, we have stated that an individual is that which can possess attributes. Also, individuals can be perceived. This clearly shows that individuals exist. But one kind of general proposition, namely universal proposition, does not assert existence. Universal propositions consider properties as such; they do not consider the individuals that possess these properties.

Coming to the *distinction between general propositions and compound propositions,* we find that compound propositions are formed by combining other propositions. But a general proposition is a single statement. It cannot be analyzed into propositions.

SUMMARY

There are two different classifications of propositions. These are the traditional classification and the modern classification. The modern 'logicians classify propositions into simple, compound and general propositions.

A **simple proposition** does not contain another proposition on as a component. The four kinds of simple propositions are subjectless proposition, subject-predicate proposition, relational proposition and class-membership proposition.

A **compound proposition** contains another proposition (or propositions) as its component. There are five kinds of compound propositions. These are negatives, conjunctive, disjunctive, implicative and equivalent propositions.

General propositions are about classes. There are three distinct kinds of general propositions. These are purely general propositions, existential propositions, and general propositions asserting relations between classes. Traditional logicians were interested in the last type of propositions. They called such propositions 'A', 'E', 'I' and 'O' propositions.

Universal propositions assert the relation of implication between properties. They do not consider the individuals that possess these properties. However, they differ from implicative propositions.

TEST QUESTIONS

1. Distinguish between simple and compound propositions. Explain the various kinds of simple propositions.
2. Explain, with illustrations, any two kinds of compound propositions.

3. When are compound propositions true, and when are they false?
4. Analyze, with illustrations, the nature of general proposition.
5. Distinguish between the following :
   1. Strong and weak disjunction.
   2. General proposition and class-membership proposition.
   3. General proposition and implicative proposition.
6. Define the following terms :

   (1) Simple proposition (2) Compound proposition

   (3) Implicans (4) Implicate

   (5) Weak disjunction (6) Strong disjunction

   (7) Conjunctive proposition (8) Equivalent proposition

   (9) General proposition
7. Why is an equivalent proposition true when both of its components are false?
8. Answer the following in one or two sentences :
   1. when is a proposition said to be simple?
   2. When is a proposition said to be compound?
   3. When is a negative proposition true?
   4. When is a conjunctive proposition false?
   5. when is a disjunctive proposition true?
   6. When is an implicative proposition false?
   7. When is an equivalent proposition false?
   8. In what sense does logic use the connective "or"?
9. Give technical terms used in logic for the following groups of words:
   1. A compound proposition which is false when one of its components is false.
   2. A compound proposition which is true when one of its component is true.
   3. A disjunction in which both alternatives can be true.
   4. A proposition which is true if and only if both of its components have the same truth value.
10. State whether the following statements are true or false :
    1. All the constituents of a simple proposition are particulars.
    2. A disjunctive proposition is false only when both the disjuncts are false.
    3. A conjunctive proposition is false even when one component is false.
    4. An implicative proposition is true when the implicate is true.
    5. An implicative proposition is true when the implicans is false.
    6. An equivalent proposition is true when both the components are false.
    7. When we deny a simple proposition, we get a compound proposition.
    8. The implicans and the implicate of a general proposition are themselves propositions.
11. Fill in the blanks with the appropriate alternatives :
    1. _____ simple propositions are singular. (All/Some/No)
    2. If a proposition does not contain logical constants and quantifiers, it is a _____ proposition. (simple/compound/universal/particular)
    3. A _____ proposition can be analyzed into other propositions. (singular/ compound/general/particular)

4. A subjectless proposition is _____. (singular/particular/universal)
5. Subject predicate propositions are _____ . (particular/singular/universal)
6. Epsilon is a _____ . (constituent/component/constant /variable).
7. A relational proposition contains _____ of relation. (only one term/only two terms/two or more terms/more than two terms)
8. A subject-predicate proposition emphasizes the ______ aspect, while a class-membership proposition emphasizes the _____ aspect. (denotative/connotative)
9. When a simple proposition is denied, we get a _____ proposition. (simple/compound/general)
10. _____ constituents of a general proposition is particular. (At least one/Only one/No)

12. Point out the kind of simple proposition and symbolize its form in the case of the following :
    1. Alexander was a military leader.
    2. The sea is calm tonight.
    3. Vijayalaxmi is Indira's aunt. [Relational - R(x, y)]
    4. That big dog chases cats.
    5. Lincoln was one of the Presidents of the United States.
    6. That is an artificial satellite.
    7. Karachi is to the north of Bombay.
    8. Helen Keller was one of the world's most interesting characters.
    9. I am feeling better.
    10. Badger is an amusing nickname.
    11. This is rough.
    12. John smokes.
    13. Marco Polo travelled from Venice to China.
    14. Savitri likes classical music.
    15. Bharatiya Vidya Bhavan is among the farmous cultural organizations.
    16. It's real cool.
    17. France had great trust in the Maginot line.
    18. Romulus was nursed by a she-wolf.

13. Identify the kind of proposition and represent its form with symbols in case of the following :
    1. It is false that if a tribe is nomadic, it builds permanent shelters.
    2. Either monkeys do not sing or tigers do not dance.
    3. The standard of living will go up if and only if real income increases.
    4. In case the ice is thin, we will not skate (in case = if).
    5. History does not repeat itself.
    6. Unless a soldier is wounded, he will not be relieved from war duty. (unless = if not)
    7. If and only if he scores a double century, his side will not the match.
    8. It is true both that Dr. Khorana is an Indian and has succeeded in "Gene Synthesis".
    9. It is not true that man has wings as well as a tail.

10. It is not the case that either air is a good conductor of heat or water is a good conductor of heat.
11. It is false that Churchill was a journalist, but not a Prime Minister of England.
12. Either the barometer is not falling or there will be a storm.
13. If and only if he has influence as well as ability, he will get the job.
14. No work is degrading unless it becomes so in the mind of the worker.
15. A man can guard against his enemies, but never against his friends.
16. Neither Sunita nor Sangita can dance to this tune.
17. It is false to say that Laplace was a great astronomer.
18. If Hitler was insane, then either he was not a Jew or he was put in a mental hospital.
19. It is not the case that India is both a democracy and not a democracy.
20. Fire-walkers of Bequa Island walk on live coals, but they do not get burnt.
21. Jawaharlal Nehru was not a communist; nor was he a communal-minded person.
22. Lincoln was not a handsome man, but he looks good on a five dollar note.
23 It is false that if a person does not have kidney trouble, then his skin colour will change.
24. He is clever and he is either rich or lucky.
25. It is false that if and only if a person is rich, he is honoured.
26. If whale is not a fish, then it is a mammal and is warm-blooded.

CHAPTER – 6

QUANTIFICATION AND GENERAL PROPOSITIONS

DO YOU KNOW THAT ......

* *it is true that "giants eat grass; simply because there are no giants?*
* *as there are no fairies, it is not true to say, "Some fairies are beautiful"?*
* *quantifiers, like locks, close the door, and turn propositional functions into general propositions?*

While dealing with the modern classification of propositions, we classified propositions under three heads. These are simple proposition, compound proposition, and general proposition. In Section 7 of that chapter we have seen that general propositions differ from singular propositions and compound propositions.

The inner logical structure of general propositions differs from that of singular propositions. This can be seen when these proposi-tions are represented with the help of special symbols of modern logic. Propositional functions and quantifiers are techniques for analyzing the inner logical structure of general propositions.

1. PROPOSITIONAL FUNCTION

We shall clarify the notion of propositional function with the help of examples. Let us consider the following propositions :

Saira Banu is beautiful.

Taj Mahal is beautiful.

Each of these propositions is about a different individual. But both of them have the same pattern. The predicate (or property) which is affirmed of the individual is the same. Suppose we leave a blank in place of the individual (keeping the predicate same), we shall get :

__________ is beautiful.

Now instead of leaving a blank (_____), may use the letter "x". In that case, we shall get the expression :

x is beautiful.

The symbol "x" is called the individual variable. (For individual variables, the small letters 'x', 'y', 'z' are used.) **Thus, an individual variable is a symbol which stands for any individual whatsoever.**

In the expression "x is beautiful", the individual variable "x" serves the same purpose as a blank does in "_____ is beautiful." And once the proper name of an individual, or **individual constant,** is inserted in its place, the expression becomes a proposition.

In logic, an expression such as "x is beautiful" is called a propositional function. **Thus, a propositional function is an expression which contains a variable, and becomes a proposition when the variable is replaced by a suitable constant**. In the expression "x is beautiful", "x" is an individual variable. So the suitable constants with which this variable can be replaced are individual constants. We may state here that the small letters 'a' to 'w' are used as individual constants. Also, the proper name of an individual is to be considered as an individual constant.

There are two methods of obtaining propositions from a propositional function. These are instantiation and quantification (or generalization).

Moreover, a proposition is either true or false. But the question of the truth or falsity of a propositional function does not arise. The propositional function "x is beautiful" is neither true nor false. In it the symbol "x" is like a bank; it does not stand for any particular individual. That is why we cannot consider the truth-value of a propositional function.

2. SYMBOLIZING SINGULAR PROPOSITIONS

Singular propositions assert a property about an individual.[1] We shall adopt the convention to use *small letters from "a" to "w" for individuals and capital letters for properties.* These small letters are called *individual constants,* because they stand for names of specific individuals, while capital letters are called *predicate constants,* because they stand for names of specific properties. Let us take a few singular propositions, and symbolize them

1. Chanakya is wise. (Using 'W' for 'wise' and 'c' for 'Chanakya', we get "Wc".)
2. London is a large city. (Using 'C' for 'large city' and 'l' for 'London', we get "Cl".)
3. Samson is not weak. (This is a negative singular proposition.[2] Using 'W' for 'weak', 's' for 'Samson', and '~' for negation, we get '~Ws'.)

3. QUANTIFICATION (UNIVERSAL AND EXISTENTIAL QUANTIFIERS)

Quantification (or generalization) consists in asserting a propositional function of all or some of the values of the variable. The values of an individual variable are individuals. Thus, the values of the individual variable 'x' are x's, that of 'y' are y's, and so on.

Quantification may be universal quantification or existential quantification. If we assert a propositional function of all the values of the variable, we obtain a general proposition by universal quantification. If we assert it of some values of the variable, we get a general proposition by existential quantification.

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[1] We shall symbolize only subject-predicate and class-membership propositions. Basically, there is no difference between the two. In a class-membership proposition, the class name stands for a property.

[2] Negative propositions are compound propositions. But they can be symbolized by using individual constants, predicate constants, and the sign of negation '~'.

A proposition which is obtained by universal quantification is a universal general proposition. That which is obtained by existential quantification is an existential general proposition.

Universal quantification (or universal generalization) : A propositional function contains a variable (or variables). In the propositional function "x is destructible", 'x' is an individual variable. If this variable is asserted of every 'x', we shall get a proposition by universal quantification. The following universal general proposition is obtained by universal quantification :

For every x, x is destructible.

This is usually stated thus :

Given any x, x is destructible.

It is also expressed as "Whatever x may be, x is destructible". In the common man's language, this proposition will be expressed as : "Everything is destructible".

In the proposition "Given any x, x is destructible", or "Everything is destructible", the expression "given any x" is the universal quantifier. In ordinary language, the phrase "given anything whatsoever" or "whatever a thing may be" is the universal quantifier. Here the word 'thing' is the individual variable.

The universal quantifier is symbolized as "(x)". In the universal quantification of a propositional function, the quantifier is placed to the left of the propositional function.

Existential quantification (or existential generalization) : If we assert the propositional function "x is destructible" of some 'x', we shall get a proposition by existential quantification. Here the word "some" is used in the sense of "at least one". The following existential general proposition is obtained by existential quantification :

"There is an x such that x is destructible."

In ordinary language, this will be expressed thus : "Something is destructible."

In the above proposition, the expression "there is an x such that" is the existential quantifier. In ordinary language, the phrase "there is a thing such that" expresses the existential quantifier. Existential quantifier is symbolized as '($x)'. As in the case of universal quantification, in existential quantification too, the quantifier is placed to the left of the propositional function.

4. SYMBOLISING GENERAL PROPOSITIONS INVOLVING ONE PROPERTY

All general propositions are not of the same kind. This will become clear when we symbolize them by using propositional functions and quantifiers. In this section we shall see how general propositions containing one property expression are to be symbolized.

1. A universal general proposition which affirms a property of everything : The following proposition is of this kind :

Everything changes.

This proposition may be expressed thus :

Given any thing, it changes.

This way of stating the proposition shows that it consists of two expressions. We may separate these expressions, by using brackets, as follows :

(Given anything) (it changes)

In the expression "it changes", the pronoun "it" refers to the word 'thing'. Using the individual variable "x" in place of the pronoun "it" and the word "thing", the above proposition will be expressed as :

(Given any x) (x changes)

As we have stated in Section 2, it is a practice in logic to use capital letters for properties. (These capital letters are called predicate constants.[3]) Further, the capital letter for the property is to be placed to the left of the letter representing the individual (here the individual variable "x"). By doing so, we get :

(given any x) (Cx)

As we have stated earlier, the expression "given any x" is the universal quantifier. The universal quantifier is symbolized as "(x)". Let us now express the above proposition by using "(x)" for the universal quantifier.

(x) (Cx)

This is to be read thus : "Given any x, x changes".

2. A universal proposition which denies a property of everything : An example of such a proposition is :

Nothing is permanent.

This proposition denies the property of permanence in respect of all things. It states : "Given any thing, it is not permanent." Separating the two expressions, we get :

(Given any thing) (it is not permanent)

Let us use the symbol "(x)" for the universal quantifier "given any x", and the predicate constant 'P' for the property of being permanent. The proposition is now symbolized thus :

(x) (~Px)

It will be noticed that the symbol for negation is placed before 'P'. This is because the property of being permanent is denied.

3. Existential propositions : The above two propositions were symbolized by using the universal quantifier. In the symbolic translation of the next two propositions we shall use the existential quantifier. So, these propositions are called existential propositions.

3. Lions exist.
4. Something is not beautiful.

These propositions affirm existence. The proposition "Lions exist" (or the proposition "There are lions") affirms the existence of lions ; and the proposition "Something is not beautiful" affirms the existence of at least one thing which is not beautiful.

Existence is not a description. The proposition "Lions exist" does not state what type of thing a lion is. The proposition only says : "There is a thing (i.e. at least one thing) such that it is a lion." When it is stated in this way, we find two expressions in it. Let us separate these expressions by brackets :

(There is a thing such that) (it is a lion)

In this proposition the pronoun "which" refers to the word "thing". Using the individual variable "x" in place of the pronoun "which" and the word "thing", the above proposition will be expressed as :

(There is an x such that) (x is lion)

---

[3] The first letter of the property word is used as predicate constant.

In the last section, we have stated the expression "there is an x such that" is the existential quantifier. We have also said that it is symbolically expressed as "($\exists$x)".

Using the symbol for the existential quantifier, the proposition is symbolized thus :

$$(\exists x)\ (Lx)$$

Here 'Lx' stands for "x is lion"

Let us now come to the fourth proposition : "Something is not beautiful". This proposition denies a property of at least one thing. It states : "There is a thing such that it is not beautiful." When we separate the two expressions, we get :

(There is a thing such that) (it is not beautiful)

Using the individual variable 'x' for the word 'thing' and the word 'it', we get :

(There is an x such that) (x is not beautiful)

Let us use the symbol for the existential quantifier, and the predicate constant 'B' for the property of being beautiful. This is now symbolized as :

$$(\exists x)\ ({\sim}Bx)$$

5. SYMBOLIZING THE FOUR TRADITIONAL FORMS OF PROPOSITIONS

All the above general propositions are about one property. But general propositions may express relations between two (or more) properties. The traditional logicians were interested in such propositions. These were classified into universal affirmative (or 'A'), universal negative (or 'E'), particular affirmative (or 'I'), and particular negative (or 'O') propositions.

1. Symbolic translation of 'A' : Universal affirmative (or 'A') propositions are statements like the following :

All parrots are birds.

This proposition expresses a certain relation between being a parrot and being a bird. It states, "Given any thing, if it is parrot, then it is bird." If we separate the expression "given any thing" from the rest of the expression, we get :

(Given any thing) (if it is parrot, then it is bird)

By using the individual variable "x" for the "it" as well for the word "thing", we get :

(Given any x) (if x is parrot, then x is bird)

In the expression "if x is parrot, then x is bird", the individual variable "x" occurs. So this expression is a propositional function. But this propositional function is complex. It expresses an implication between two propositional functions : "x is parrot" and "x is bird". The relation of implication is symbolized as "$\supset$". Using this symbol, we get:

(Given any x) (x is parrot $\supset$ x is bird)

Using the predicate constants for properties and the symbol "(x)" for the universal quantifier, the proposition is symbolized thus :

$$(x)\ (Px \supset Bx)$$

Here 'Px' stands for "x is parrot", and 'Bx' for "x is bird".

2. Symbolic translation of 'E' : Universal negative propositions are statements of the following kind :

No thief is reliable.

Like 'A' proposition, this proposition too will be symbolized by using the universal quantifier. The proposition states: "Given any thing, if it is thief, then it is not reliable".

Using the individual variable 'x' for the words 'thing' and 'it', we get :

(Given any x) (if x is thief, then x is not reliable)

Here too, the propositional function is complex. It is a conditional between the propositional function "x is thief" and "x is not reliable". By using predicate constants and the symbol for the universal quantifier, the proposition is symbolized thus :

$$(x)(Tx \supset \sim Rx)$$

Here 'Tx' stands for "x is thief", and 'Rx' for "x is reliable".

It will observed that the sign for negation is placed before 'R'. This is because the property of being 'reliable' is denied.

3. Symbolic translation of 'I' : Particular affirmative propositions are statements like the following :

Some roses are white.

Symbolic translation of 'I' (and 'O') proposition differs from that of universal propositions. The above 'I' proposition states : "There is a thing such that it is rose and it is white." It is obvious that this proposition expresses that there exists at least one individual which possesses the two stated properties.

By using the individual variable 'x', we get "There is an x such is rose and x is white."

As in 'A' and 'E' propositions, in 'I' proposition too, the propositional function (x is rose and x is white) is complex. But here it expresses a conjunction between the two propositional functions (i) "x is rose"; (ii) "x is white".

The symbol for conjunction is " . ". Let us now use the symbol for the existential quantifier, and symbolize the proposition :

$$(\exists x)\ (Rx\ .\ Wx)$$

Here 'Rx' stands for "x is rose", and 'Wx' for "x is white".

4. Symbolic translation of 'O' : The following kind of proposition is called particular negative, or 'O' proposition :

Some men are not lucky.

This proposition states : "There is a thing such that it is man and it is not lucky." It will be symbolized (as shown above) by using the existential quantifier thus :

$$(\exists x)\ (Mx\ .\ \sim Lx)$$

Here 'Mx' stands for "x is man", and 'Lx' for "x is lucky".

We must point out that 'O' proposition does not deny existence. Rather, it affirms the existence of at least one thing which possesses one property, but not the other property. That is why the symbol for negation (~) is placed before the second property letter.

6. SYMBOLS USED

We have used various kinds of symbols in this Chapter. These are :

1. Small letters from "a" to "w", called individual constants.
2. Capital letters for properties, called predicate constants.
3. The letter "x", called individual variable.[4]

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[4] We have not used the Greek letters "F" and "Y". Such letters are called predicate variables.

4. The symbols "~", "•" and "⊃", called logical constants, are propositional connectives. (We have not used "~" and "≡", which are also logical constants.)
5. The quantifiers, "(x)" and "(∃x)".

It will be noticed that in a propositional function, the variable 'x' is not preceded by a quantifier. On the other hand, when we symbolize general propositions, this variable is preceded either by the universal quantifier or by the existential quantifier. When a variable is preceded by the (appropriate) quantifier, it is called a **bound variable.** But when a variable is not preceded by the (appropriate) quantifier, it is called a *free variable*. Thus, we see that a propositional function contains (at least one) free variable, while a proposition does not contain a free variable.

As individual variable "x" stands for any individual whatsoever, the predicate variables "F" and "Y" stand for any properties whatsoever.

SUMMARY

Propositional function : A propositional function is an expression which contains a free variable. When values are assigned to this variable, the expression becomes a proposition. Quantification is a method of obtaining propositions from propositional functions.

Quantification : Quantification (or generalization) consists in asserting a propositional function of all or some of the values of the variable.

In a propositional function, there is at least free variable, while in a proposition a free variable (or variables) do not occur.

TEST QUESTIONS

1. What is a propositional function? How are general propositions obtained from it?
2. Why is "x is a poet" a propositional function? How does it differ from "Given any thing it is a poet"?
3. Distinguish between the following :
   1. Propositional function and proposition.
   2. Free and bound variables.
4. Define the following terms :
   - i) Propositional function
   - ii) Quantification
   - iii) Individual constant
   - iv) Predicate constant
   - v) Individual variable
   - vi) Free variable
   - vii) Bound variable
5. Symbolize the following propositions by using propositional functions and quantifiers.
   1. All politicians are ambitious. (This proposition states : "Given anything, if it is a politician, then it is ambitious." It is symbolized by using the universal quantifier thus : (x) (P ⊃Ax)". Here 'Px stands for "x is politician", and 'Ax' for "x is ambitious".)
   2. Poets are never guided by reason. (This proposition asserts : "Given any thing, if it is a poet, then it is not guided by reason." It is symbolized by using the universal quantifier thus : "(x) (Px ⊃ ~Gx)". Here 'Px stands for "x is poet", and "Gx" for "x is guided by reason".)
   3. A few actors are successful. (This proposition states : "There is a thing such that it is actor and it is successful." It is symbolized by using the existential

quantifier thus : "(∃x) (Ax . Sx)". Here 'Ax' stands for "x is actor", and 'Sx' for "x is successful".

4. Some shopkeepers do not use false weights. (This proposition asserts : "There is a thing such that it is a shopkeeper and it does not use false weights." It is symbolized by using the existential quantifier thus : "(∃x) (Sx . ~Fx)". Here 'Sx' stands for "x is a shopkeeper", and 'Fx' for "x uses false weights".)
5. Ghosts do not exist. (This proposition denies the existence of ghosts. It states : "It is not the case that there is a thing such that it is ghost." It is symbolized by using the existential quantifier thus : "~(∃x) (Gx)". Here "Gx" stands for "x is a ghost". The symbol for negation is placed before the existential quantifier, because the proposition denies existence.)
6. Dead men tell no tales.
7. Not all mangoes are sweet.
8. Every diamond is a precious stone.
9. There are tigers.
10. Most Indians believe in rebirth.
11. A few horses are not fast-runners.
12. Some ladies gossip.
13. Dishonest men are never unselfish.
14. Something is not a green cow.
15. Nothing is changeless.
16. Scientists are always open-minded.
17. Everything comes to an end.
18. Lemons are sour.

CHAPTER – 7

OPPOSITION OF PROPOSITIONS

DO YOU KNOW THAT ....
* *two affirmative propositions with the same subject and the same predicate may be opposites of each other ?* * *opposition of propositions is a basis for certain simple inferences?* * *two contradictory propositions involve the greatest extent of opposition?*

The logician is interested in those relations between propositions which make inferences possible. These are implication relations. A set of propositions may be so related that, assuming the truth or falsity of one or more of them, it may be possible to infer the truth or falsity of other proposition (or propositions). The proposition (or propositions) from whose truth or falsity the inference proceeds is called the premise. The proposition whose truth or falsity follows from the premise is called the conclusion.

If the premise of an inference is sufficient to justify the conclusion, the inference is said to be deductive. *Thus, in a deductive inference, no evidence other than that offered by the premise is required for drawing the conclusion.*

1. IMMEDIATE AND MEDIATE INFERENCES

In chapter 1 we have dealt with the nature of inference. In that chapter, we have also seen how inference differs from implication. Let us now consider what immediate inferences are and how these inferences differ from mediate inferences.

Traditionally, deductive inferences have been classified into immediate and mediate. An immediate inference consists in inferring a proposition from a single other proposition. **Thus, in an immediate inference we proceed from one given proposition (the premise) to another proposition (the conclusion), without requirng anything further for drawing the conclusion.** That is, in an immediate inference one proposition is sufficient for drawing the conclusion.

On the other hand, **a mediate inference is one in which the conclusion is drawn from two or more propositions, taken together.** In this type of inference the conclusion does not follow from each premise, taken separately.

Immediate inferences are generally divided into (inferences based upon) Opposition of propositions and Eductions. We shall deal with Opposition of propositions in this chapter.

2. OPPOSITION OF PROPOSITIONS AND ITS KINDS

The doctrine of Opposition of Propositions may be considered from two points of view. Firstly, we may consider it as expressing *the relations between propositions in the traditional schedule (viz.* 'A', 'E', 'I' and 'O' propositions). Secondly, we may consider it *as a process of inference.*

The term "opposition" is used for the relation between two propositions having the same subject and the same predicate, but differing either in quantity, or in quality, or in both (quantity and quality). The traditional logicians applied the doctrine of opposition of propositions to the four kinds of categorical propositions.

Taking 'A', 'E', 'I' and 'O' propositions in pairs, four kinds of opposition are possible. These are Contradiction, Contrariety, Subcontrariety and Subalternation.

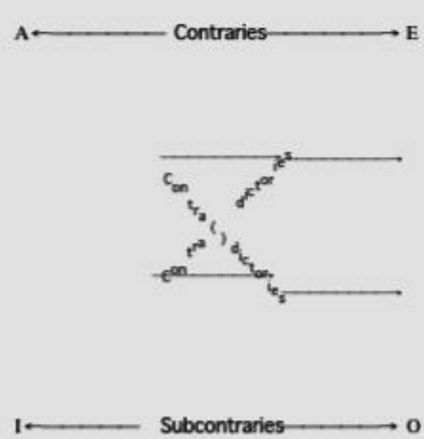
Contradictory Opposition (or Contradiction) : Contradictory opposition is the relation between two propositions (having the same subject and the same predicate) which differ both in quantity and quality. It is the relation between 'A' and 'O' propositions, and between 'E' and 'I' propositions. Thus, the propositions *"All honest men are happy"* and *"Some honest men are not happy"* are contradictories. Similarly, the propositions *"No politicians are unselfish"* and *"Some politicians are unselfish"* are contradictories.

Contrary Opposition (or Contrariety) : Contrary opposition is the relation between two universal propositions differing in quality. It is the relation between 'A' and 'E' propositions. Thus, the propositions *"All ministers are politicians"* and *"No ministers are politicians"* are contraries.

Subcontrary Opposition (or Subcontrariety) : Subcontrary opposition is the relation between two particular propositions differing in quality. It is the relation between 'I' and 'O' propositions. Thus, *"Some dishonest men are rich"* and *"Some dishonest men are not rich"* are subcontraries.

Subaltern Opposition (or Subalternation) : Subaltern opposition is the relation between two propositions having the same quality, but differing in quantity. 'A' and 'I' propositions, as well as 'E' and 'O' propositions, are subalterns. "All *painters are artists"* and *"Some painters are artists"* are subalterns. Similarly, *"No saints are immoral"* and *"Some saints are not immoral"* are subalterns.

In this kind of opposition, the universal is called *subalternant* and the particular is called *subalternate* or *subaltern.* Thus, 'A' is the subalternant of 'I', while 'I' is the subalternate (or subaltern) of 'A' . Similarly, 'E' is the subalternent of 'O', and 'O' is the subalternate of 'E'.



Square of Opposition

The four forms of opposition have been traditionally represented by a diagram. This diagram, called the Square of Opposition, is reproduced above.

3. INFERENCES BY OPPOSITION OF PROPOSITIONS

The relations of "opposition" are the basis of some elementary inferences. Given the truth or falsity of any proposition, we can see which of the opposed propositions must be true, which false, and which remain doubtful.

1. Contradictory Opposition : *Two contradictory propositions can neither be true together nor false together.* If one of the contradictories is true, the other must be false; and if one of them is false, the other must be true. Let us consider pairs of contradictory propositions.

1. All spiritual persons are sincere.

   Some spiritual persons are not sincere.

2. No fools are good friends.

   Some fools are good friends.

In the first pair, if the proposition *"All spiritual persons are sincere" is* true, the proposition *"Some spiritual persons are not sincere"* cannot be true; it must be false. On the other hand, if the proposition "All spiritual persons are sincere" is false, the proposition "Some spiritual persons are not sincere" must be true. Similar is the case with the second pair.

2. Contrary Opposition : *Contraries can never be true together; but they may both be false.* Thus, if the proposition "All immoral persons are undesirable" is true, its contrary "No immoral persons are undesirable" must be false; and vice versa. Let us understand the reasons for this. 'A' proposition affirms the predicate of the whole subject. If this is true, we cannot deny the predicate of any member of the subject class. Therefore, 'E' proposition, which denies the predicate of the whole subject class, must be false.

On the other hand, both the contraries may be false. To understand this, let us consider the contrary propositions "All men are wise" and "No men are wise." The proposition "All men are wise" may be false. But this does not imply that the proposition "No men are wise" is true. The reason for this is as follows: When we say that affirming the predicate of the whole subject is false, there are two possibilities. These are: (i) the proposition which denies the predicate of the whole subject is true or (ii) the proposition which denies the predicate of some members of the subject class is true. In the former case, 'E' proposition will be true; in the latter case it will be false. From the form of a proposition (logic not being concerned with the contents of propositions), we cannot know which of these is the case. Therefore, if one of the contraries is false, the other is doubtful (or unknown).

3. Subcontrary Opposition : *Subcontraries cannot be false together, but they may both be true.* Thus, if the proposition "Some lions are grass-eaters" is false, its subcontrary "Some lions are not grass-eaters" must be true. This is because "some" in logic means "at least one". Now the proposition which affirms the predicate of even one member of the class of lions is false. Therefore, the proposition which denies the predicate of the whole class of lions will be true. If the proposition which denies the predicate of the whole subject is true, the proposition which denies it of a part of the subject is bound to be true. That is why, when 'I' proposition is false, 'O' proposition is true. Similar is the case when we proceed from the falsity of 'O' proposition. That is, when 'O' proposition is false, 'I' proposition must be true.

Now, both the subcontraries may be true together. That is to say, if one of the subcontraries is true, we cannot say that the other is false. Nor can we say that the other subcontrary is true. To take an example, if the proposition "Some mathematicians are philosophers" is true, we cannot say whether its subcontrary "Some mathematicians are philosophers" is true or false. This is because the word 'some' in logic does not exclude the possibility of all. Now if, as a matter of fact, the predicate is applicable to the whole subject, then the other subcontrary will be false. But if the predicate is not applicable to the whole subject, then the other subcontrary will be true. From the form of a proposition we cannot know which is the case. Therefore, if one of the subcontraries is true, the other is considered to be doubtful.

4. Subalternation : Subalternation is the relation between a universal and a particular proposition, having the same quality. Now it is clear that when the universal proposition is true, the particular proposition will also be true. This is because the relation of a universal proposition to a particular proposition is that of the whole class to a part of the class. On the other hand, if a particular proposition is true, we cannot say whether the corresponding universal proposition will also be true. If the proposition "Some Brahmins are vegetarians" is true, we cannot say whether its subalternant "All Brahmins are vegetarians" is true or false. The reason for this is that the word "some" in logic does not exclude the possibility of "all". What is true of a part of the class may or may not be true of the whole class. Therefore, if the particular is true, the universal is considered to be doubtful.

Coming to the inferences from falsity, we find that when a particular proposition is false, the corresponding universal proposition must also be false. Thus, if the proposition "Some crows are white" is false, its subaltenant "All crows are white" must be false. Because if affirming the predicate 'white' of even one ("some" means "at least one") crow is false, affirming it of the whole class of crows must be false. On the other hand, if a universal proposition is false, its corresponding particular proposition need not be false. To take an example, if "All Hindus are religious-minded" is false, we cannot know whether its subalternate "Some Hindus are religious-minded" is also false. This is because when affirming the predicate of the whole class is false, there are two possibilities. These are : (l) the proposition which affirms the predicate of some members of the subject is true, or (2) the proposition which denies the predicate of the whole subject is true. In the former case, the particular proposition will be true; in the latter case, it will be false. Now, from the form of a proposition, we cannot know which of these is the case. Therefore, the only inference we can draw is that when a universal proposition is false, the particular proposition is doubtful.

We may summarize the results thus :

A being given true, E is false, I true, O false.

E being given true, A is false, I false, O true.

I being given true, A is doubtful, E false, O doubtful.

O being given true, A is false, E doubtful, I doubtful.

A being given false, E is doubtful, I doubtful, O true.

E being given false, A is doubtful, I true, O doubtful.

I being given false, A is false, E true, O true.

O being given false, A is true, E false, I true.

These results are summarized in the table below. The table has the merit of enabling one to find out, mechanically, from the truth or falsity of any given proposition, the truth, falsity or doubtfulness of its opposites.

T	F	T	F
A	E	I	**O**
E	**A**	**O**	I
I	**O?**	**A?**	E
O	I?	E?	**A**

Instructions for drawing this table : It is not necessary to remember the position of all the propositions. It will be observed that 'A and 'O are printed in black type. 'A' and 'O' are to be written in the diagonals (as shown above), and the gaps have to be filled by writing 'E' and 'I' propositions in the remaining columns. The gaps are to be filled by proceeding in the order A-E-I-O. Further, while drawing the table, we have to take four middle propositions in the lower half of the square to be doubtful. These doubtful propositions have been shown by "?".

Instructions for using the table : When any proposition is given as true, we have to take the proposition written under 'T' (to the extreme left) as true. Then we have to proceed in the same line (i.e. horizontal line) to the other three propositions. The truth or falsity of the three opposites is indicated by the letters 'T ' and 'F ' above the column. Doubtful opposites are indicated by a question mark. On the other hand, when any proposition is given as false, we have to take the proposition written under 'F' (to the extreme right) as false; and then we have to proceed in the same line (i.e. horizontal line) to the other three propositions.

4. OPPOSITION OF SINGULAR PROPOSITIONS

Singular propositions do not have the distinctions of quantity. All of them are universal. The only difference between them is that of quality. Now what are we to call the opposition between an affirmative singular proposition and a negative singular proposition? Is it to be called contrary opposition or contradictory opposition?

According to the traditional square of opposition, the relation between 'A' and 'E' propositions is that of contrary opposition. On this basis, the relation between an affirmative singular proposition and a negative singular proposition would be contrary opposition. But there is a difficulty. While two contrary propositions cannot be true together they can be false together. We find that two singular propositions differing in quality can neither be true together, nor false together, Thus, if the proposition *"Indira is tall"* is true, the proposition *"Indira is not tall" is* false; and vice versa. Now, this is the characteristic of contradictory propositions. As Keynes points out, in the case of singular propositions (so long as they have the same terms), we cannot go beyond simple denial. Therefore, the opposition between singular propositions is to be called contradictory opposition. Moreover, the relation of contradiction is a fundamental concept of logic. Its application is not limited to the traditional schedule of propositions. In view of this, we maintain that the relation between an affirmative singular proposition and a negative singular proposition is that of contradictory opposition.

SUMMARY

Immediate and mediate inferences : Deductive inferences are classified into immediate and mediate. In an immediate inference the conclusion is deduced from only one premise; in a mediate inference it is drawn from two or more premises. Inferences based upon opposition of propositions and eductions are immediate inferences. Opposition of propositions may be considered either as a relation between propositions in the fourfold classification or as a process of inference.

Kinds of Opposition : Propositions differing in quantity as well as quality are contradictories. Universal propositions differing in quality are contraries. Particular propositions differing in quality are subcontraries. Propositions differing in quantity are subalterns.

Opposition as a process of inference : Contradictories can neither be true together nor false together. Contraries cannot be true together, but both of them may be false. Both subcontraries can be true, but both of them cannot be false. The truth of the universal implies the truth of the particular, but not vice versa. The falsity of the particular implies the falsity of the universal, but not vice versa.

There is no difference between contradictory and contrary opposition in the case of singular propositions. However, the opposition between singular propositions may better be called contradiction.

TEST QUESTIONS

1. Distinguish between immediate and mediate inferences. Why is opposition of propositions said to be an immediate inference?
2. What is meant by "opposition" of propositions? explain its forms.
3. Fill in the blanks with appropriate alternatives :
   1. Inference by apposition of propositions is ______ inference.
      (relational/immediate/mediate)
   2. In an immediate inference one premise is ______ to draw the conclusion.
      (sufficient/not sufficient)
   3. In opposition of propositions, two opposites ______ be true together.
      (must/can/cannot)
   4. Two ______ cannot be false together, but both of them may be true.
      (contradictories/contraries/subcontraries/subalterns)
   5. In the relation of subalternation, if the universal is false, the particular will be ______ . (true/false/doubtful)
   6. If one of the ______ is false, the other must be true.
      (contraries/ contradictories/subalterns)
   7. In the opposition between ______ propositions, if one proposition is true, the other is false; and vice versa. (contrary/subcontrary/singular)
   8. While drawing inferences from truth or falsity, in the case of ______ we cannot say that the inferred opposite is doubtful.
      (contrariety/contradiction/subalternation/subcontrariety)

5. What inferences by opposition can be drawn from the truth of the following propositions ?

   (The given proposition is to be brought to its logical form, before drawing inferences from it.)

   1. Not all questions have simple answers.

2. All political ideals are disguised bids for power.
4. No overpopulated country can be prosperous.
5. Any society can work towards being democratic.
6. Hardly any person likes to renounce this world.
7. William Lilley predicted the Great Fire of London.

6. What inferences by opposition can be drawn from the falsity of the following?
   1. All difficult books are profound.
   2. No immoral books have literary value.
   3. Atheists are immoral.
   4. A few carefree persons do not lead a happy life.
7. What inferences by opposition can be drawn, assuming the truth and the falsity of the following propositions?
   1. All beggars are a nuisance.
   2. Many vegetarians enjoy good health.
   3. Some soldiers do not have national spirit.
   4. No donkeys dance.
8. Point out the relation of the second proposition to the first proposition in the following pairs of propositions :
   1. All that glitters is not gold.
      Nothing that glitters is gold.
   2. No lady gossips.
      Many ladies gossip.
   3. Phosphorus dissolves in water.
      Phosphorus does not dissolve in water.
   4. Every truly great man is broad-minded.
      Few truly great men are not broad-minded.
   5. That which is born will die.
      Nothing that is born will die.
   6. Some fish live on dry land.
      Some fish do not live on dry land.
   7. No one loves a fool.
      Everyone loves a fool.
9. Assuming that the first proposition in the above pairs is true, what can you say regarding the truth or falsity of the other proposition in the pair?
10. Assuming that the second proposition in the above pairs of propositions is false, what can you say about the truth or falsity of the other proposition in the pair?

CHAPTER – 8

EDUCTIONS AND OTHER IMMEDIATE INFERENCES

DO YOU KNOW THAT ....

- *Obversion is based on the general principle that every proposition can be expressed either affirmatively or negatively ?*
- *In conversion we merely change the places of terms ?*
- *Full inverse turns each term into its own contradictory ?*
- *Added determinants merely lays down the limits to the application of terms ?*
- *Material obversion greatly differs from obversion ?*
- *The doctrine of distribution of terms affects even eductions ?*

While dealing with opposition of propositions, we have distinguished between immediate and mediate inferences. We have seen that, in an immediate inference, the conclusion is drawn from only one proposition. In eductions also, the conclusion is drawn from one proposition. Therefore, they are immediate inferences. However, eductions differ from opposition of propositions. In all kinds of eductions if the premise is true, the conclusion (i.e. the inferred proposition) is true. On the other hand, in opposition of propositions when the premise is true, the inferred proposition may be true, false or doubtful.

Eductions are those forms of immediate inference in which, from a given proposition, we deduce another proposition, differing from it in subject, in predicate, or in both. The truth of the conclusion is implied by the truth of the premise.

There are seven kinds of eductions. Two of these are fundamental. The remaining five are arrived at by the operation of these two kinds. The basic eductions **are** ***Conversion*** and *Obversion*.

1. CONVERSION

In a broad sense, conversion is change in the position of terms in a proposition. However, logic is concerned with conversion only so far as the truth of the inferred proposition follows from the truth of the given proposition. Thus, conversion *is a process of immediate inference in which, from a given proposition, we infer another proposition, having the predicate of the original proposition as its subject and having the subject of the original proposition as its predicate.* That means, in conversion the predicate of the given proposition becomes the subject of the inferred proposition. The position of terms in converse is :

Given S – P

Converse P – S

In this type of inference the given proposition is called the *convertend* and the inferred proposition is called the *converse.*

There are two **rules of conversion.** These are : (i) the Rule of Quality and (ii) the Rule of Distribution. The rule of quality is that the *converse must have the same quality as the original proposition.* As regards the rule of distribution, *no term can be distributed in the converse unless it is distributed in the original proposition.* (When a term is distributed, it is taken in its entire denotation; when it is undistributed, it is taken in its partial denotation.) Now what is true of a part of a class may not be true of the whole class. That is why when a term is not distributed in the original proposition, it cannot be distributed in the converse.

Let us find out the converse of all the four kinds of propositions in the traditional schedule.

'A' proposition : The converse of 'A' proposition is 'I' proposition. This is because in converse the original predicate becomes the subject. Now in *'A'* proposition the predicate term is not distributed. Therefore, it cannot be distributed in the converse. That is why the converse of "All S is P " will be *"Some P is S ".* To take an example, the converse of *"All bald men are sensitive"* will be *"Some sensitive beings are bald men."*

When the converse of 'A' proposition is 'I' proposition, it is called **conversion per accidens.** The term "conversion per accidens" is used, because there is change in quantity. The original proposition is universal, while the inferred proposition is particular.

However, when the denotation of both the terms is the same, the converse of 'A' can be 'A' proposition. This type of converse is especially useful when both the terms in 'A' proposition are singular. Both the terms in the proposition *"The shortest of the essays in the book is the best"* are singular. When we infer the converse from this proposition, we merely change the position of its terms. The converse of this proposition will be the 'A' proposition: *"The best essay in the book is the shortest."* Similarly, the converse of 'A' will be 'A' proposition, when the predicate is the definition of the subject, or when it is a peculiar quality possessed only by the subject. Thus, the converse of "All triangles are plane figures enclosed by three straight lines" is "All plane figures enclosed by three straight lines are triangles." The converse of "All men are laughing animals" is "All laughing animals are men." (Here "laughing" is a quality possessed only by men.) The converse of 'A' proposition to 'A' proposition is called **simple converse.**

Leaving aside the propositions in which both the terms are singular, in other propositions it is difficult to find out whether the denotation of the predicate is the same as that of the subject. We can find this out only by examining the content of the proposition. But formal logic is not concerned with our knowledge of content. Therefore, the converse of 'A' proposition is taken to be 'I' proposition.

The converse of 'E proposition and 'I' proposition will be 'E ' and 'I' propositions, respectively. To take examples :

E	Original	No ghost is beautiful.
	Converse	No beautiful being is a ghost.
I	Original	Some diamonds are black.
	Converse	Some black things are diamonds.

The converse of 'E' and 'I' propositions is called **simple converse.** This is because the quantity of the converse is the same as that of the original proposition. *In fact, in simple conversion, the converse is equivalent to the original proposition.* That is why, when we convert 'E' and 'I' propositions, we do not lose information. As such, we can pass back from the converse to the original proposition, without there being any change.

Converse of 'O' proposition is not possible. This is because the converse of 'O' proposition violates the rule of distribution of terms. One of the rules of conversion is that the quality of converse must be the same as that of the given proposition. The given proposition is negative. Therefore, the converse will be negative. The converse, being negative, will distribute its predicate. (Negative propositions distribute their predicate.)

The predicate of the converse is the subject of the given proposition. This term is not distributed in the given proposition (as it stands as the subject of 'O' proposition). Therefore, it cannot be distributed in the converse. If the conversion of 'O' proposition is attempted, it will commit a fallacy. This is called the **fallacy of illicit conversion.**

Let us summarize the above results in a table.

Original (Converted)		Converse	Simple or per accidens
A	All S is P.	Some P is S. (I)	Converse per accidens
E	No S is P.	No P is S. (E)	Simple Converse
I	Some S is P	Some P is S. (I)	Simple Converse
O	Some S is not P.	(None)	—

2. OBVERSION

Obversion is the process of inference in which the subject of the inferred proposition is the same as that of the original proposition, but the predicate is the contradictory of the original predicate. The quality of the proposition also changes. The position of terms in obverse is :

Given $S - P$

Obverse $S - \bar{P}$

The given proposition is called the **obvertend,** and the inferred proposition is called the obverse.

A	Original	All journalists are pessimists.
	Obverse	No journalists are non-pessimists.
E	Original	No capitalists are far-sighted.
	Obverse	All capitalists are non-far-sighted.
I	Original	Some lazy persons are successful.
	Obverse	Some lazy persons are not non-successful.

O	Original	Some Italians are not dark-haired.
	Obverse	Some Italians are non-dark-haired.

Thus, we find that in Obverse the *quantity has remained the same, though the quality has changed. We* may summarize the results thus :

Original (Obvertend)	Obverse
A All S is P.	No S is non-P. (E)
E No S is P.	All S is non -P. (A)
I Some S is P.	Some S is not non-P (O)
O Some S is not P.	Some S is non-P (I)

In obverse the inferred proposition is equivalent to the original proposition. Obversion depends upon the general principle that every proposition can be expressed either affirmatively or negatively. *Obversion is simply a way of obtaining a negative equivalent for an affirmative proposition, or an affirmative equivalent for a negative proposition.*

The modern logicians explain obversion by the notion of the complement of a class. The complement of a class (also called complementary class) is the collection of all the things which do not belong to a given class. Thus, the complement of the class of pessimists is the class of, "non-pessimists". In the example of 'A' proposition taken above, in the obverse the predicate is "non-pessimists".

3. OBVERTED CONVERSE

All the eductions that we shall deal with now onwards are based upon conversion and obversion.

Obverted Converse is that form of eduction in which the subject of the inferred proposition is the predicate of the given proposition and the predicate of the inferred proposition is the contradictory of the subject of the given proposition. The position of terms in obverted converse is :

Given $S - P$

Obverted Converse $P - \overline{S}$

Obverted converse is obtained by finding out first the converse, and then the obverse of the converse. Let us see the obverted converse of all the four categorical propositions.

A	Original	All elephants are big animals.
	Converse	Some big animals are elephants.
	Obverse	Some big animals are not non-elephants. (This is Obverted Converse.)
E	Original	No metals are useless.
	Converse	No useless things are metals.
	Obverse	All useless things are non-metals.
I	Original	Some residents are citizens.
	Converse	Some citizens are residents.
	Obverse	Some citizens are not non-residents.
O	Original	Some churches are not gloomy buildings.
	Converse	Not possible; therefore, obverted converse is not possible.

The following table summarizes the results :

Original	Obverted Converse
A All S is P.	Some P is not non-S. (O)
E No S is P.	All P is Non-S. (A)
I Some S is P.	Some P is not non-S. (O)
O Some S is not P.	(None)

4. CONTRAPOSITIVE (PARTIAL AND FULL)

Contrapositive also is obtained by conversion and obversion. But we start with obverse, and then find out its converse. There are two kinds of contrapositive. These are partial contrapositive and full contrapositive. *Partial contrapositive* is that form of immediate inference in which the subject of the inferred proposition is the contradictory of the original predicate and the predicate is the original subject.

Full *contrapositive* is that form of immediate inference in which the subject of the inferred proposition is the contradictory of the original predicate and the predicate is the contradictory of the original subject. Partial contrapositive is obtained by first finding out the converse of the given proposition, and then the obverse of the converse. Full contrapositive is obtained by the process of obverse, converse, and then obverse. From this, it will be clear that *full contrapositive is the obverse of partial contrapositive.*

The position of terms in partial and full contrapositive is :

Given	$S - P$
Partial Contrapositive	$\bar{P} - S$
Full Contrapositive	$\bar{P} - \bar{S}$

Let us find out the partial and the full contrapositive of 'A', 'E', 'I' and 'O' propositions.

A	Original	All lemons are sour.
	Obverse	No lemons are non-sour.
	Converse	No non-sour things are lemons. *(This is partial contrapositive.)*
	Obverse	All non-sour things are non-lemons. *(This is full contrapositive.)*
E	Original	No thoughtful persons are superstitious.
	Obverse	All thoughtful persons are non-superstitious.
	Converse	Some non-superstitious beings are thoughtful persons. *(This is partial contrapositive.)*
	Obverse	Some non-superstitious beings are not non-thoughtful persons. *(This is full contrapositive)*
I	Original	Some fruits are tasty.
	Obverse	Some fruits are not non-tasty.
	Converse	Not possible, as the above proposition is 0. *Thus 'I'*

		proposition has neither partial contrapositive nor full contrapositive.
O	Original	Some gases are not poisonous.
	Obverse	Some gases are non-poisonous.
	Converse	Some non-poisonous things are gases. *(This is partial contrapositive.)*
	Obverse	Some non-poisonous things are not non-gases. *(This is full contrapositive.)*

The results are summarized thus :

Original Proposition	Partial Contrapositive	Full Contrapositive
A All S is P.	No non-P is S. (E)	All non-P is non-S. (A)
E No S is P.	Some non-P is S. (I)	Some non-P is not non-S. (O)
I Some S is P.	—	—
O Some S is not P.	Some Non-P is S. (I)	Some non-P is not non-S. (O)

5. INVERSE (PARTIAL AND FULL)

Inverse is a process of inference in which the subject of the inferred proposition is the contradictory of the original subject. The predicate may be the same as the original predicate, or it may be the contradictory of the original predicate. When the predicate is the same, the inverse is called Partial Inverse. And when the predicate is the contradictory of the original predicate, the inverse is called Full Inverse. Thus, in *partial inverse,* the subject is contradictory of the original subject, but the predicate is the same as the original predicate. On the other hand, *in full inverse* both the terms are contradictories of the original subject and predicate.

Inverse is obtained by doing obversion and conversion alternately, till the above results are obtained. The position of terms in partial and full inverse is :

Given	$S - P$
Partial Inverse	$\bar{S} - P$
Full Inverse	$\bar{S} - \bar{P}$

Let us now find out the Partial and Full Inverse of 'A', 'E', 'I' and 'O' propositions. We shall illustrate these with symbols only. We shall not take concrete examples. Later on we shall find out directly the partial and full inverse, wherever possible.

A All S is P	Converse	Some P is S.
	Obverse	Some P is not non - S.
	Converse	Not possible.
Let us now start with obverse	Obverse	No S is non - P.
	Converse	No non - P is S.
	Obverse	All non – P is non - S.
	Converse	Some non - S is non - P. *(This is full inverse.)*

	Obverse	Some non-S is not P.
		(This is partial inverse)
E No S is P.	Converse	No S is non-P.
	Obverse	No non-P is S.
	Converse	All non-P is non-S.
		Some non-S is non-P.
		(This is full inverse.)
	Obverse	Some non-S is not P.
		(This is partial inverse.)

It will be observed that, in the case of 'E' proposition, we obtained partial inverse and full inverse by starting with converse. If we start with obverse, we shall not be able to obtain these inferences. Let us see this.

	Obverse	All S is non-P.
	Converse	Some non-P is S.
	Obverse	Some non-P is not non-S.
	Converse	Not possible.
I Some S is P.	Converse	Some P is S.
	Obverse	Some P is not non-S.
	Converse	Not possible.

Let us start with obverse.

	Obverse	Some S is not non-P.
	Converse	Not possible.
O Some S is not P.	Converse	Not possible.

Let us start with obverse.

	Obverse	Some S is non-P.
	Converse	Some non-P is S.
	Obverse	Some non-P is not non-S.
	Converse	Not possible.

From the above it is clear that we can obtain inverse (partial and full) only in the case of universal propositions. In the case of particular propositions, we cannot obtain inverse. We have also seen that in the case of 'A' proposition we have to start with obverse, while in the case of 'E' proposition we have to start with converse. Let us summarize these results.

Original	Partial Inverse	Full Inverse
A All S is P.	Some non-S is not P. (O)	Some non-S is non-P. (I)
E No S is P.	Some non-S is P.	Some non-S is not non-P. (O)
I Some is P.	—	—
O Some S is not P.	—	—

We shall find out partial inverse and full inverse in the case of 'A' and 'E' propositions directly, by applying the above results.

A	Original	All Arabs are hospitable.
	Partial Inverse	Some non-Arabs are not hospitable.
	Full Inverse	Some non-Arabs are non-hospitable.
E	Original	No circles are squares.
	Partial Inverse	Some non-circles are squares.
	Full Inverse	Some non-circles are not non-squares.

We have dealt with all the seven kinds of eductions. Before we summarize the results, we may mention that it will be better to use symbols as follows :

Contradictory of S (non-S) $\bar{S}$

Contradictory of P (non-P) $\bar{P}$

Quality and Quantity of proposition		Writing small letter indicating the kind of proposition, thus :			
A	All S is P	will	be	written	as	S a P
E	No S is P	..	..	..	..	S e P
I	Some S is P	..	..	..	..	S i P
O	Some S is not P	..	..	..	..	S o P

In the summary of results of the various kinds of eductions we shall use the symbols as indicated above.

Original	SaP	SeP	SiP	SoP
Converse	PiS	PeS	PiS	–
Obverse	$Se\bar{P}$	$Sa\bar{P}$	$So\bar{P}$	$Si\bar{P}$
Obverted Converse	$Po\bar{S}$	$Pa\bar{S}$	$Po\bar{S}$	–
Partial Contrapositive	$\bar{P}eS$	$\bar{P}iS$	–	$\bar{P}iS$
Full Contrapositive	$\bar{P}a\bar{S}$	$\bar{P}o\bar{S}$	–	$\bar{P}o\bar{S}$
Partial Inverse	$\bar{S}oP$	$\bar{S}iP$	–	–
Full Inverse	$\bar{S}i\bar{P}$	$\bar{S}o\bar{P}$	–	–

6. OTHER IMMEDIATE INFERENCES

In addition to the seven kinds of eductions, four other kinds of immediate inferences have been recognized. These are Material Obversion, inference by Added Determinants, inference by Complex Conception and Converse Relation. The validity of these inferences cannot be judged from the form of inference. Knowledge of the content is necessary for deciding whether these inferences are valid or invalid.

Material Obversion : Bain mentions that, in addition to obversion, we may have another inference, called material obversion. Material obversion is the process of inference in which the subject and the predicate of the inferred proposition are the contraries of the subject and the predicate of the given proposition. The quality of the proposition remains the same. The validity of these inferences depends upon the contents of the propositions. To take examples :

1. Heat expands bodies.

∴ Cold contracts them.

2. Knowledge is power.

∴ Ignorance is weakness.

If we examine these two inferences, we shall find them to be valid. On the other hand, the following inference is invalid :

Women are broad-minded.

∴ Men are narrow-minded.

Inference by material obversion has no similarity to obversion. In obversion the subject remains the same, while the predicate is the contradictory of the original predicate. Really speaking, these inferences are similar to inversion. But they differ from inversion in this: The terms in the inverse (i.e. full inverse) are contradictories of those in the given proposition, while the terms in material obverse are contraries.

Inference by Added Determinants : Inference by Added Determinants consists in limiting the original subject and the original predicate by qualifying them with the same determinant. This determinant is generally an adjective. The qualification narrows down the application of the subject and the predicate. The following are inferences of this type :

1. All cars are vehicles.

∴ All black cars are black vehicles.

2. All students are human beings.

∴ All intelligent students are intelligent human beings.

In the above examples, the subject and the predicate are determined in the same manner. The colour "black" as applied to the term "car" and to the term "vehicle" means the same thing. Similarly, the meaning of the determinant "intelligent" in the second example is the same for both the terms. Therefore, the above inferences are valid. However, quite often the determinant does not have the same meaning in the case of the two terms. Consider the following inference :

An elephant is an animal.

∴ A small elephant is a small animal.

In this example the adjective "small" does not have the same meaning. Being small in the case of an elephant is different from being small in the case of an animal. In fact, a large number of invalid inferences by Added Determinants arise, because we fail to consider that language is often ambiguous. Now to avoid fallacies in these kinds of inferences, we have to assume that the determinant *shall* receive the same interpretation in both the terms. Let us apply the same interpretation to the adjective "small" in the above example. When we do so, the inferred proposition will be "A small elephant is a small animal, compared with elephants generally."[1]

Inference by Complex Conception : This inference is similar to inference by added determinants. Here also, the subject and the predicate are limited. But the limitation is of a different kind. In this kind of inference, the subject and the predicate become parts of a more complex conception. To take examples :

1. An elephant is an animal.

∴ The tail of an elephant is the tail of an animal.

---

[1] Keynes, *Formal Logic, p. 149.*

2. Quinine is a medicine.

∴ A dose of quinine is a dose of medicine.

The above inferences are valid. This is because the limitation placed on the subject and the predicate has the same meaning. On the other hand, the following inference is invalid :

Philosophy is not poetry.

∴ The writers of philosophy are not the writers of poetry.

It is obvious this this inference is invalid. When we deny 'being a writer of poetry' about writers of philosophy, the meaning changes. Philosophy is not poetry; but this does not mean that a writer of philosophy cannot be a writer of poetry.

Inference by Converse Relation : We have discussed relational propositions while dealing with the modern classification of propositions. In relational propositions, there are two or more subjects of relation. A relational proposition asserts relation between them. Here we are concerned with those relational propositions in which there are only two subjects of relation. In inference by converse relation, the direction of relation changes and the word by which the relation is expressed is replaced by its correlative. To take examples :

1. A is the husband of B.

∴ B is the wife of A.

2. Calcutta is to the east of Bombay.

∴ Bombay is to the east of Calcutta.

The first inference is valid, while the second one is invalid. It may appear that we determine the validity of these inferences on the basis of our knowledge of the content. But it is not so. Once we have classified a relation as being of a particular kind, we do not need to refer to the contents of the propositions. We can proceed on formal grounds only. Both the following inferences are valid, though their contents differ :

1. Karachi is to the north of Bombay.

∴ Bombay is to the south of Karachi.

2. China is to the north of India.

∴ India is to the south of China.

Thus, the validity of inference by converse relation does not depend upon the terms of relation. It depends upon the nature of relation. This will become clear when we deal with relations and relational arguments in Chapter 13.

7. TESTING VALIDATY OF IMMEDIATE INFERENCES

Let us consider the conditions under which immediate inferences become invalid. In the case of the seven formal inferences (viz. eductions), the summary of results will indicate when valid inferences are not possible. Let us indicate them again.

1. Converse	Not possible for 'O'.
2. Obverted Converse	Not possible for 'O'.
3. Contrapositive (Partial and Full)	Not possible for 'I'.
4. Inverse (Partial and Full)	Not possible for 'I' and 'O'.

In addition to these, fallacies may also arise when the inferred proposition is an "opposite" of a valid inference. For example, if the valid inference is 'I' proposition and we infer 'A', 'E' or 'O' proposition, the inference will be fallacious. We have to remember that when a given proposition is taken to be true, its opposites may be true, false or doubtful.

In the case of material immediate inferences (except inference by converse relation), the validity of the inference has to be judged with reference to the contents of the propositions.

Before testing the validity of these inferences, we have to reduce the given proposition and the inferred proposition to their strict logical form. This will help us in detecting fallacies. However, in the case of material inferences, we do not have to bring them to their logical form. We may also mention that symbolic representation of the given proposition and the inferred proposition (as shown below) will help in finding out the kind of inference.

1. Every ambitious man is selfish. Therefore, every selfish man is ambitious.

LF SaP All ambitious men are selfish.

PaS ∴ All selfish men are ambitious.

This inference is the Subalternant of Converse. (The converse of SaP is PiS.) If 'I' proposition is true, 'A' proposition is doubtful. Therefore, the inference is invalid.

2. All those who love success love work. Therefore, none who do not love work are those who do not love success.

LF SaP All persons who love success are persons who love work.

$\bar{P}e\bar{S}$ ∴ No persons who do not love work are persons who do not love success.

The inference is the Contrary of Full Contrapositive. (Full Contrapositive is $\bar{P}a\bar{S}$.) If 'A' is true, 'E' is false. Therefore, the inference is invalid.

3. Every politician is not a patriot. Therefore, every patriot is not a politician.

LF SoP Some politicians are not patriots.

PoS ∴ Some patriots are not politicians.

This inference is invalid, because 'O' proposition has no converse.

4. A tortoise is an animal. Therefore, a swift tortoise is a swift animal.

This is inference by Added Determinants. The adjective 'swift' does not apply to the terms 'tortoise' and 'animal' in the same sense. Therefore, the inference is invalid.

5. Many snakes are poisonous. Therefore, many non-poisonous things are not snakes.

LF SiP Some snakes are poisonous.

$\bar{P}o$ S ∴ Some non-poisonous things are not snakes.

This inference is an attempt at Partial Contrapositive. As 'I' proposition has no Contrapositive, the inference is invalid.

6. No poets are guided by reason. Therefore, all those who are not poets are guided by it.

LF SeP No poets are guided by reason.

$\bar{S}aP$ ∴ All non-poets are guided by reason.

This inference is the Subalternant of Partial Inverse. (Partial Inverse is $\bar{S}i\bar{P}$). If 'I' is true, 'A' is doubtful. Therefore, the inference is invalid.

7. A is older than B. Therefore, B is younger than A.

This is inference by Converse Relation. The relation 'younger than' is the exact converse of the relation 'older than'. Therefore, the inference is valid.

8. No accidents are unavoidable. Therefore, some accidents are not avoidable (unavoidable = non-avoidable).

This is already in logical form. The inference is contradictory of Obverse. (The obverse is $Sa\bar{P}$.) If 'A' is true, 'O' is false. Therefore, the inference is invalid.

SUMMARY

Eductions are those forms of immediate inference in which the conclusion differs from the premise either in subject, or in predicate, or in both. The truth of the conclusion is implied by that of the premise. Conversion and obversion are the fundamental kinds of eductions. Other kinds are derived by the operation of these two.

Conversion involves change in the position of terms. The quality remains the same; and a term can be distributed in the converse only if it is distributed in the given proposition. From the rule of distribution, we see that the converse of 'A' is 'I', and that of 'O' is not possible. However, when 'A' proposition distributes both the terms, its converse is 'A'. Conversion of 'A' to 'I' is called *conversion per accidens.*

In *Obverse* the subject is same; the predicate is contradictory; there is change in quality, but not in quantity. *Obverted Converse* is obtained by the operation of first converse, and then obverse. Obverted converse of 'O' is not possible.

Partial Contrapositive involves the operation of first obverse, and then converse. *Full Contrapositive* is the obverse of Partial Contrapositive. Position of terms in partial contrapositive is $\bar{P} - S$; in full contrapositive it is $\bar{P} - \bar{S}$. There is no contrapositive of 'I'.

In *Partial Inverse* the subject is the contradictory of the original subject, but the predicate remains the same. In *Full Inverse* both the terms are contradictories. Partial inverse of 'A' is 'O', and that of 'E' is 'I'. Full inverse of 'A' is 'I', and that of 'E' is 'O'. *Inverse of 'I' and 'O' propositions is not possible.*

In addition to seven kinds of eductions, there are four other types of immediate inferences. These are *Material Obversion,* inference by *Added Determinants,* inference by *Complex Conception*, and inference by *Converse Relation*.

TEST QUESTIONS

1. What is the difference between inference by Opposition of Propositions and Eductions?
2. Explain why the converse of 'O' proposition and the contrapositive of 'I' proposition are not possible.
3. Why is the converse of 'A' proposition 'I' proposition ?
4. Why does 'O' proposition have no obverted converse?
5. Fill in the blanks with appropriate alternatives :
    1. In all the kinds of educations, if the premise is _____ the conclusion cannot be ______. (affirmative/negative/universal/particular)
    2. In ______ if the premise is negative, the conclusion must be affirmative. (obverted converse/full contrapositive/full inverse)
    3. In ______ if the premise is affirmative, the conclusion cannot be negative. (obverse/partial inverse/full inverse)
    4. In ______ if the premise is universal, the conclusion must be particular. (obverse/obverted converse/inverse)

5. In ______ the contradictory of the original predicate stands as the subject. (obverse/obverted converse/partial contrapositive)
6. In ______ the contradictory of the original subject stands as the predicate. (obverse/converse/obverted converse/ full inverse)
7. The converse of 'A' is ______ 'I '. (always/sometimes/never)
8. The obverted converse of 'A' is ______ 'E'. (always/never/sometimes)
9. In ______ the inferred proposition is always equivalent to the given proposition.
   (obverse/converse/inverse)

6. Test the validity of the following inferences :
   1. Every diamond is a hard jewel. Therefore, everything that is not a hard jewel is a non-diamond.
   2. Few coaches are lenient. Therefore, few lenient persons are coaches.
   3. Calcutta is the largest city of India. Therefore, the centre of Calcutta is the centre of the largest city of India.
   4. Romanticists are always idealists. Therefore, idealists are always romanticists.
   5. A few teachers are not stimulating lecturers. Therefore, a few non-stimulating lecturers are non-teachers.
   6. Goblins are never visible. Therefore, every visible being is non-goblin.
   7. A model is attractive. Therefore, a non-model is non-attractive.
   8. Antiques are generally expensive. Therefore, few non-expensive things are antiques.
   9. None of the bankers is a pauper. Therefore, none of the non-paupers is a non-banker.
   10. Life is misery. Therefore, death is happiness.
   11. Few restless persons are non-excitable. Therefore, few non-restless persons are not non-excitable.
   12. Japanese are artistic. Therefore, non-Japanese are not artistic.
   13. A large number of villagers lead a simple life. Therefore, a large number of people who lead a simple life are villagers.
   14. Maya is sister of Meena. Therefore, Meena is sister of Maya. (Invalid inference by converse relation. We have to consider the nature of relation "being sister of", and not our knowledge of the terms of relation.)
   15. All philosophers think. Therefore, those who are not philosophers do not think.
   16. Ambitious men are sometimes successful. Therefore, some unsuccessful men are not ambitious.
   17. Many drunkards are not criminals. Therefore, a few criminals are drunkards.
   18. All idlers waste their time. Therefore, a man who does not waste his time is not an idler.
   19. No stimulant nourishes. Therefore, some things which do not nourish are stimulants.
   20. A politician is a man. Therefore, a good politician is a good man.
   21. No man welcomes disaster. Therefore, all non-men welcome it.

22. A few profound books are non-readable. Therefore, few profound books are readable.

7. What is the relation of the following propositions to the proposition "All crystals are solid" ?
   1. Some solids are not crystals.
   2. Some non-crystals are not solid.
   3. No crystals are non-solid.
   4. Some non-solids are crystals.
8. Give, where possible, contradictory, converse and contrapositive of the following :
   1. No crocodiles shed tears.
   2. All logic books contain misprints.
   3. All are not saints that go to temple.
   4. Duronacharya was a great teacher.
   5. Brave soldiers win rewards.
   6. Not every tale is believable.

CHAPTER – 9

SYLLOGISM

DO YOU KNOW THAT ......

* *The middle term is the medium through which syllogistic inferences are drawn ?*
* *The validity of syllogistic inferences can only be decided by analyzing the logical structure of their constituent propositions?*
* *The position of the middle term determines the figure of a syllogism?*
* *Though both the premises may be universal, the conclusion may be particular?*

In an earlier chapter we have discussed the distinction between immediate and mediate inferences. Now we shall deal with syllogism, which is a mediate inference.

The theory of Syllogism was propounded by Aristotle. *Aristotle considered syllogism as an argument in which the middle term stands in a certain relation to the other two terms.* And only categorical propositions can be analyzed into terms. Now, some logicians have extended the term 'syllogism' to arguments containing hypothetical and disjunctive propositions as premises. But, following Joseph, we shall not use the term 'syllogism' in this extended sense.

1. NATURE OF SYLLOGISM - ITS STRUCTURE

Syllogism is composed of three propositions. **It is a mediate inference in which the conclusion is deduced from two given propositions.** The given propositions are called the *premises*. The proposition which follows from them is called the *conclusion*. Let us take an example of syllogism.

All politicians are ambitious.

All ministers are politicians.

∴ All ministers are ambitious.

In this syllogism the first two propositions are the premises; the third one is the conclusion.

Let us now analyze the nature of syllogism. As a *mediate inference,* syllogism differs from immediate inferences like eductions and opposition of propositions. The conclusion of syllogism is jointly implied by the two premises. It is not drawn from each of the premises, separately.

Syllogism is a deductive inference. Therefore, its conclusion cannot assert more than what is asserted by its premises. That is to say, if one of the premises is particular, the conclusion cannot be universal.

Structure of syllogism : In a syllogism the constituent propositions are analyzed into terms. These terms are given names. The predicate of the conclusion is called the *major term*. The subject of the conclusion is called the *minor term*. The term which occurs in both the premises, but not in the conclusion, is called the *middle term*. The major term is represented by the symbol 'P', the minor term by the symbol 'S', and the middle term by the symbol 'M'.

The premise in which the major term occurs is called the *major premise;* and that in which the minor term occurs is called the *minor premise*. In the major premise, the middle term is related to the major term; and in the minor premise, the middle term is related to the minor term. The relation between the middle term and the other two terms may be that of affirmation or negation.

The *validity of a syllogism* does not depend upon the order in which the three constituent propositions are expressed. However, when a syllogism is reduced to its logical form, the constituent propositions are stated in a certain order. This order is :

Major premise

Minor premise

Conclusion

2. FUNCTION OF THE MIDDLE TERM

The conclusion follows from the premises, because there is a common element between them. This common element is the middle term. As we have stated, the middle term is that term which occurs in both the premises, but not in the conclusion.

Now, the conclusion can be deduced from the premises, because there are certain relations between the terms. Thus, in a syllogism the inference depends upon the analysis of the constituent propositions. The conclusion depends upon the manner in which the terms are related in the premises.

As we have stated above, in a syllogism the conclusion is jointly implied by both the premises. It does not follow from either of the premises, taken separately. Let us take examples.

1. All teachers are educated persons.

   All lions are ferocious.

These two propositions have no common element. They cannot be joined together.[1] Therefore, there is no question of the conclusion following from them. Now consider the following argument :

2. All cats are *animals.*

   All dogs are *animals.*

   ∴ All dogs are cats.

In this argument there appears to be a common element. This common element, called the middle term, is "animals". But though there is a middle term, the middle term is not able to perform its function of relating the major and the minor term. This

[1] We are referring to their being joined together to form premises of a syllogistic argument.

is because the middle term is taken in partial denotation in both the premises. In both the premises, it stands as the predicate of 'A' proposition. Now 'A' proposition does not distribute its predicate. Therefore, the middle term is not distributed. Since the middle term is not distributed, it is possible that the part of the middle term which is related to the major term may not be the part which is related to the minor term. That is why the middle term is not able to perform its function of relating the two terms. This will be clear from the following diagram :

Function of the Middle Term

The part of the class of animals which are 'cats' ('C') is different from the part of the class of animals which are 'dogs' ('D').

It may be pointed out that, in some syllogistic arguments, even though the middle term is not distributed, the conclusion appears to follow from the premises. But really this is not possible. Let us take an argument and discuss this point.

All philosophers are *thinkers*.

Some poets are *thinkers*.

∴ Some poets are philosophers.

In this argument the middle term remains undistributed in both the premises (being the predicate of affirmative propositions); yet the conclusion is true. However, though the conclusion is true, it is not validly drawn. Here the relation between the premises and the conclusion is independent of the connection provided by the middle term. Therefore, the conclusion does not necessarily follow from the premises.

Syllogism is a formal inference. It is not concerned with the content, either of the premises or of the conclusion. That is why, every syllogistic argument can be represented symbolically, and its validity decided on the basis of formal relations between the premises and the conclusion. If the premises imply the conclusion, the inference is valid; if not, it is invalid.

3. RULES OF SYLLOGISM

In a syllogism, the conclusion is deduced from the two premises, taken together. But we cannot draw any conclusion from any premises, because the implications of different kinds of propositions are different. For instance, when one of the premises is a particular proposition, we cannot draw a universal proposition as the conclusion. As we shall see later, this is the basic condition of deductive inference. Aristotle provided a method for testing the validity of syllogisms. This principle is called the *Dictum de omni et nullo*. We shall deal with *the dictum* in the next chapter.

The traditional logicians observed that we can test the validity of a syllogistic argument by applying certain rules. A syllogism whose conclusion is drawn in accordance with these rules would be valid. If a syllogism violates any of these rules, it would be invalid. *When a syllogism is invalid, it is said to commit a fallacy.*

There are *seven rules* of syllogism. Two of these are the rules of structure, two of them are concerned with the distribution of terms, and three of them deal with quality.

Rules of Structure :

1. *There must be three and only three terms in a syllogism.*

This can hardly be said to be a rule of syllogism. It is the condition which determines whether an argument is a syllogism.

When a syllogism has more than three terms, it is said to commit *the fallacy of four terms.* This happens especially when one of the terms is ambiguous. A term is ambiguous when it is used in two different senses. Really speaking, what is ambiguous is a word, and not a term. Terms have a fixed and definite meaning. A word becomes a term when it stands as subject or predicate of a proposition. Now, when a word occurs in a proposition (i.e. becomes a term), it cannot have more than one meaning. However, the fallacy arising out of the ambiguous use of a term is considered to be a fallacy of syllogism. This is called **the fallacy of equivocation.** Let us take an example.

Sound is that which travels at 1120 feet a second.

His knowledge of History is *sound.*

∴ His knowledge of History is that which travels at 1120 feet a second.

Here the middle term "sound" is ambiguous. It means "what is heard" in the major premise, and "free from defect' in the minor premise.

The fallacy of equivocation may arise with regard to any of the terms. Since there are three terms, it takes three forms. These are called the fallacies of **Ambiguous Major, Ambiguous Minor** and **Ambiguous Middle.** The above example is that of Ambiguous Middle.

2. *There must be three and only three propositions in a syllogism.*

This rule restricts the scope of syllogism. Various kinds of arguments will be ruled out on the basis of this rule. In some arguments the conclusion follows from three, four, or even more premises. The traditional logicians would express such arguments in units of three propositions each. They would consider each unit of three propositions as a syllogism, and the whole argument as a series of syllogisms. To take an example :

Logic is a science.

All sciences are those that aim at truth.

All things that aim at truth are useful.

∴ Logic is useful.

This argument is called sorites. We shall not discuss such arguments. However, we shall analyze the above argument, and show that it consists of syllogisms.

1. All sciences are those that aim at truth.

   Logic is a science.

   ∴ Logic is that which aims at truth.

2. All things that aim at truth are useful.

   Logic is that which aims at truth.

   ∴ Logic is useful.

Rules of Distribution of terms

The most important factor which would determine the validity or otherwise of a syllogism is *the range of generality of a term.* By range of generality, we mean whether a term is taken in its entire denotation or whether it is taken in its partial denotation. There are two rules regarding the distribution of terms.

3. *The middle term must be distributed at least once in the premises.*

We have seen (in section 2 above) that the function of the middle term is to unite the major term and the minor term. The middle term cannot perform this function, if it is not distributed.

The violation of this rule involves the fallacy of *Undistributed Middle.* Let us take examples of syllogisms committing this fallacy.

1. All good citizens are *those who vote.*

 Some women are *those who vote.*

∴ Some women are good citizens.

2. Some *taxes* are levied at death.

 Excise duty is a tax.

∴ Excise duty is levied at death.

In the first argument the middle term is the predicate in both the premises. Both the premises being affirmative, they do not distribute the predicate. Therefore, the first argument commits the fallacy of Undistributed Middle. In the second argument, the middle term is the subject of the major premise which is '1' propositions and the predicate of the minor premise (which is 'A' proposition). So it remains undistributed in both the premises. As such, this argument also commits the fallacy of Undistributed Middle.

4. *No term can be distributed in the conclusion unless it is distributed in the premise.*

There are two terms in the conclusion. These are the major term and the minor term. Therefore, this rule means that the major term cannot be distributed in the conclusion unless it is distributed in the major premise. Similarly, the minor term cannot be distributed in the conclusion unless it is distributed in the minor premise.

This rule expresses the general condition of deductive inference. In deduction the conclusion cannot go beyond the evidence.

The violation of this rule results in *the fallacy of illicit process of terms.* Since there are two terms in the conclusion, two fallacies arise. These are the fallacy of *Illicit Major* and the fallacy of *Illicit Minor.* To take examples :

Fallacy of Illicit Major

All tigers are *ferocious.*

No tiger is a tea-drinking creature.

∴ No tea-drinking creature is *ferocious.*

The major term *"ferocious"* is not distributed in the major premise, being the predicate of 'A' proposition. But it is distributed in the conclusion, being the predicate of 'E' proposition.

Fallacy of Illicit Minor

No ghosts are contented.

All ghosts are *terrifying.*

∴ No *terrifying things* are contented.

The minor term *"terrifying things"* is not distributed in the minor premise, being the predicate of 'A' proposition. But it is distributed in the conclusion, being the subject of 'E' proposition.

Rules of Quality

5. *No conclusion can be drawn from two negative premises.*

The three rules of quality (i.e. rules 5, 6 and 7) can be proved by taking examples. We have stated earlier that the premises of a syllogism imply its conclusion. As such, it could not be the case that the premises are true, but the conclusion is false. Now let us take two arguments with negative premises.

1. No Arabs are Catholics.

   No Britishers are Arabs.

∴ All Britishers are Catholics.

2. No Arabs are Catholics.

   No Britishers are Arabs.

∴ No Britishers are Catholics.

The premises of these arguments are true; yet the conclusion is false. As such, the relation between the premises and the conclusion is not that of implication. It will be noticed that the conclusion of the first argument is affirmative, while that of the second argument is negative. This shows that no conclusion (neither affirmative nor negative) can be drawn from two negative premises.

The violation of this rule involves **the fallacy of negative premises.** The above arguments commit this fallacy.

6. *When one of the premises is negative, the conclusion must be negative; and conversely, when the conclusion is negative, one of the premises must be negative.*

Let us suppose that one of the premises is negative, but the conclusion is affirmative. In that case, the following argument will be valid :

1. All lions are carnivorous.

   No camels are carnivorous.

∴ All camels are lions.

Though the premises of this argument are true, its conclusion is false. This shows that the relation between the premises and the conclusion is not that of implication. Therefore, the argument is invalid. Thus, we see that when one of the premises is negative, the conclusion cannot be affirmative; it must be negative. In fact, the negative proposition "No camels are lions", which is a true proposition, could have been deduced from the premises.

We shall now prove the converse of the rule. We have already seen (while proving the 5th rule) that both the premises cannot be negative. The only other possibility is the syllogism in which the conclusion is negative and both the premises are affirmative. Let us take an example of such a syllogism.

All healthy persons are those who have good appetite.

All athletes are healthy.

∴ No athletes are those who have good appetite.

The premises of this argument are true, but its conclusion is false. Therefore, the premises do not imply the conclusion. As such, the argument is invalid. This shows that when the conclusion is negative, both the premises cannot be affirmative; one of them must be negative.

7. *When both the premises are affirmative, the conclusion must be affirmative; and conversely, when the conclusion is affirmative both the premises must be affirmative.*

Let us suppose that both the premises are affirmative, but the conclusion is negative. An example of such an argument will be :

All unfriendly creatures are unwelcome.

All wasps are unfriendly.

∴ No wasps are unwelcome.

We see that the premises of this argument are true, but its conclusion is false. Therefore, the premises do not imply the conclusion. As such, the argument is invalid. This proves that when both the premises are affirmative, the conclusion cannot be negative; it must be affirmative.

Let us proceed to the converse of this rule. While proving the fifth rule, we have shown that when both the premises are negative, no conclusion can be drawn. There we have taken an example to show that, from two negative premises, we cannot deduce affirmative proposition as the conclusion. We shall now take an example to show that when the conclusion is affirmative, not even one of the premises can be negative.

All pigmies are those who have small feet.

No policeman is a pigmy.

∴ All policemen are those who have small feet.

Obviously, here the conclusion is false, though the premises are true. Therefore, the argument is invalid. Thus, we have proved that when the conclusion is affirmative, both the premises must be affirmative.

4. COROLLARIES FROM RULES

In addition to the above rules, there are certain corollaries that follow from the rules. We shall deal with these corollaries.

1. From two particular premises no conclusion can be drawn.

If both the premises are particular, they may be both affirmative, both negative, or one affirmative and the other negative. There are four possible combinations. These are: II, IO, OI and OO. The fourth combination (OO) is clearly invalid, because both the premises are negative. Let us deal with the remaining three combinations.

The combination II does not distribute any term. Therefore, it will involve the fallacy of Undistributed Middle.

The combinations IO and OI have the same propositions as premises. Therefore, they are taken together. These combinations distribute only one term, which is the predicate of 'O' proposition. One of the premise, being negative, the conclusion will be negative. The negative conclusion will distribute its predicate, the major term. Thus, to avoid fallacies, the premises must distribute the middle term and the major term. But the premises, together, distribute only one term. Therefore, syllogisms with these combinations will commit either the fallacy of Undistributed Middle or the fallacy of Illicit Major.

2. If one of the premises is particular, the conclusion will be particular.

Here also the premises may be both affirmative, both negative, or one affirmative and the other negative. The possible combinations are : AI, IA, AO, OA, EI, IE, EO and OE.

The combinations of two negative premises, viz. EO and OE, commit the fallacy of Negative Premises. The combination IE is also invalid. In this combination, the minor premise being negative, the conclusion must be negative. The negative conclusion will distribute its predicate, which is the major term. But the major premise is 'I' proposition, and the major term is not distributed in it. As such, this combination involves the fallacy of llicit Major. Therefore, it is invalid.

The combination AI and (IA) distributes only one term. To avoid the fallacy of Undistributed Middle, this must be the middle term. Therefore, the minor term will not be distributed in the minor premise. As such, it cannot be distributed in the conclusion. Therefore, the conclusion must be particular. (When the conclusion is universal, it distributes its subject, which is the minor term.)

The combination AO (and OA) and the combination EI will be taken together for proof. (All these combinations distribute only two terms, and in all of these one premise is negative.) Now, if one of the premises is negative, the conclusion will be negative. The negative conclusion will distribute its predicate, which is the major term. To avoid the fallacy of Illicit Major, the major term must be distributed in its premise. The middle term must also be distributed in at least one of the premises. Since the premises distribute only two terms, these have to be the major term and the middle term. The minor term is not distributed in the minor premise. Therefore, it cannot be distributed in the conclusion. As such, the conclusion must be particular.

3. *From a particular major premise and a negative minor premise, no conclusion can be drawn.*

The minor premise being negative, the conclusion will be negative and the major premise will be affirmative. The negative conclusion will distribute its predicate, which is the major term. Now the major premise, being particular affirmative (I proposition), distributes no term. Therefore, the major term, which is distributed in the conclusion, will remain undistributed in the major premise. This involves the fallacy of Illicit Major.

5. FIGURES OF SYLLOGISM

Syllogisms differ from one another as regards the position of the middle term in the premises. The middle term may stand as the subject or as the predicate in the premises. Depending upon the position of the middle term in the premises, we have four kinds of syllogisms. These are called figures. *Thus, figure is the form of syllogism as determined by the position of the middle term in the premises.* There are four possible positions. Therefore, there are four figures.

First figure is the form of syllogism in which the middle term stands as subject in the major premise and as predicate in the minor premise.

	M	P
	S	M
∴	S	P

Second figure is the form of syllogism in which the middle term stands as predicate in both the premises.

	P	M
	S	M
∴	S	P

Third figure is the form of syllogism in which the middle term stands as subject in both the premises.

	M	P
	M	S
∴	S	P

Fourth figure is the form of syllogism in which the middle term stands as predicate in the major premise and as subject in the minor premise.

	P	M
	M	S
∴	S	P

The fourth figure was not recognized by Aristotle. Galen added it later.

6. MOODS

While figures depend upon the position of the middle term, moods depend upon the quality and quantity of the constituent propositions. The term "mood" is used in three different senses. By mood we may mean the form of syllogism as determined by the quality and quantity of the premises. Secondly, we may mean by it the form of syllogism as determined by the quality and quantity of all the three propositions. Thirdly, we may mean by it the form of syllogism in which the conclusion is validity drawn.

Let us take the first sense. There are four kinds of propositions ('A', 'E', 'I' and 'O'). These propositions can combine in various ways in the premises. Thus we get 16 moods in each figure. These are :

AA	AE	AI	AO
EA	EE	EI	EO
IA	IE	II	IO
OA	OE	OI	OO

As there are sixteen moods in each figure (as regards the quality and quantity of the premises), there will be 64 moods in all.

Now if we consider the conclusion, four different conclusions are possible from each of the above combinations. Therefore, in the second sense, there will be 256 moods.

Though, theoretically, there are 256 moods, actually there are 19 valid moods, if we consider the premises; and there are 24 valid moods, if we consider the conclusion too.[2]

We shall now find out those combinations which yield valid conclusions. We have seen above that there are 16 combinations, when we consider the quality and the quantity of the premises. Some of them would be invalid in every figure. The combinations EE, EO, OE and OO commit the fallacy of Negative Premises. The combinations II, IO and OI consist of two particular premises. The combination IE is also rejected. (In this combination the major premise is particular and the minor premise is negative. It commits the fallacy of Illicit Major.) Thus, there are eight possible combinations which may yield valid conclusion. These are:

AA, AE, AI, AO, EA, EI, IA and OA

All these combinations would not yield valid conclusion in all the four figures.

7. VALID MOODS AND RULES OF FIGURES

There are two ways of finding out the valid moods. Firstly, we may take all the above eight combination, and consider them in the different figures. Secondly, we may determine the special rules of the figures, and then, on the basis of those rules, find out what combinations are valid. We shall follow the second method. We may mention here that the rules themselves depend upon the position of the middle term.

RULES OF FIG. I : In the first figure the middle term stands as subject in the major premise and as predicate in the minor premise. On the basis of these positions, two rules are stated. These are :

1. *The minor premise must be affirmative.*
2. *The major premise must be universal.*

Proof of Rule 1 : Suppose the minor premise is negative, the conclusion will be negative and the major premise will be affirmative. The negative conclusion would

[2] Usually, 19 valid moods are considered. These moods have been given names.

distribute its predicate, which is the major term. Now, in the major premise, the major term stands as predicate of an affirmative proposition. Therefore, it remains undistributed in the major premise. This involves the fallacy of Illicit Major. Therefore, our assumption, that the minor premise is negative, is false. Thus, the minor premise must be affirmative.

Proof of Rule 2 : As the minor premise is affirmative, it will not distribute the middle term. Therefore, the middle term must be distributed in the major premise. The middle term stands as subject in the major premise. Only universal propositions distribute subject. Therefore, the major premise must be universal.

VALID MOODS OF FIG. I : When we apply the above rules to the eight combinations (shown above), we find that four of them do not yield valid conclusion. The combinations AE and AO are rejected, because the minor premise is negative. The combinations IA and OA are rejected, because the major premise is particular. Thus, the four combinations which yield valid conclusion are AA, AI, EA and EI.

In the combination AA, both the premises are affirmative and, therefore, the conclusion will be affirmative. Now, both the premises are universal. Therefore, the conclusion *may* be universal. Since the minor term is distributed in the minor premise (being the subject of 'A' proposition), it can be distributed in the conclusion. Thus, the conclusion can be universal affirmative (A). This is mood AAA, called **Barbara.** We shall take an example of this mood.

A All *prudent persons* are those who avoid mad dogs.

A All bankers are *prudent.*

A ∴ AII bankers are those who avoid mad dogs.

The combination AI consists of two affirmative propositions. Therefore, the conclusion will be affirmative. The minor premise being particular, the conclusion will be particular. Thus, we get the mood AII This is called **Darai.** To take an example :

A *All things that raise prices* are harmful to the customer

I Some import duties are *those that raise prices.*

I ∴ Some import duties are harmful to the customer.

In the combination EA, one of the premises is negative. Therefore, the conclusion will be negative. Now, both the premises are universal. Therefore, the conclusion may be universal. As the minor term is distributed in the minor premise, it can be distributed in the conclusion. Thus, the conclusion will be universal negative (E). This is mood EAE, called **Celarent.** To take an example :

E No *insects* are eight-legged.

A All wasps are *insects.*

E ∴ No wasps are eight-legged.

In the combination EI, the major premise is negative and the minor premise is particular. Therefore, the conclusion will be particular negative (O). This is mood EIO, called **Ferio.** To take an example :

E No *shy person is* a successful salesman.

I Some intellectuals are *shy.*

O ∴ Some intellectuals are not successful salemen.

RULES OF FIG. II : The two special rules of the second figure are as follows :

1. *One of the premises must be negative.*
2. *The major premise must be universal.*

Proof of Rule 1 : The middle term stands as predicate in both the premises. To distribute the middle term, one of the **premises must be** negative. (Only negative propositions distribute predicate.)

Proof of Rule 2 : As proved above, one of the premises being negative, the conclusion will be negative. The negative conclusion will distribute its predicate, which is the major term. To avoid the fallacy of Illicit Major, the major term must be distributed in the major premise. Now, the major term stands as the subject of the major premise. Therefore, to distribute it, the major premise must be universal.

VALID MOODS OF FIG. II : On the basis of the above two rules, the combinations AA, AI, IA and OA are rejected. Thus, the four combinations which yield valid moods are AE, AO, EA and EI.

In the combination AE, the minor premise is negative. Therefore, the conclusion will be negative. It will be universal negative (E proposition), because the minor term is distributed in the minor premise (being the subject of 'E' proposition). This is mood AEE. It is called **Camestres;** e.g.

A All good men are *those who can be believed.*

E No liar is *one who can be believed.*

E ∴ No liar is a good man.

In the combination AO, the minor premise is particular negative. Therefore, the conclusion will be particular negative. This is mood AOO, called **Baroco;** e.g.

A All great musicians are *talented.*

O Some savages are not *talented.*

O ∴ Some savages are not great musicians.

In the combination EA, both the premises are universal and the major premise is negative. Therefore, the conclusion may be universal negative. Now, the minor term is distributed in the minor premise (being the subject of 'A' proposition). Therefore, it can be distributed in the conclusion. Hence the conclusion can be universal. This is mood EAE, called **Cesare**; e.g.

E No friendly person is *one who avoids company.*

A All ascetics are *those who avoid company.*

E ∴ No ascetic is a friendly person.

In the combination EI, the major premise is negative and the minor premise is particular. Therefore, the conclusion will be particular negative. This is mood EIO, called **Festino**; e.g.

E No bores are *interesting people.*

I Some poets are *interesting people.*

O ∴ Some poets are not bores.

RULES OF FIG. III : The special rules of the third figure are :

1. *The minor premise must be affirmative.*
2. *The conclusion must be particular.*

Proof of Rule 1 : If the minor premise is negative, the conclusion will be negative and the major premise will be affirmative. The negative conclusion will distribute its predicate, the major term. But the major term is not distributed in the major premise (being the predicate of an affirmative proposition). Therefore, to avoid the fallacy of Illicit Major, the minor premise cannot be negative. It must be affirmative.

Proof of Rule 2 : The minor premise, being affirmative, does not distribute the minor term, which stands as its predicate. Therefore, the minor term cannot be distributed in the conclusion. Hence the conclusion must be particular.

VALID MOODS OF FIG. III : On the basis of the above rules, the combinations AE and AO are rejected. The remaining six combinations yield valid conclusion. These are AA, AI, EA, EI, IA and OA.

We have already stated that the conclusion in this figure is a particular. Therefore, from the combination AA, we will get 'I proposition as the conclusion (since the premises are affirmative). This is mood AAI, called **Darapti**; e.g.

A *All women* are bothered about their looks.

A All *women* are those who like to marry.

I ∴ Some beings who like to marry are bothered about looks.

From the combination AI, we shall get 'I' proposition as the conclusion (both premises being affirmative). This is mood AII, **Datisi**; e.g.

A All *rich men are* honoured.

I Some *rich men* are fools.

I ∴ Some fools are honoured.

In the combination EA, the major premise is negative. Therefore, the conclusion will be negative. Since the conclusion is particular (according to the second rule), it will be 'O' proposition. This is mood EAO, called **Felapton;** e.g.

E No *pigs* are able to fly.

A All *pigs* are greedy.

O ∴ Some greedy creatures are not able to fly.

The combination EI consists of negative major premise. Therefore, its conclusion will be negative. It will be 'O' proposition. This is mood EIO, called **Ferison**; e.g.

E No *astrological predictions* are scientific.

I Some *astrological predictions* are those that come true.

O ∴ Some things that come true are not scientific.

In the combination IA, both the premises are affirmative. Therefore, the conclusion with be affirmative. It will be 'I' proposition. This is mood IAI, called **Disamis;** e.g.

I Some *political parties* are those which have good support.

A All *political parties* are organizations which aspire for power.

I ∴ Some organizations which aspire for power are those which have good support.

The combination OA has 'O' proposition as its major premise. Therefore, its conclusion will be 'O'. This is mood OAO, called **Bocardo;** e.g.

O Some *books* are not interesting.

A All *books* are a result of labour.

O ∴ Some things which are a result of labour are not interesting.

RULES OF FIG. IV : The special rules of the fourth figure are as follows :

1. *If the major premise is affirmative, the minor premise must be universal.*
2. *If either of the premises is negative, the major premise must be universal.*
3. *If the minor premise is affirmative, the conclusion must be particular.*

Proof of Rule 1 : The major premise, being affirmative, does not distribute its predicate, which is the middle term. To distribute the middle term, the minor premise must be universal.

Proof of Rule 2 *:* If either premise is negative, the conclusion will be negative. The negative conclusion will distribute its predicate, which is the major term. The major term stands as subject of the major premise. Therefore, to distribute it, the major premise must be universal.

Proof of Rule 3 : If the minor premise is affirmative, it will not distribute its predicate, which is the minor term. Therefore, the minor term cannot be distributed in the conclusion. Hence the conclusion must be particular.

VALID MOODS OF FIG. IV : On the basis of the above rules, the combinations AI, AO and OA are rejected. Thus, there are five combinations which yield valid moods. These are AA, AE, EA, EI and IA.

From the combination AA, we shall get 'I' proposition as the conclusion (as per Rule 3). This is mood AAI, called **Bramantip;** e.g.

A All moderate exercises are *beneficial to health.*

A *All things beneficial* to *health* are approved by the Moral Code.

I ∴ Some things approved by the Moral Code are moderate exercises.

The combination AE consists of one negative premise. Therefore, its conclusion will be negative. It will be 'E' proposition. (The minor term is distributed in the minor premise and, therefore, it can be distributed in the conclusion.) This is mood AEE, called **Camenes**; e.g.

A All businessmen are *self-confident.*

E No *self-confident person* is easily discouraged.

E ∴ No being who is easily discouraged is a businessman.

From the combination EA, we shall get 'O' proposition as the conclusion. (According to Rule 3, the minor premise being affirmative, the conclusion will be particular. As the major premise is negative, the conclusion will be negative.) This is mood EAO, called **Fesapo**; e.g.

E No American is a *slave.*

A All *slaves* are those who want freedom.

O ∴ Some people who want freedom are not Americans.

In the combination EI, the major premise is negative and the minor premise is particular. Therefore, the conclusion will be O. This is mood EIO, called **Fresison;** e.g.

E No cripple is a *strong person.*

I Some *strong persons are* those who hate to work.

O ∴ Some persons who hate to work are not cripples.

From the combination IA, we shall get 'I' proposition as the conclusion. This is because both the premises are affirmative and the major premise is particular. This is mood IAI, called **Dimaris;** e.g.

I Some virtuous persons are *bores.*

A *All bores* are those who lack sympathetic imagination.

I ∴ Some persons who lack sympathetic imagination are virtuous.

The nineteen valid moods are summarized in the following table :

Figure	Moods
First Figure	Barbara, Celarent, Darii, Ferio
Second Figure	Cesare, Camestres, Baroco, Festino
Third Figure	Darapti, Disamis, Datisi, Felapton, Bocardo, Ferison
Fourth Figure	Bramantip, Camenes, Dimaris, Fesapo, Fresison

The vowels in the names of the moods indicate the constituent propositions. The first vowel stands for the major premise, the second vowel for the minor premise, and the third vowel for the conclusion.

8. ENTHYMEMES

In everyday life we do not express our reasonings fully. Often, syllogisms are expressed without stating all the three constituent propositions. Part of the reasoning is understood by implication. Such reasonings are called enthymemes.

An enthymeme is a syllogism in which some of the constituent propositions are suppressed. What is suppressed may be the major premise, the minor premise or the conclusion. Sometimes only one proposition has the force of syllogism. That is to say, sometimes two propositions are suppressed.

Depending upon what is suppressed, enthymemes are said to be of **four kinds.** These are enthymemes of the First Order, the Second Order, the Third Order, and the Fourth Order. When the major premise is suppressed, the enthymeme is said to be of the first order. When the minor premise is suppressed, the enthymeme is said to be of the second order. When the conclusion is suppressed, it is said to be of the third order. When only one proposition has the force of syllogism, the enthymeme is of the fourth order. To take examples :

In the argument *"She is too sweet to be cunning"*, the major premise is suppressed. Therefore, this is an enthymeme of the first order. We shall express it fully.

No sweet person is cunning.

She is sweet.

∴ She is not cunning.

Take the argument *"Bees are useful little insects, since all insects that gather honey are useful."* In this argument the minor premise is suppressed. Therefore, this is an enthymeme of the second order. When fully expressed, it will be :

All insects which gather honey are useful little insects.

All bees are those which gather honey.

∴ All bees are useful little insects.

In the argument *"No industrial city is a health resort and Bombay is an industrial city"*, the conclusion is suppressed. Therefore, this is an enthymeme of the third order. In its logical form, it will be :

No industrial city is a health resort.

Bombay is an industrial city.

∴ Bombay is not a health resort.

The proposition *"After all, judges are men"* has the force of syllogism. It states that judges are men and, therefore, they are liable to error. This is an enthymeme of the fourth order. When fully expressed, it will be :

All men are liable to error.

All judges are men.

∴ All judges are liable to error.

9. TESTING VALIDITY OF SYLLOGISMS

Generally, syllogisms are not given in the strict logical form. The conclusion may occur at the beginning, or it may occur at the end. Often the premises too are not in the logical order. Sometimes the minor premise occurs before the major premise. To test the validity of a syllogistic argument, we have to express the syllogism in its strict logical form. To do so, we have to find out the conclusion. The premise in which the subject of the conclusion occurs is the minor premise, and the premise in which the predicate of the conclusion occurs is the major premise.

Conclusion is usually indicated by expressions like *"therefore"*, *"hence"*, *"thus"*, *"so"* and *"it follows"*. If none of these expressions occurs, then we have to find out the premises. If we are able to find out the premises, what remains will be the conclusion. Premises are indicated by expressions like *'for"*, *"because"*, *"as"*, *"when"* and *"since"*.

The quality and quantity of the constituent propositions have to be determined, and propositions are to be expressed in their strict logical form.

After a syllogism is reduced to its logical form, we have to apply the general rules of syllogism, and find out whether the argument is valid. We shall take some examples.

1. Starches contain no nitrogen. Some foods are not starches and, therefore, some foods do not contain nitrogen.

   E No *starches* are those which contain nitrogen.

   O Some foods are not *starches*.

   O ∴ Some foods are not those which contain nitrogen.

   As this argument contains two negative premises, it commits the *fallacy of Negative Premises*. Therefore, it is invalid.

2. Every government depends upon the consent of people. Since absolute monarchy is a government, it depends upon the consent of people.

   A All *governments* are those that depend upon the consent of people.

   A All absolute monarchies are *governments*.

   A ∴ All absolute monarchies are those that depend upon the consent of people.

   This is a valid argument. It is in mood AAA (Barbara) of the first figure. **(For testing validity, stating the name of the mood is not necessary.)**

3. Most scientists are well-trained. Since no scientist is untrained, it follows that most well-trained persons are untrained.

   E No *scientists* are untrained.

   A Some *scientists* are well-trained.

   A ∴ Some well-trained persons are untrained.

   This syllogism is invalid, because the major premise is negative, but the conclusion is affirmative.

4. We have to admit that Jayshree is a precious stones, for she is a jewel and every jewel is a precious stone.

   A All *jewels* are precious stones.

   A Jayshree is a *jewel*.

   A ∴ Jayshree is a precious stone.

   In this syllogism the middle term 'jewel' is used in two senses. In the major premise "jewel" is a kind of precious stone; in the minor premise it means a good person. Therefore, the syllogism commits the fallacy of Ambiguous Middle. Hence it is invalid.

5. Some thieves are saintly, for every thief is a man and some men are saintly.

   I Some *men* are saintly.

   A All thieves are *men*.

   I ∴ Some thieves are saintly.

This argument commits the fallacy of Undistributed Middle. The middle term 'men' is neither distributed in the major premise nor in the minor premise. It is invalid.

6. If every wealthy man is dishonest and no wealthy man is a philosopher, it follows that no dishonest man is a philosopher.

   E No *wealthy men* are philosophers.

   A All *wealthy men* are dishonest.

   E ∴ No dishonest men are philosophers.

   This argument commits the fallacy of Illicit Minor. The minor term "dishonest men" is not distributed in the minor premise, but it is distributed in the conclusion. Therefore, the argument is invalid.

7. Living things change. Since some compounds are not living, they do not change.

   A All *living things* are those that change.

   O Some compounds are not *living things*.

   O ∴ Some compounds are not those that change.

   This argument commits the fallacy of Illicit Major. The major term "things that change" is not distributed in the major premise, but it is distributed in the conclusion Therefore, the argument is invalid.

SUMMARY

Syllogism is a mediate inference in which the conclusion is deduced from two premises. The premise in which the major term occurs is the major premise, and that in which the minor term occurs is the minor premise.

The middle term is the common element between the two premises. It is because of the middle term that the conclusion can be deduced from the premises. Not only this, if the middle term remains undistributed in both the premises, the conclusion cannot be drawn.

Rules : There are seven general rules of syllogism. These may be broadly classified into rules of structure, rules of distribution of terms and rules of quality.

Figures : With regard to the position of the middle term, syllogisms are classified into four forms. These are called figures of syllogism. Each figure has certain special characteristics.

Moods : Forms based upon the quality and quantity of the constituent propositions are called moods. There are 19 valid moods if we consider the premises alone, and 24 valid moods if we consider the conclusion too. Moods can be determined, either by applying the general rules (and corollories) of syllogism or by applying the special rules of figures.

Enthymemes and Sorites : When some of the constituent propositions of a syllogism are suppressed, it is called an **enthymeme.** When the conclusion follows from three or more premises, the argument is called **sorites.**

TEST QUESTIONS

1. What is syllogism ? Explain the function of the middle term in it.
2. Explain the 'figure' and 'mood'. How are valid moods determined?
3. State and prove the special rules of the four figures.
4. Point out, with reference to the rules and corollaries of syllogism, why the following moods are invalid.

(Some moods violate more than one rule. In such cases, all the rules including corollaries must be stated.)

(i) AAE, (ii) AIA, (iii) EEA, (iv) III, (v) AOA, (vi) IEO, (vii) AEI, (viii) OEO, and (ix) OIO.

5. Point out, with reference to the general rules and corollaries of syllogism, whether the following moods in the first figure are valid :

   (i) AEE, (ii) OAO, (iii) AOO, (iv) IAI, (v) AEO, (vi) IEO, (vii) AAI, and (viii) EAO.

6. Determine, with reference to the rules and corollaries of syllogism, whether the following moods are valid in the second figure :

   (i) AAA, (ii) AII, (iii) IEO, (iv) OAO, (v) AAI, (vi) IAI, (vii) AEO and (viii) EAE.

7. Point out with reference to the rules and corollaries of syllogism, whether the following moods are valid in the third figure :

   (i) EAE, (ii) AOO, (iii) AAA, (iv) IEO, (v) AEE, (vi) AEO, (vii) IAI and (viii) OAO.

8. Point out, with reference to the rules and corollaries of syllogism, whether the following moods are valid in the fourth figures :

   (i) AOO, (ii) AII, (iii) EAE, (iv) AAA (v) IEO, (vi) OAO, (vii) AEE and (viii) AAI.

9. From the general rules of syllogism, determine what type of valid conclusion, if any, can be drawn from the following premises :

   (i) AA, (ii) AE, (iii) EI, (iv) IE, (v) IA, (vi) AI, (vii) OA and (viii) IO.

10. Point out whether the following statements are true or false :

    1. If the premises of a valid syllogism are false, the conclusion must be false.
    2. In a valid syllogism, if the major term is distributed in the major premise, it must be distributed in the conclusion.
    3. If both the premises of a valid syllogism are universal, the conclusion must be universal.
    4. If the major premise of a valid syllogism is affirmative, the conclusion must be affirmative.
    5. If the minor premise of a valid syllogism is particular, the conclusion cannot be universal.
    6. In a valid argument in the first figure, the minor premise cannot be negative.
    7. In a valid argument in the second figure, the conclusion can be affirmative.
    8. The major term occurs only in the major premise.

11. Rewrite the following statements if they are incorrect :

    1. In a valid syllogism, if the major term is distributed in the conclusion, it must be distributed in the major premise.
    2. In a valid syllogism if the minor term is distributed in the minor premise, it must be distributed in the conclusion.
    3. If the conclusion of a valid syllogism is particular, both the premises must be particular.
    4. If the conclusion of a valid syllogism is false, both the premises must be false.
    5. If the minor premise of a valid argument in the fourth figure is affirmative, the conclusion must be particular.
    6. In a valid argument in the first figure, the minor premise can be negative.
    7. In a valid argument in the second figure, the major premise cannot be negative.

8. In a valid argument in the third figure, the minor premise must be affirmative.

12. Fill in the blanks with appropriate alternatives :

1. Syllogism is a _____ inference. (immediate/mediate/relational)
2. If the major term is distributed in its premise, but not in the conclusion, the syllogism is _____ . (valid/invalid)
3. In a valid syllogism if the major premise is particular, the minor premise _____ be negative. (may/ must/cannot)
4. In a valid argument in the first figure, the major premise must be _____. (affirmative/negative/universal/particular)
5. In a valid argument in the second figure, the conclusion must be _____. (affirmative/negative/universal/particular)
6. In a valid argument in the third figure, the minor premise must be _____. (affirmative/negative/universal/particular)
7. In a valid argument in the fourth figure, if the major premise is affirmative, the minor premise must be _____. (affirmative/negative/universal/particular)

13. Bring the following to the strict logical form of syllogism and test their validity :

1. Every parapsychologist believes in extra-sensory perception. No one who believes in extra-sensory perception is an experimental psychologist. Therefore, every experimental psychologist is not a parapsychologist.
2. A few persons who take exercises are unhealthy, because a few anaemic persons do not take exercises and every anemic person is unhealthy.
3. Picasso is a painter. Some painters play chess. Therefore, Picasso played chess.
4. A scientist is never superstitious. Since several teachers are superstitious, several teachers are not scientists.
5. We know that radio plays always provide escape from boredom and whatever provides escape from boredom reduces misery. From this it follows that all things that reduce misery are radio plays.
6. A strike causes hardship. Many strikes are difficult to resolve. Hence many things difficult to resolve cause hardship.
7. No pilot is poorly paid, for no navigator is a pilot and no navigator is poorly paid.
8. Any pain should be avoided. Since Pravin is in pain, he should be avoided.
9. No medicines that can be purchased without a doctor's prescription are habit-forming drugs. Since some intoxicants can be purchased without a doctor's prescription, they are not habit-forming drugs.
10. This syllogism is valid, for all invalid syllogisms commit an illicit process and this syllogism commits no illicit process. (Here "this syllogisms is valid" is the conclusion. But since the terms have to be kept the same, the conclusion will be taken as "This syllogism is not invalid.)
11. Some epics cannot be good poems, for all epics have a hero and some good poems do not have a hero.
12. A few horses are spirited animals. All spirited animals are difficult to manage. Therefore, a few beings who are difficult to manage are horses.

13. Some women are not good citizens, since all good citizens vote and some women do not.
14. Ill-managed business is always unprofitable. Railways are never ill-managed. So it follows that railways are never unprofitable.
15. All drunkards are short-lived. Since no priest is a drunkard, no priest is short-lived.
16. All mistakes are forgivable. Some mistakes are not lucky. So some lucky things are not forgivable.
17. Popular poetry is never obscure. Since all good poetry is obscure, it is not popular.
18. Curious cats often die young. A majority of bold cats are curious. Therefore, a majority of bold cats die young.
19. All rare things are valuable. All valuable things are expensive. Therefore, some expensive things are not rare. (In this syllogism, the conclusion is negative, while the premises are affirmative. According to the rules of syllogism, when both the premises are affirmative, the conclusion must be affirmative. Therefore, this syllogism commits a fallacy. The fallacies of this kind thave not received a distinct name. However, this may be called the fallacy of drawing negative conclusion from affirmative premises.)
20. No one who is frustrated is satisfied. This follows from the fact that every pessimist is frustrated and no satisfied person is a pessimist.
21. Every robber leads a risky life. No one who leads a risky life is easy to trap. Therefore, no one who is easy to trap is a robber.
22. No learned act is innate and every conditioned reflex is learned. So it follows that no innate act is a conditioned reflex.
23. Any war is risky and any political experiment is risky. Therefore, any war is a political experiment.
24. An exact science is always accurate. Since meteorology is never accurate, it is not an exact science.
25. Some persons who study the stock market do not make errors, for some businessmen do not study the stock market and every businessman makes errors.
26. No gorilla is peace-loving. Everyone who is peace-loving is welcome. Therefore, a gorilla is never welcome.
27. Prudent rulers are generally benevolent. Benevolent persons are generally admired. Therefore, prudent rulers are generally admired.
28. Every spinster is a woman and every woman desires to marry. Hence everyone who desires to marry is a spinster.
29. No baboon is beautiful. All beautiful creatures are admired. Therefore, none who is admired is a baboon.
30. This man is a bachelor, because he has no wife.

CHAPTER – 10

DEDUCTIVE PROOF

DO YOU KNOW THAT ......

- *If someone offers you a bride and a bungalow, logic is on your side if you were to welcome the bride and refuse the bungalow?*
- *If you are a musician, logic permits you to say that you are either a musician or a magician?*
- *When a school-going child says "2+ 3" is the same as "3 + 2" he is using a rule of logic?*
- *The rule of replacement says, "I shall offer you equal value for anything you present?*
- *DeMorgan laws are like a magician's wand–transforming "or" into "and", or "and" into "or"?*
- *You can prove your argument by disproving your apponent?*

1. DEDUCTIVE PROOF

A deductive proof is a formal proof in which the validity of an argument is established by deducing the conclusion from its premises by a sequence of (valid) elementary arguments. These elementary arguments are known to be valid.

Since the conclusion is deduced from its premises by using valid arguments only, this proves that the original argument is valid. A proof of an argument constructed in this way is called a *formal proof of validity*. It is also called a **deductive proof**.

Deductive proofs may be classified into direct deductive proof, conditional proof, and indirect proof.

Direct deductive proof : In a direct deductive proof, the conclusion is deduced from the premises, by a sequence of (valid) elementary arguments. The elementary arguments used for this purpose are called Rules of Inference. Rules of Inference are sub-divided into two groups. The first group consists of Nine Rules and the second group includes rules based on the Rule of Replacement.

2. NINE RULES OF INFERENCE

Before we see how direct deductive method is to be used, we shall state Rules of Inference. In this Section, We shall deal with nine rules which form the first group.

1. Rule of Modus Ponens (M.P.) : If an implicative proposition is true and its antecedent is also true, then its consequent is true. The form of inference is :

$p \supset q$

p

$\therefore\ q$

An argument of this form is to be said to be in the Modus Ponens. This is written in short as "M.P."

2. Rule of Modus Tollens (M.T.) : This rule of inference also deals with an implicative proposition. By denying the consequent of an implicative proposition, we can deny its antecedent. The form of inference is :

$p \supset q$

$\sim q$

$\therefore\ \sim p$

3. Rule of Hypothetical Syllogism (H.S.) : This rule of inference can be applied when all the propositions are implicative. If the consequent of one implicative proposition is the antecedent of another one, we can draw a third implicative proposition as the conclusion. The conclusion will have the antecedent of the first and the consequent of the second implicative proposition. This find of inference is called Hypothetical syllogism. Its form is :

$p \supset q$

$q \supset r$

$\therefore\ p \supset r$

4. Rule of disjunctive Syllogism (D.S.) : This rule enables us to draw a conclusion from a disjunctive proposition and the negation of one of its disjuncts. If the first disjunct is denied, the second can be affirmed in the conclusion. The form of inference is :

$p \vee q$

$\sim p$

$\therefore\ q$

This rule is based on the nature of disjunction. If disjunction is true, then at least one of the disjuncts must be true. So if the first disjunct is denied, the second one must be affirmed.

5. Rule of Constructive Dilemma (C.D.) : In this kind of inference we require two premises. One of these is formed by the conjunction of two conditional propositions. The other one is a disjunctive proposition, which affirms the antecedents of the two conditionals. From these, a disjunctive proposition, which affirms the consequents of the two conditionals, is drawn as the conclusion. The form of inference is :

$(p \supset q) \cdot (r \supset s)$

$p \vee r$

$\therefore\ q \vee s$

6. Rule of Destructive Dilemma (D.D.) : As in the case of Constructive Dilemma, one of the premises is formed by the conjunction of two conditional propositions. But the other premise differs. It denies the consequents of the two conditionals. From these, a disjunctive proposition, which denies the antecedents of the two conditionals, is drawn as the conclusion. The form of inference is :

$(p \supset q) \cdot (r \supset s)$

$\sim q \vee \sim s$

$\therefore \sim p \vee \sim r$

7. Rule of Simplification (Simp.) : This rule is based on the nature of conjunction. If a conjunctive proposition is true, both the conjuncts must be true. *So we can infer the first conjunct as the conclusion from a conjunctive proposition.* The form of inference is :

$p \cdot q$

$\therefore p$

8. Rule of Conjunction (Conj.) : This rule states that *if each of the conjuncts is separately true, the conjunction is true.* While dealing with conjunctive proposition, we have already seen this. The form of the rule is :

p

q

$\therefore p \cdot q$

9. Rule of Addition (Add.) : This rule expresses the fact that *if a proposition is true, then its disjunction with any other proposition will also be true.* The form of inference here is :

p

$\therefore p \vee q$

The Rule of Addition is based on the nature of disjunction. In a true disjunction, at least one disjunct must be true. So if 'p' stands for a true statement, "p v q" will be true. It does not matter whether "q" is true or false.

Note : These nine Rules of Inference cannot be applied to a part of a statement. They can be applied to the whole statement only.

3. FORMAL PROOF OF VALIDITY

We may now state how formal proofs of validity (by the direct deductive method) are constructed. The procedure to be followed is this : The premises are to be listed first; and numbered. The conclusion is to be put to the right of the last column, and separated by a slanting line, thus :

1. ______________
2. ______________
3. ______________ / ∴ ______________

Here 1, 2 and 3 are premises.

From these premises, other propositions (which help to prove the conclusion) are to be obtained by using the Rules of Inference. These propositions are also to be numbered; and the numbering is to begin after the numbers given to the premises. The justification for each of these propositions is to be written to the right. This consists in writing the *Rule of Inference,* and the numbers of the earlier propositions from which the given proposition is obtained. A new proposition so obtained is an additional premise. It can itself be used for deducing other propositions. *In each line of proof, only one Rule of Inference is to be used.*

Let us construct formal proofs of validity for some arguments. These proofs will use the nine Rules of Inference stated above. At the end of Section 4, we shall take some aruments in ordinary language. But here we shall use arguments which have already been symbolized. However, the symbols for simple propositions will be capital letters, and not propositional variables. This is because we are now dealing with actual arguments.

1. 1. C v D
   2. ~C
   3. D É E / ∴ E
   4. D   1, 2, D.S.
   5. E   3, 4, M.P.

Line 4 logically follows (as the conclusion) from lines 1 and 2 by the rule of Disjunctive Syllogism, thus :

Line 1		C v D
Line 2	~	C
Line 4	∴	D

This sequence of three propositions (lines 1, 2 and 4) is a substitution instance of the following argument form (Disjunctive Syllogism) :

p v q
~p
∴ q

Line 5 logically follows from lines 3 and 4 by the rule of Modus Ponens, thus :

Line 3		D ⊃ E
Line 4		D
Line 5	∴	E

Line 5 is the conclusion.

2. 1. A ⊃ B
   2. ~A ⊃ ~C
   3. C v (D · E)
   4. ~B   / ∴ D v F
   5. ~A   1, 4, M.T.
   6. ~C   2, 5, M.P.
   7. D · E   3, 6, D.S.
   8. D   7, Simp.
   9. D v F   8, Add.

The sequence of steps from lines 5 to 9 may be analyzed thus :

Line 5 logically follows from lines 1 to 4 by the rule of Modus Tollens, thus :

Line 1		A ⊃ B
Line 4		~B
Line 5	∴	~A

Line 6 follows from lines 2 and 5 by the Rule of Modus Ponens thus :

Line 2		~A ⊃ ~C
Line 5		~A
Line 6	∴	~C

Line 7 follows from lines 3 and 6 by the Rule of Disjunctive Syllogism, thus :

Line 3		C v (D . E)
Line 6		~C

Line 7	∴	D · E

Line 8 follows from line 7 by the Rule of Simplification, thus :

Line 7		D · E
Line 8	∴	D

Line 9 follows from line 8 by the Rule of Addition, thus :

Line 8		D
Line 9	∴	D v F

Line 9 is the conclusion.

3.

1.	Q v ~R	
2.	~R ⊃ S	
3.	Q ⊃ ~T	/ ∴ ~T v S
4.	(Q ⊃ ~T) · (~R ⊃ S)	3, 2, Conj.
5.	~T v S	4, 1, C.D.

4.

1.	~A v ~B	
2.	C ⊃ A	
3.	D ⊃ B	/ ∴ ~C v ~D
4.	(C ⊃ A) · (D ⊃ B)	2, 3, Conj.
5.	~C v ~D	4,1, D.D.

4. RULE OF REPLACEMENT

For constructing some formal proofs, the nine Rules of Inference are not sufficient. We require an additional rule. This is *the Rule of Replacement*. (It is also called the Principle of Extensionality.) The Rule of Replacement permits us to replace a proposition, or any part of it, by another proposition which is logically equivalent to the replaced part. In this Section we shall deal with ten logical equivalences. These will be used as additional rules of inference. These equivalences are numbered from ten onwards.

This set of rules (i.e. logical equivalences) differs from the first set in two important respects. Firstly, these rules express equivalences. So from the expression on the left hand side, we can deduce that on its right hand side. Or we can go from the expression on the right hand side to the expression on the left hand side. Secondly, as stated above, these rules can be applied to the whole proposition, or to any of its parts. On the other hand, as stated in Section 2, the nine Rules of Inference can be applied to the whole proposition only.

10. DeMorgan's Laws (DeM.) : There are two important equivalences, known as DeMorgan's laws (or DeMorgan's Theorems).

~(p · q) ≡ (~p v ~q)

~(p v q) ≡ (~p · ~q)

We can understand the first DeMorgan's law by considering the nature of conjunction. To negate (or deny) "p · q" is to say that at least one of them is false. The disjunction "~p v ~q" says exactly this.

When we negate the disjunction between "p", "q", we are saying that 'p' is not true; and 'q' is not true. (The disjunction "p v q" is true if at least one of them is true. So when it is false (i.e. denied), "p" is not true and "q" is not true.) The conjunction "~p · ~q" expresses exactly this. The rule of Inference which allows us to go from "~(p v q)" to "~p · ~q" is another DeMorgan's Law.

11. Commutative Laws (Com.) : Commutation is the "turn around" property. That is, the order of the propositions makes no difference. There are two commutative laws. One of these is for disjunction, and the other for conjunction. These are :

$(p \vee q) \equiv (q \vee p)$

$(p \cdot q) \equiv (q \cdot p)$

12. Associative Laws (Assoc.) : Association means grouping together. When all the component propositions are disjuncts, or when all of them are conjuncts, we can group them together any way. These associative laws are :

$[p \vee (q \vee r)] \equiv [(p \vee q) \vee r]$

$[p \cdot (q \cdot r)] \equiv [(p \cdot q) \cdot r]$

13. Distributive Laws (Dist.) : Two other equivalences are known as Distributive laws. These are :

$[p \cdot (q \vee r)] \equiv [(p \cdot q) \vee (p \cdot r)]$

$[p \vee (q \cdot r)] \equiv [(p \vee q) \cdot (p \vee r)]$

From the above equivalences we observe these : First, the propositional connective within brackets in different from the one outside brackets. Second, if the connective within brackets is disjunction, then the connective outside brackets is conjunction; and vice versa.

It will be noticed that, in the Distributive laws, the connective which is within brackets is placed outside.

14. Rule of Double Negation (D.N.) : This rule states that a proposition is equivalent to the negation (or denial) of its contradictory. That is to say, it is equivalent to the negation of its negation. The rule is :

$p \equiv {\sim}{\sim}p$

15. Rule of Transposition (Trans.) : This rule lays down that *in a conditional proposition we may interchange the antecedent and the consequent by negating both of them*. The rule is :

$(p \supset q) \equiv ({\sim}q \supset {\sim}p)$

16. Material Implication (Impl.) : This rule states the definition of implication. The rule is :

$(p \supset q) \equiv ({\sim}p \vee q)$

We may recall that a conditional proposition is true either when its antecedent is false or when its consequent is true. This is what "~p v q" says. (To assert "~p" is to say that "p is false".)

17. Rule of Material Equivalence (or Biconditional) (Equiv) : *This rule gives us two definitions of material equivalence.* These are :

$(p \equiv q) \equiv [(p \supset q) \cdot (q \supset p)]$

$(p \equiv q) \equiv [(p \cdot q) \vee ({\sim}p \cdot {\sim}q)]$

In the second chapter we have stated that the two components of a materially equivalent (or biconditional) proposition imply each other. This is what the first definition of material equivalence brings out. We had further stated that a equivalent (or biconditional) proposition is true either when both of its components are true, or when both of them are false. The second definition expresses this.

18. Rule of Exportation (Exp.) This rule is :

$[(p \cdot q) \supset r] \equiv [p \supset (q \supset r)]$

We see that this rule can be applied when we have a conditional preposition with three components.

19. Rule of Tautology (Taut.) : There are two rules of tautology. One is for disjuncts, and the other for conjuncts. These are :

$p \equiv (p \vee p)$

$p \equiv (p \cdot p)$

These rules require no explanation.

5. DIRECTIONS FOR CONSTRUCTING DIRECT DEDUCTIVE PROOF

No mechanical rules can be laid down for constructing proofs of validity. But we may give, in a general way, some hints.

There are two ways of proceeding for constructing formal proofs of validity. One is to begin with the premises, and deduce conclusions by the Rules of Inference. And as more and more statements become available, the likelihood of seeing the way to arrive at the conclusion would be greater. Another method is to go backwards from the conclu-sion. That is, one may see where the components in the conclusion appear, and how these could be obtained. However, which of these would be the more suitable method depends upon the given argument.

To use the Rules of Modus Ponens, Modus Tollens and Disjunctive Syllogism, in most cases, we require a statement with a single component. When all the statements in the premises are implicative propositions, the rule of Hypothetical Syllogism is likely to be of use.

If the conclusion to be proved is a disjunctive proposition, three likely ways of obtaining it may be considered. These are (1) using Rules of Constructive and Destructive Dilemmas; (2) deducing a proposition with one of the components, and then obtaining a disjunction from it by the Rule of Addition; and (3) deducing an implicative proposition, and then changing it into a disjunctive proposition by the definition of implication.

If the conclusion is a conjunctive proposition, in most cases, we have to prove the conjuncts separately. Then the conjunction is obtained by using the Rule of Conjunction.

If the conclusion is an implication, two likely ways of obtaining it are these : (i) by using the rule of Hypothetical Syllogism; (ii) by dedu-cing a disjunctive proposition, and changing it into an implication by the definition of implication.

If the conclusion is an equivalent proposition, in most cases, we have to deduce each of its components, which are implications, separately. Then, by the Rule of Conjunction, we have to combine them. And, finally, applying the definition of equivalence, we obtain an equivalent proposition from the two implications.

If the components in the conclusion do not appear in the premises, we may be able to deduce the conclusion by following this procedure : (i) Obtain a statement; (ii) obtain the negation of this statement; (iii) from the statement (without negation) obtain a disjunctive proposition containing the conclusion by using the Rule of Addition; and finally, (iv) from the disjunctive proposition, along with the negation of its first component, obtain the conclusion by using the Rule of Disjunctive Syllogism. This procedure is illustrated in the first example solved here.

1. If the movie has good songs, then it is popular. The movie is not popular, but it has good songs. Therefore, the movie will be a great success.

   Using 'G' for "Movie has good songs", 'P' for "Movie is popular", and 'S' for "Movie will be a great success", the argument has been symbolized. A formal proof of validity for it is constructed thus :

   1. $G \supset P$
   2. $\sim P \cdot G$ $\quad / \therefore S$

3.	$\sim P$	2, Simp.
4.	$\sim G$	1, 3, M.T.
5.	$G \cdot \sim P$	2, Com.
6.	G	5, Simp.
7.	$G \vee S$	6, Add.
8.	S	7, 4, D.S.

2. If it has rained heavily and there is high tide, then roads are flooded. There is high tide, but roads are not flooded. Therefore, it has not rained heavily.

   Using 'R' for "It has rained havily", 'T' for "There is high tide", and 'F' for "Roads are flooded", the argument has been symbolized. A formal proof of validity is constructed for it, thus :

1.	$(R \cdot T) \supset F$	
2.	$T \cdot \sim F$	$/ \therefore \sim R$
3.	$R \supset (T \supset F)$	1. Exp.
4.	$\sim\sim T \cdot \sim F$	2, D.N.
5.	$\sim(\sim T \vee F)$	4, DeM.
6.	$\sim(T \supset F)$	5, Impl.
7.	$\sim R$	3, 6, M.T.

3. If he hits below the belt, then the Boxing Association will not allow him to compete. If the Boxing Association will not allow him to compete, then his fans will be disappointed. If he does not hit below the belt, then he will lose the round. Therefore, either his fans will be disappointed or he will lose the round.

   We shall use 'H' for "He hits below the belt", 'B' for "The Boxing Association will allow him to compete", 'F' for "His fans will be disappointed", and 'L' for "He will lose the round". The argument is symbolized, and a formal proof of validity is constructed for it, thus :

1.	$H \supset \sim B$	
2.	$\sim B \supset F$	
3.	$\sim H \supset L$	$/ \therefore F \vee L$
4.	$\sim H \vee \sim B$	1, Impl.
5.	$(\sim H \supset L) \cdot (\sim B \supset F)$	3, 2, Conj.
6.	$L \vee F$	5, 4, C.D.
7.	$F \vee L$	6, Com.

4. If Pakistan makes atom bomb, India will do so. Either India does not make atom bomb or India's defence budget rises. India's defence budget does not rise. If South Africa makes atom bomb, Pakistan too will make it. Therefore, if South Africa makes atom bomb, India will make it. (P, I, D, S)

   The argument is symbolized by using the capital letters indicated within brackets, and a formal proof of validity constructed thus :

1.	$P \supset I$	
2.	$\sim I \vee D$	
3.	$\sim D$	
4.	$S \supset P$	$/ \therefore S \supset I$
5.	$D \vee \sim I$	2, Com.
6.	$\sim I$	5, 3, D.S.

7. ~P 1, 6, M.T.

8. ~S 4, 7, M.T.

9. ~S v I 8, Add.

10. S ⊃ I 9, Impl.

Note : A much simpler proof would have been to obtain the conclusion from 4 and 1 by H.S.

The proof would have been as follows :

5. S ... I 4, 1, H.S.

Now premises 2 and 3 are not required.

5. If nations join world government, they will have to give up sovereignty. If nations join power blocks, then they cannot have independent policies and have to give up sovereignty. Either nations join world government or they join power blocks. Therefore, they have to give up sovereignty. (W,S,P,I)

1. W ⊃ S	
2. P ⊃ (~I . S)	
3. W v P	/ ∴ S
4. (W ⊃ S) . [P ⊃ (~I . S)]	1,2, Conj.
5. S v (~I . S)	4,3, C.D.
6. (S v ~I) · (S v S)	5, Dist.
7. (S v S) · (S v ~I)	6, Com.
8. S v S	7, Simp.
9. S	8, Taut.

6. RULE OF CONDITIONAL PROOF

As stated above, apart from the direct deductive proof, there are two other kinds of formal proofs of validity. These are the Conditional Proof and the Indirect Proof. If the conclusion of an argument is an implicative proposition, we can construct conditional proof of validity. The method of conditional proof is based upon the Rule of Conditional Proof.

The Rule of Conditional Proof enables us to construct shorter proofs of validity for some arguments. Further, by using it, we can prove the validity of some arguments which cannot be proved by using the above 19 rules.

The Rule of Conditional Proof may be expressed in a simple way thus :

By assuming the antecedent of the conclusion as an additional premise, when its consequent is deduced as the conclusion, the original conclusion will be taken to have been proved. To illustrate, let us construct a conditional proof of validity for the following argument :

~A ⊃ B

∴ ~B ⊃ A

The proof may be written as follows :

1. ~A ⊃ B	/	∴ ~B ⊃ A
2. ~B		Assumption
3. ~~A		1, 2, M.T.
4. A		3, D.N.

Here line 2 is the antecedent of the conclusion. It is used as an assumption.

From the premise (line 1) and the assumption (line 2), we have deduced the consequent of the conclusion. However, the proof is not complete. We have yet to arrive at the conclusion. To do so, one more step remains to be taken. This is to write down the conclusion ("~B ⊃ A" above). The proof is now written by adding Line 5, thus :

1. ~A ⊃ B	/	∴ ~B É A
2. ~B		Assumption
3. ~~A		1, 2, M.T.
4. A		3, D.N.
5. ~B ⊃ A		2-4, C.P.

The conclusion (line 5 above) has not been deduced from the assumption. So the conclusion lies outside the scope of the assumption. That is, the scope of the assumption ends with the last line which depends upon it (line 4 above)[1]. To mark this out clearly, the device of a bent arrow may be used. The head of the arrow points at the assumption. The arrow runs down till it reaches the last statement which is deduced on its basis. Then the arrow bends inwards, and discharges (or closes) the assumption. The conclusion (at line 5 above) will lie outside the scope of the assumption. The proof may now be written down, thus :

1.

1 ~A ⊃ B	/	∴ ~B ⊃ A
2. ~B		
3. ~~A		1,2, M.T.
4. A		3, D.N.
5. ~B ⊃ A		2-4, C.P.

The head of the arrow indicates that line 2 is an assumption. So the word "assumption" need not be written as the justification for line 2.

If a conditional proof of validity uses more than one assumption, we are to indicate clearly the scope of each assumption. Consider the following proof :

2.

1 G v H		
2. (F v C) ⊃ D	/	∴ [~G ⊃ (H v R)] . (C ⊃ D)
3. ~G		
4. H		1,3, D.S.
5. H v R		4, Add.
6. ~G ⊃ (H v R)		3-5, C.P.
7. C		
8. C v F		7, Add.
9. F v C		8, Com.
10. D		2,9, M.P.
11. C ⊃ D		7-10, C.P.
12. [~G ⊃ (H v R)] . (C ⊃ D)		6,11, Conj.

Here, the scope of the assumption at line 3 is independent of the scope of the assumption at line 7. But, in the next example, one assumption lies within the scope of the other assumption.

[1] Every assumption in a conditional proof of validity has a limited scope. It never extends to the last line of the proof. (Copi, "Symbolic Logic", 4th Edition, p. 60.)

3.

1	(F · G) ⊃ H	/ ∴ ~H ⊃ [F ⊃ (~G v K)]
2.	~H	
3.	~(F · G)	1, 2, M.T.
4.	~F v ~G	3, DeM.
5.	F	
6.	~~F	5, D.N.
7.	~G	4, 6, D.S.
8.	~G v K	7, Add.
9.	F ⊃ (~G v K)	5-8, C.P.
10.	~H ⊃ [F ⊃ (~G v K)	2-9, C.P.

Here, the assumption at line 5 lies within the scope of the assumption at line 2.

7. RULE OF INDIRECT PROOF

The methods of direct deductive proof and conditional proof have one thing in common. While using them, we deduce the conclusion from the premises. The method of indirect proof is completely different from those. This method is based on the principle of *reductio ad absurdum*. We show that the opposite of what is to be proved leads to an absurdity. That is, it results in contradiction. Now since the negation of the conclusion is impossible (leads to a contradiction), the conclusion is taken to have been proved.

An indirect proof of validity for an argument is constructed by assuming the negation of the conclusion as an additional premise. From this additional premise, along with the original premises, a contradiction is derived. Now a contradiction is a conjunction in which one conjunct is the denial of the other conjunct. Thus, "A · ~A", "~A · ~~A" and "(A v B) · ~(A v B)" are contradictions.

When this method of proof is used, the validity of the original argument is said to follow by the rule of Indirect Proof. We may mention here that the method of Indirect proof can be used irrespective of the nature of the conclusion.

Let us construct an indirect proof of validity for the following arguments :

1. ~A v B
   ~B
   ∴ ~A

The proof is as follows :

1.	~A v B	
2.	~B	/ ∴ ~A
3.	~~A	I.P.
4.	B	1, 3, D.S.
5.	B · ~B	4, 2, Conj.

In the above proof, the expression "I.P." shows that the Rule of Indirect Proof is being used.

2.

1.	D ⊃ E	
2.	F ⊃ E	
3.	D v F	/ ∴ E
4.	~E	I.P.
5.	(D ⊃ E) · (F ⊃ E)	1, 2, Conj.
6.	E v E	5, 3, C.D.
7.	E	6, Taut.

8. E · ~E 7, 4, Conj.

3. 1. (Q v ~P) ⊃ S / ∴ Q ⊃ S
2. ~(Q ⊃ S) I. P.
3. ~(~Q v S) 2, Impl.
4. ~~Q · ~S 3, DeM.
5. ~~Q 4, Simp.
6. Q 5, D.N.
7. Q v ~P 6, Add.
8. S 1, 7, M.P.
9. ~S · ~~Q 4, Com.
10. ~S 9, Simp.
11. S · ~S 8, 10, Conj.

In this argument, the conclusion was an implication. So the method of conditional proof could have been used. (In fact, the proof would have become shorter.) However, our intention was to show that the method of Indirect Proof can be used irrespective of the nature of the conclusion.

8. CONDITIONAL PROOF OF TAUTOLOGY

A tautology (or a tautologous proposition) is always true. It does not matter whether the component propositions are true or false.

We can use the methods of Conditional Proof and Indirect Proof for proving that certain propositions (and propositional forms) are tautologies.

The method of Indirect Proof can be used for proving any tautology whatsoever. But the method of Conditional Proof is limited in its scope. This method can be applied only when a tautology is an implication.

The conditional proof of a tautology involves the same procedure as the conditional proof of an argument. Let us repeat this.

i) The antecedent is to be assumed as an additional premise.
ii) From this, the consequent of the tautology is to be deduced.
iii) The assumption is to be discharged (or closed) by the devise of a bent arrow.
iv) The last line of the proof will be the tautology itself. This will lie outside the scope of the assumption.
v) If the rule of Conditional Proof has been used more than once, the scope of each assumption is to be clearly indicated.

Let us take two tautologies, and prove them by the method of Conditional Proof.

1. To prove that "(P ⊃ Q) ⊃ (~Q ⊃ ~P)" is a tautology.

1 P ⊃ Q
2. ~Q ⊃ ~P 1, Trans.
3. (P ⊃ Q) ⊃ (~Q ⊃ ~P) 1-2, C.P.

2. To prove that "(Q ⊃ R) ⊃ [(P ⊃ Q) ⊃ (P ⊃ R)]" is a tautology.

1 Q ⊃ R
2. P ⊃ Q
3. P ⊃ R 2, 1, H.S.
4. (P ⊃ Q) ⊃ (P ⊃ R) 2 - 3, C.P.
5. (Q ⊃ R) ⊃ [(P ⊃ Q) ⊃ (P ⊃ R)] 1-4, C.P.

9. INDIRECT PROOF OF TAUTOLOGY

As stated above, we can give indirect proof of any tautology. To give Indirect Proof of a tautology, we have to negate the tautology, and assume it as a premise. From this premise, we have to deduce a contra-diction. Let us take some examples :

1. To prove that "$\sim\sim A \equiv A$" is a tautology :

1. $\sim(\sim\sim A \equiv A)$	I.P.
2. $\sim[(\sim\sim A \supset A) \cdot (A \supset \sim\sim A)]$	1, Equiv.
3. $\sim[(A \supset A) \cdot (A \supset A)]$	2, D.N.
4. $\sim(A \supset A)$	3, Taut.
5. $\sim(\sim A \vee A)$	4, Impl.
6. $\sim\sim A \cdot \sim A$	5, DeM.
7. $A \cdot \sim A$	6, D.N.

2. To prove that "$A \vee (A \supset B)$" is a tautology :

1. $\sim[A \vee (A \supset B)]$	I.P.
2. $\sim[A \vee (\sim A \vee B)]$	1, Impl.
3. $\sim A \cdot \sim(\sim A \vee B)$	2, DeM.
4. $\sim A \cdot (\sim\sim A \cdot \sim B)$	3, DeM.
5. $(\sim A \cdot \sim\sim A) \cdot \sim B$	4, Assoc.
6. $\sim A \cdot \sim\sim A$	5, Simp.

SUMMARY

Deductive proofs of validity can be constructed for certain arguments. There are three kinds of deductive proofs. There are the direct deductive proof, the conditional proof and the indirect proof.

Rules of Inference : The direct deductive proof involves the use of 19 rules. These rules are divided into two groups. The first group of nine rules are Rules of Inference. These rules can be used on a statement as a whole. The second group consists of equivalences. These equivalences are used as rules of inference, because the Rule of Replacement (or the Principle of Extentionality) permits us to do so. The second group of rules differs from the first group in two important respects. Firstly, we can infer the expression on the right hand side of the equivalence from the one on the left hand side, and vice-versa. Secondly, these rules can be applied to a statement as a whole, or to any of its parts.

Direct deductive proof and the Conditional proof prove the conclusion itself. On the other hand, in Indirect Proof, we assume the negation of the conclusion as a premise. From this, along with the original premise, we obtain a contraction.

Proof of tautologies : The rules of Conditional and Indirect Proof can also be used to prove that a propositional form, or a proposition, is a tautology. Of these, the rule of Indirect Proof has wider application. It can be used for any tautology whatsoever. But the rule of Conditional Proof can only be used when a tautology is in the form of implication.

TEST QUESTIONS

1. Give reasons for the following :
    1. Why are rules of inference divided into two groups?
    2. Why are rules of Replacement applicable either to a part of a statement or to the whole?
    3. Why are rules of inference divided into two groups?

4. If an implicative statement is true and its antecedent is true, why must its consequent be true?
5. Why are the rules of M.P. and M.T. not applicable to a part of a statement?
6. Why are DeMorgan's laws applicable to the whole statment?
7. In the rules of Exportation and Distribution, why can we proceed from the left hand side to the right hand side, and vice verse?
8. Why is "~(p . q)" equivalent to "~p v ~q"?
9. Why is the law of Commutation said to be called "turn around" property?
10. Why does the rule of D.N. enable us to arrive at the original statement?
11. Why is "p ⊃ q" equivalent to "~p v q"?
12. Why is 'p ≡ q" equivalent to "(p . q) v (~p . ~q)"?
13. Why is "p v q" equivalent to [(p v q) . (p v q)] " ?

2. Give technical terms for the following :
   1. [(p . q) v (~p. ~q)] ≡ (p ≡ q)
   2. [(p . q) ⊃ r] ≡ [p ⊃ (q ⊃ r)]
   3. p ≡ (p . p)
   4. [(p v (q v r)] ≡ [(p v q) v r)
   5. [(p . (q v r)] ≡ [(p . q) v (p . r)]
   6. [(p ⊃ q) . (q ⊃ p) ≡ (p ≡ q)
   7. ~(p v q) ≡ (~p . ~q)
   8. (q v p) ≡ (p v q)
   9. ~~p ≡ p
   10. (p . q) ≡ (q . p)
   11. p ≡ (p v p)
   12. (p ⊃ q) ≡ (~p v q)

3. State whether the following statements are true or false :
   1. If 'P ⊃ Q' is true, then 'P' must be true.
   2. If 'P ⊃ Q' is true and 'Q' is false, then 'P' is false.
   3. If 'P v Q' is true and 'P' is false, then 'Q' is true.
   4. If 'P ⊃ Q' is true and 'Q' is true, then 'P' is true.
   5. If 'P v Q' is true and 'P' is false, then 'Q' is true.
   6. If 'P ⊃ Q' is true and 'P ⊃ R' is true, then 'Q ⊃ R' is true.

4. Fill in the blanks in the following :
   1. Suppose the statement 'N' is true, then the statement 'N v R' is ________.
   2. If the statement : '~A ⊃ ~B' is true, then the statement 'B ⊃ A' is ________.
   3. (p . q) ≡ ________ by the rule of Commutation.
   4. [p . (q v r)] ≡ ________ by the rule of Distribution.
   5. The Rule involved in [(p ⊃ q) v r] ≡ [r v (p ⊃ q)] is ________.
   6. The Rule involved in [~(p ≡ q) v r] ≡ [(p ≡ q) ⊃ r] is ________.
   7. The Rule involved in ~[(p ⊃ q) v r)] ≡ [~(p ⊃ q) . ~r] is ________.
   8. The Rule involved in [(p ⊃ q) · (r v s)] ≡ [(p ⊃ q) . r] v [(p ⊃ q) . s] is ________.
   9. The Rule involved in [(p v q) ⊃ r] ≡ [~(p v q) v r] is ________.
   10. The Rule involved in [(p ≡ ~q) ⊃ ~r] ≡ [~(p ≡ ~q) v ~r] is ________.

11. The Rule involved in $[\sim(p \vee q) \cdot \sim(p \vee q)] \equiv \sim(p \vee q)$ is ______.

5. On the basis of the Nine Rules of Inference, state which of the following argument forms are valid, and which invalid :

[**Note :** A formal proof of validity for valid inferences is not required. The student is merely to say whether the inference is valid. If valid, the Rule of Inference on which its validity depends is to be stated.]

1. $\sim q \vee p$
   $\therefore q$

2. $\sim p \cdot q$
   $\therefore p$

3. $q \vee p$
   $\sim q$
   $\therefore p$

4. $p \supset q$
   $\sim p$
   $\therefore q$

5. $\sim q \supset p$
   $\sim p$
   $\therefore \sim\sim q$

6. $(p \supset q) \cdot (r \supset q)$
   $p \vee r$
   $\therefore q \vee q$

7. $(p \supset \sim q) \cdot (\sim r \supset \sim s)$
   $\sim\sim q \vee \sim\sim s$
   $\therefore \sim p \vee \sim\sim r$

8. q
   $\therefore q \vee r$

9. $\sim p \supset \sim q$
   $\sim q \supset \sim r$
   $\therefore \sim p \supset \sim r$

10. $\sim q \cdot p$
    $\therefore \sim p$

11. $\sim p \supset \sim q$
    $\sim q \supset \sim r$
    $\therefore \sim p \supset \sim r$

12. $p \vee q$
    $\sim p$
    $\therefore \sim q$

13. $\sim p \supset \sim q$
    $\sim p$
    $\therefore \sim q$

14. $(P \vee r) \cdot (q \vee s)$
    $p \vee q$
    $\therefore r \vee s$

6. State which of the following equivalences are correct and which incorrect :

[N.B. : For correct equivalences, name the Rule.]

1. $(p \vee q) \equiv (\sim p \cdot \sim q)$
2. $(\sim p \vee \sim q) \equiv \sim(p \cdot q)$
3. $\sim(p \ldots q) \equiv \sim(\sim p \vee q)$
4. $\sim(\sim p \cdot q) \equiv \sim(\sim p \vee \sim q)$
5. $(p \cdot \sim q) \equiv (q \cdot \sim p)$
6. $(\sim p \vee q) \equiv (q \vee \sim p)$
7. $[(r \vee q) \vee \sim p] \equiv [\sim r \vee (q \vee p)]$
8. $[(\sim p \cdot q) \cdot \sim r] \equiv [(p \cdot \sim q) \cdot \sim r)]$
9. $\sim\sim s \equiv s$
10. $(p \supset q) \equiv (q \supset p)$
11. $[(q \supset p) \cdot (p \supset q)] \equiv (q \equiv p)$
12. $[p \supset (q \supset r) \equiv [(p \cdot q) \supset r]$
13. $(\sim p \vee \sim p) \equiv (\sim p)$

7. State the justification for each step of the formal proof of validity given in the following arguments :

1\.
1. A ⊃ B
2. (~B v D) . ~D
3. ~(~A . E)/ ∴ ~E
4. ~B v D
5. ~D · (~B v D)
6. ~D
7. D v ~B
8. ~B
9. ~A
10. ~~A v ~E
11. A v ~E
12. ~E

2\.
1. (R . Q) ⊃ S
2. ~S v T
3. ~T / ∴ R ⊃ ~Q
4. S ⊃ T
5. (R · Q) ⊃ T
6. ~(R · Q)
7. ~R v ~Q
8. R ⊃ ~Q

3\.
1. F ⊃ (B . G)
2. D ⊃ ~(B . G)
3. ~(E . ~D) . E/ ∴ ~F
4. ~(E . ~D)
5. ~E v ~~D
6. E . ~(E . ~D)
7. E
8. ~~E
9. ~~D
10. D
11. ~(B · G)
12. ~F

4\.
1. A ⊃ B
2. ~(B . C)
3. C / ∴ ~A
4. ~B v ~C
5. ~C v ~B
6. ~~C
7. ~B
8. ~A

5\.
1. (D v E) ⊃ F
2. ~(F . ~G)
3. ~D ⊃ H
4. ~G / ∴ H
5. ~F v ~~G
6. ~F v G
7. G v ~F
8. ~F
9. ~(D v E)
10. ~D · ~E
11. ~D
12. H

6\.
1. (S . T) ⊃ R
2. ~R
3. T / ∴ ~S
4. S ⊃ (T ⊃ R)
5. T . ~R
6. ~~T · ~R
7. ~(~T v R)
8. ~(T ⊃ R)
9. ~S

7\.
1. (~H ⊃ K) ⊃ (N . B)
2. B ⊃ C
3. ~C/ ∴ ~H
4. ~B
5. ~B v ~N

8\.
1. R ⊃ G
2. (G ⊃ H) . ~H
3. ~(~R . S) / ∴ ~S
4. G ⊃ H
5. R ⊃ H

6. $\sim N \vee \sim B$
7. $\sim(N.B)$
8. $\sim(\sim H \supset K)$
9. $\sim(\sim\sim H \vee K)$
10. $\sim(H \vee K)$
11. $\sim H \cdot \sim K$
12. $\sim H$

6. $\sim H \cdot (G \supset H)$
7. $\sim H$
8. $\sim R$
9. $\sim\sim R \vee \sim S$
10. $R \vee \sim S$
11. $\sim S$

8. **Construct a formal proof of validity for each of the following arguments :**

(Use the suggested capital letters for simple statements.)

1. **Either Ranjit does not get a scholarship or he will be go to Europe. Ranjit has got a scholarship. Either he does not go to Europe or he will visit Napales. Therefore, Ranjit will visit Napales. (S,E, N)**
2. **Either he gets admission to Commerce or he gets admission to Arts. If he gets admission to Arts, then he will take either Logic or Psychology. He does not get admission to Commerce. He will not take Psychology. Therefore, he will take Logic. (C,A, L, P)**
3. **If this argument is not invalid, then its conclusion is not false. Either this argument is not invalid or the proof for it is wrong. The conclusion of this argument is false. Therefore, the proof for it is wrong. (I, C, P)**
4. **If we trust science then we progress; and if we have faith in religion then we have mental peace. Either we trust science or we have faith in religion. If either we progress or have mental peace, then we shall lead a happy life. Therefore, we shall lead a happy life. (S, P, R, M, H)**
5. **If either nations join World Government or they join power blocks, then they will give up independent policies. If nations want security, then they join World Government. Nations will not give up independent policies. Therefore, nations do not want security. (W, P, I, S)**
6. **If bat is a mammal, then either it breast-feeds its young or it is cold-blooded. It is false that bat is not a mammal. But is not cold-blooded. Therefore, bat breast-feeds its young. (M,B, C)**
7. **If Shakespeare wrote Hamlet, then he was not a musician. If Shakespeare was not a film critic, then he wrote Hamlet. If Shakespeare was a film critic, then he did not write plays. Shakespeare wrote plays. Therefore, Shakespeare was not a musician. (H, M, F, P)**
8. **Either Taj Mahal is beautiful and is at Agra, or it is a national monument. If Taj Mahal is beautiful and is at Agra, then it was built by Shah Jehan. If Taj Mahal is a national momument, then it was built by Shah Jehan. Therefore, Taj Mahal was built by Shah Jehan. (B, A, N, S)**
9. **If he can climb, then he will go hiking. If he can climb, then he will go to Matheran. Either he will not go hiking or he will not go to Matheran. Therefore, either he will go to Delhi or he cannot climb. (C, H, M, D)**
10. **If we open separate schools for girls, then farmers' daughters will go to school. Either farmers' daughters will not go to school or they will learn housekeeping. Therefore, either farmers' daughters will learn housekeeping or we do not open separate schools for girls. (G, F, H)**
11. **Either Taj Mahal is a national monument or it is beautiful. If Taj Mahal is beautiful, then it is a modern building. It is not a modern building. Therefore, if it is not a national monument, then it was built by Shah Jehan. (N, B, M, S)**

12. If Russell was not a scientist, then either he was not respected or he was not a genius. If Russell was a great logician, then he was respected. If Russell was a great musician, then he was a genius. Russell was not a scientist. Therefore, if Russell was a great logician, then he was not a great musician. (S, R, G, L, M)

13. If Panchtantra contains fables, then it is interesting to read. Either Panchatantra contains fables or Upanishads contain fables. Upanishads do not contain fables. Therefore, if Panchtantra is not interesting to read, then it is a scientific work. (F, I, U, S)

14. Either workers do not get bonus or there is increase in production. If there is increase in production, then prices come down. Therefore, if prices do not come down, then workers do not get bonus. (B, I, P)

15. If science gives knowledge of facts, then it is worth studying; and if science improves living conditions, then it will help our country. If science makes men selfish, then either it is not worth studying or it will not help our country. Science makes men selfish. Therefore, if science gives knowledge of facts, then it does not improve living conditions. (F, W, I, H, S)

16. Either Radha did not have influence or she got the job. Either she did not get the job or she was interested in studying further. Therefore, if Radha was not interested in studying further, then she did not have influence. (I, J,S)

17. If the lecture is not boring, then students like to attend classes. If the lecturer reads from notes, then the lecture is to the point. Either the lecture is not boring or the lecture is not to the point. Students do not like to attend classes. Therefore, the lecturer does not read from notes and students do not like to attend classes. (B, C, R, P)

18. If we trust science, then we shall have progress. If we trust science, then we shall explore outer space. We trust science. Therefore, we shall have progress and explore outer space. (S, P, E)

19. If I keep the lamp burning, then I can study hard. If either I do not keep the lamp burning or I go to bed early, then I shall fail. I cannot study hard. Therefore, I shall not keep the lamp burning and shall fail. (L, S, B, F)

20. If hawkers have strong union, then they will get stalls. Hawkers will not move from the main roads and they will not get stalls. If they will not move from the main roads, then people will find difficulty in walking. Therefore, hawkers do not have a strong union and people will find difficulty in walking. (U,S, M,D)

9. Construct a conditional or indirect proof of validity for the following arguments :

a)
1. $F \supset G$
2. $J \supset \sim G \ / \therefore F \supset \sim J$

b)
1. $\sim K \vee L$
2. $\sim L \vee M \ / \backslash \sim M \supset \sim K$

c)
1. $D \supset F$
2. $F \supset (D \supset H)$
3. $G \supset D \ / \therefore G \supset H$

d)
1. $(F \vee G) \supset (H . D)$
2. $D \supset \sim E$
3. $E \ / \therefore \sim F$

e)
1. $A \supset C$
2. $\sim(\sim D . C)$
3. $E \vee A$
4. $\sim D \ / \therefore E$

f)
1. $(B . D) \vee E$
2. $C \supset \sim E$
3. $F \supset \sim E$
4. $C \vee F \ / \therefore B . D$

g)
1. $(R . S) \supset T$
2. $\sim T$
3. $S / \therefore \sim R$

h)
1. $\sim Q \supset P$
2. $\sim P \supset S$
3. $\sim Q \vee \sim S \ / \therefore P$

i) 1. $A \vee (B \cdot C)$
2. $A \supset C$ / ∴ $\sim B \supset C$

j) 1. $A \supset B$
2. $C \supset D$ / ∴ $(A \cdot C) \supset (B \cdot D)$

k) 1. $A \vee \sim B$
2. $A \vee \sim C$ / ∴ $(B \vee C) \supset A$

l) 1. $K \vee L$
2. $(K \vee M) \supset (N \cdot P)$
3. $\sim P$ / ∴ L

m) 1. $(B \vee C) \supset \sim A$
2. $D \supset A$
3. B / ∴ $D \supset \sim E$

n) 1. $\sim C \supset (E \supset \sim D)$
2. $F \vee \sim C$
3. $D \vee \sim G$ / ∴ $\sim F \supset (E \supset \sim G)$

o) 1. $P \vee (Q \supset S)$
2. $P \supset R$
3. Q / ∴ $\sim R \supset \sim(P \vee \sim S)$

p) 1. $(\sim G \supset H) \supset J$
2. $K \supset G$
3. J / ∴ K

10. Use the method of conditional proof or indirect proof to verify that the following are tautologies :

1. $P \supset (P \vee Q)$
2. $(Q \supset P) \supset (\sim P \supset \sim Q)$
3. $(P \cdot Q) \supset P$
4. $(P \vee Q) \vee (\sim P \vee Q)$
5. $(P \supset Q) \supset [P \supset (P \cdot Q)]$
6. $[(P \supset Q) \cdot (Q \supset R)] \supset (P \supset R)$
7. $\sim P \vee (P \supset P)$
8. $[S \supset (T \supset R)] \supset [R \vee \sim(S \cdot T)]$
9. $P \supset (Q \supset P)$
10. $A \vee (A \supset B)$
11. $[(\sim A \vee B) \cdot (\sim B \vee C)] \supset (A \supset C)$
12. $(Q \supset R) \supset [(P \vee Q) \supset (P \vee R)]$
13. $P \vee (P \supset P)$
14. $[(\sim P \vee Q) \supset R] \supset (\sim R \supset \sim Q)$
15. $\sim A \vee (\sim A \supset \sim A)$
16. $(P \supset Q) \vee (Q \supset P)$

CHAPTER – 11

NON–FORMAL FALLACIES

DO YOU KNOW THAT.....

- *You can't prove God's existence by quoting Gita, nor can you justify caste system by doing so?*
- *What is true of the whole need not be true of its parts?*
- *When you accept an actor's recommendation about a cigarette, you are not using your reasoning ability?*
- *If a smuggler detained under MISA pleads for our pity due to his ill-health, he wants us to commit a logical error?*
- *When a person in good health claims the facilities he enjoyed while he was sick, he is being illogical?*
- *When you call someone dirty names and then don't believe him, you are being irrational?*

1. WHAT IS A FALLACY?

The common man's interest in logic is due to his desire to find out errors in reasoning. Logicians use the term "fallacy" for an error in reasoning. Now logic deals primarily with valid forms of inference. But logicians have also determined what fallacies are committed in everyday reasonings.

An argument is said to commit a fallacy when it appears to establish a conclusion, but does not really do so. Thus, if we are not deceived by faulty reasoning, no fallacy arises. Therefore, it is said that the notion of fallacy is psychological.

Eaton classifies fallacies into three groups. These are :

i) fallacies due to inattention to logical form;

ii) fallacies due to inattention to the ambiguities of language; and

iii) fallacies due to inattention to the other features of an argument.

The first kind of fallacies are called formal fallacies. *Formal fallacies* arise due to inattention to logical form. Thus, when any rule of inference is violated, we get a formal fallacy. The other two kinds of fallacies are *non-formal fallacies. These fallacies arise either when words are used ambiguously or when some relevant feature of the* *argument is ignored*. In the remaining Sections of this Chapter, we shall deal with some of the common non-formal fallacies.

2. FALLACIES DUE TO INATTENTION TO THE AMBIGUITIES OF LANGUAGE

1. Equivocation : This fallacy arises due to *the ambiguous use of a word or a phrase in an argument*. Now, a word or a phrase is equivocal when it can be understood in two or more senses. While dealing with syllogism, we have seen some of the varieties of this fallacy. The fallacies of *Ambiguous Major, Ambiguous Minor* and *Ambiguous Middle* arise from the equivocal use of terms in a syllogism. However, equivocation is a common source of error. It is not restricted to syllogism. To take examples of this fallacy.

1. Modern surgery is a miracle of science; therefore, man has progressed.

In this argument, the term "progress" is ambiguous.

2. Many things are more difficult than to do nothing. Nothing is more difficult than to walk on one's head. Therefore, many things are more difficult than to walk on one's head.

In this argument, the word "nothing" is ambiguous. In one case it means "remaining idle"; and in the other case it means "none of the things".

2. Amphiboly : This fallacy arises due to *ambiguous construction of a sentence*. In this fallacy the sentence has two or more meanings. This fallacy differs from the fallacy of equivocation in that no word or phrase is ambiguous. The construction of the sentence is faulty.

1. The house was built as a present for Mrs. X, who married in 1967, at a cost of ₹ 50,000.

The construction of this sentence is ambiguous. The sentence is capable of two interpretations. It may mean that "Mrs. X married at a cost of ₹ 50,000", or it may mean that "the house was built at a cost of ₹ 50,000."

2. Advertisement : "PET HOSPITAL. Dogs called for, bathed, fleas removed, and returned to you for ₹ 5."

This may mean fleas are removed and returned to you for ₹ 5, or it may mean that dogs are sent back after removing fleas for a charge of ₹ 5.

3. Account : This is *ambiguity arising from emphasis* placed upon a certain word or phrase in a sentence. This fallacy arises mainly in conversation.

The sentence "He said, saddle me the ass. And they saddled him" involves this fallacy. If the emphasis is placed on the word "me", the fallacy of accent will be committed. If the emphasis is on "the ass", there would be no fallacy.

4. Figure of Speech (or Paronymous terms) : This fallacy arises when we consider that *words derived from the same root have the same meaning*,. e.g.

1. Since men are able to reason and he is a man, he is reasonable.

Here the word "reasonable" does not have the same meaning as the expression "able to reason", though the words "reason" and "reasonable" are derived from the same root.

2. Pity is divine. His condition is pitiable. Therefore, his condition is divine.

The meaning of the word "pitiable" is different from the meaning of the word "pity". "Pitiable" means so miserable that he deserves pity, while "pity" is a noble emotion.

5. Fallacy of Division and Fallacy of Composition : A group (class) possesses certain qualities which its members do not share. In a similar way, the qualities of a whole need not be possessed by its parts. Conversely, individual members may have qualities which may not be possessed by the group (class); and the qualities of the parts need not be possessed by the whole.

When we say that a quality is possessed by a class, as a collection of members, we are using the class term *collectively*. On the other hand, when we state a quality which is possessed by each member, separately, we are using the class term *distributively*. In the proposition "All the fish in the basket weigh ten pounds", the term "fish" is used collectively. The proposition states that all fish, together, have this weight. Similarly, in the proposition "Two wrongs do not make a right", we are denying the quality of becoming right to two wrongs, jointly. On the other hand, in the proposition "Sherlock Holmes stories are interesting", the quality of being interesting is possessed by each Sherlock Holmes story, separately.

Fallacy of Division : Sometimes we argue that *what is true of a group (class) is true of its members; or what is true of a whole is true of its parts.* When we do so, our reasoning commits the fallacy of division. Thus, we see that there are two ways in which this fallacy arises. First, when the argument proceeds from the collective use of a term to its distributive use. That is, when we say that what is true of a group is true of each member. Second, when we argue that a quality which is possessed by a whole, as such, is also possessed by its parts. To take examples :

i) A pack of wolves can easily kill a leopard. Therefore, a wolf is stronger than a leopard.

Here the argument proceeds from "a pack of wolves", taken together, to each wolf separately.

ii) The Assembly voted in favour of prohibition. Being a member of the Assembly, you also must have voted in its favour.

The argument proceeds from "Assembly", as a group, to a member of the Assembly. What is true of the Assembly may not be true of each of its members. It is possible that a particular member may have voted against a particular bill, or he may not have voted at all.

iii) A cocktail of fruit juices is tasty. It is prepared from fruit juices. So every fruit juice in it must be tasty.

Here the argument proceeds from a whole to its parts. What is true of cocktail, as a whole, need not be true of every juice in it. So the argument commits the fallacy of division.

Fallacy of Composition : In this fallacy, the argument proceeds in the opposite way from that in the fallacy of division. *When we say that a quality which is possessed by a member (or members) is also possessed by the group,* we commit the fallacy of composition. Also, when we assert that a *quality which is possessed by a part (or parts) is also possessed by the whole,* we commit this fallacy. In the former case (i.e. when we proceed from a member to the class), the argument proceeds from the distributive use of a term to its collective use.

The name of the fallacy itself indicates what happens in it. The term *"composition"* clearly points out that we are joining or uniting. That is to say, we are asserting in the conclusion something about a group, or a whole, on the basis of what is known to be true of its members, or parts. To take examples :

i) Humanity is bound to die out, for are not all men mortal?

Here the argument proceeds from the distributive use of the term "man" to its collective use. Each man, by himself, is bound to die. From this it does not follow that all men will die at the same time.

ii) Mango pickles, pineapple juice and chocolate cream are all tasty. A mixture of these is bound to be still more tasty.

Here what is true of each thing, separately, is considered to be true of the mixture (or whole). So the argument commits the fallacy of composition.

3. FALLACIES DUE TO INATTENTION TO ARGUMENT

1. Fallacy of Accident : We accept certain general principles. But almost every general principle has exceptions. That is, there are special cases, or circumstances, when these principles do not apply. Sometimes we argue that *what is true in general is also true in a special case; or that what is true under normal circumstances is also true under special (or exceptional) circumstances.* In such cases our reasoning is bad; it commits a fallacy. This fallacy is called the fallacy of accident. We agree that it is good to take exercise. But we cannot infer from this that it is good to do so when one is suffering from fever. Illness is a special circumstance; and so the fallacy of accident is committed. In the following examples also this fallacy is committed :

i) We ought not to go to war, because it is wrong to shed blood.

In general, it may be wrong to shed blood; but this does not mean that it is so in war. A nation may be justified in going to war. For instance, the war may be in self-defence.

ii) You mustn't use brandy when you catch cold, for you know that the use of brandy does people much harm.

Brandy may be harmful in general. But we cannot conclude that it would harm a man when he is suffering from cold. If he takes it within limits, it may even benefit him.

2. Converse Fallacy of Accident : In this fallacy the argument proceeds in exactly the opposite manner from the fallacy of accident.

In the converse fallacy of accident we point to a special case, and say that what is true in that case is true in general. That is to say, we ignore the particular circumstances of that special case, and we take the case as a basis for arriving at a general principle. Obviously, this makes our reasoning bad; and so we commit a fallacy. To take examples of this fallacy :

i) We should never give alms, for giving alms to professional beggars promotes laziness.

The case of giving alms to professional beggars is a special one. From this it is inferred that giving alms is always wrong. It is not proper to draw this conclusion, because there may be cases in which it is desirable to give alms.

ii) A soldier is right in killing the enemy in war. Therefore, we should not object to soldiers killing people.

The argument proceeds from the special case of killing the enemy in war to killing people in general. But what is true in special circumstances (of war) may not be true under normal circumstances. So this argument commits the converse fallacy of accident.

iii) It is wrong to have "Silence Zones". Noise doesn't disturb people; I know that my neighbour's baby enjoys cars blowing horns.

A baby may enjoy hearing the sound of a car horn. But, from this special case, we cannot infer that noise is pleasant.

3. Fallacy of Ignoratio Elenchi : The English name for this fallacy is "irrelevant conclusion". But the Latin expression *'ignoratio elenchi'* is properly translated as "ignorance of argument". **Thus, in the fallacy of ignoratio elenchi, the argument is beside the point, or irrelevant.**

Ignoratio elenchi is a group of fallacies. The common characteristic of the fallacies in this group is this : *From the evidence which has been presented, the stated conclusion cannot be drawn.* The main varieties of ignoratio elenchi are the following :

i) Argumentum ad baculum : The expression "Might is right" exactly fits what happens in this fallacy. "Might may be right" in practice; but it isn't right where logic is concerned. In logic, our conclusion is correctly drawn only when we give good reasons for it. So when we make a person accept the conclusion by *appeal to force*, our argument commits a fallacy. This fallacy is called *"argumentum ad baculum"*.

The appeal need not be to physical force. It may be to anything which arouses fear in a person. To a worker the threat of losing a job, to a politician that of losing votes, to a nation that of war, are means of arousing fear. So when we use a threat for getting our conclusion accepted, we commit this fallacy. To take examples :

a) Beware of the consequences of what you say. People will stone you.

Here the threat is physical. Since there is appeal to force, the fallacy of *argumentum ad baculum* is committed.

b) Dear Senator, I am sure you will be able to see things our way. We represent 50,000 voters in your constituency.

There is appeal to force here. The Senator is given the threat that 50,000 people may not vote for him.

ii) Argumentum ad hominem : This fallacy means "argument directed to man". The fallacy of *argumentum ad hominem* is committed when, instead of disproving the truth of what our opponent says, *we attack the man who says it.* The character, reputation, circumstances, or past beliefs of the opponent are given as reasons for rejecting his views.

It may appear that the past beliefs of a person are relevant in deciding whether we are to accept his views. Really, they are not. We all know that a person's views may change with the changing circumstances. We cannot say that a person must always hold the same views. To take examples of this fallacy :

a) In a Court : "Your honour, the evidence in this trial clearly shows that the witness is a prostitute. So she cannot be telling the truth."

b) In reply to my honourable friend's argument it may be said that he was in favour of prohibition only last year.

In both these arguments there is personal attack on the opponent.

However, we must remember that **this fallacy is committed only when the personal circumstances are irrelevant.** When they are relevant, there is no fallacy; e.g. "Mr. A should not be allowed to remain the Chief Minister of the 'X' State. He is corrupt, has taken bribes, and has helped his relatives." This argument is not fallacious. A person occupying a public position must not use that position for personal gain.

Sometimes personal attack on the opponent takes a different form. In reply to the opponent's charge, the same (or similar) fault is shown in the opponent. The traditional logicians included this under *"argu-mentum ad hominem"*. The modern logicians have given it a distinct name. It is called the fallacy of *"tu-quoque"*. The expression "tu quoque" means "You are another." By showing a similar fault in the opponent, the speaker shows that the charge against him is not serious. Example :

Who is United States to condemn Communist China? For, look, what the United States did at Hiroshima. They used atom bomb, and killed so many innocent people.

ii) Argumentum ad populum : Men are affected by feelings. But, when we are reasoning, we should not appeal to feelings and emotions for supporting our conclusion. If we do so, our argument will commit the fallacy of *argumentum ad populum*. "Cow slaughter must be banned, for cow is like the mother. How can we allow our mother to be killed?" Here we are arousing people's feelings. So the fallacy of *argumentum ad populum* is involved. To take one more example :

You say you do not believe in child marriage. Are you wiser than our ancestors who believed in it?

We would like to believe that our ancestors were right. This argument appeals to our feeling of respect for our ancestors.

iv) Argumentum ad misericordiam : In this fallacy we use an irrelevant appeal to the feeling of pity for getting a conclusion accepted. This fallacy is common in law courts. To take an example :

"Gentlemen of the Jury, I finally request you most earnestly to see the miserable condition of the poor man, my client. He is penniless, and committed the theft only to feed his baby in the arms of his weeping wife. It would, therefore, be generous of you to declare him 'not guilty'."

The Jury is to declare a person "not guilty" if they believe that he did not commit the crime. So the appeal to pity is irrelevant.

v) Argumentum ad verecundiam : We cannot always find out everything for ourselves. So we have to accept certain views on the basis of authority. But, quite often, the authority we quote is not a proper one. Say, the authority of the Gita for the caste system, of a politician for a film, or of a scientist for a painting is, obviously, an improper appeal to authority. Arguments in which the conclusion is supported by *appeal to improper authority commit the fallacy of argument ad verecundiam.*

Further, even when the people's feeling of respect for famous persons is used for asserting the conclusion, this fallacy is committed. We come across advertisements in which famous persons recommend products. For instance, one famous actor recommends a cigarette; another one praises the merits of a razor blade. When people believe that the product must be good, because the famous people say so, they commit the fallacy of *argumentum ad verecundiam*. The following are also examples of this fallacy :

a) How can you doubt it? World's greatest scientist believes in God.

This argument appeals to the authority of a scientist. A scientist is not a proper authority for deciding whether God exists.

b) There can be no doubt that Karma Yoga is a sound ethical theory, for the Bhagavad Gita says so.

The Gita is not a proper authority for what is considered to be good today.

vi) Argumentum ad ignoratiam : "Don't take advantage of the ignorance of your opponent", a logician would say. But people sometimes do so. *A man may say that his view is correct, because the opposite view cannot be proved.* When he does so, his argument commits the fallacy of *argumentum ad ignoratiam*. To take examples :

a) You have given no reasons for your belief that God does not exist. So I am right in holding that God exists.

b) Mr. A was asked how he knew that he was courageous. He said that if he were not courageous, he would have been told so. But so far no one had done this.

4. Petitio principii : This is a fallacy of proof. Here the premises claim to prove the conclusion; but they fail to do so. The conclusion can be proved when the premises contain independent evidence for it. *But in the fallacy of petitio principii, the conclusion forms a part of the evidence stated in the premises.* This is well brought out by the English name of the fallacy, *"begging the question"*.

The expression "begging the question" makes it clear that what is to be proved (i.e. the conclusion) is taken for granted. Take the argument, "To give charity to beggars is right, because it is a duty to be charitable." This argument claims to prove that giving charity is right. But something becomes a duty only if it is right. Thus, the premise contains the conclusion; and the fallacy of petitio principii is committed.

There are three main varieties of this fallacy. These are :

i) Hysteron proteron : In this fallacy we proceed in a single step by the use of synonyms, to the conclusion, which is already stated in the premise (or premises). That means, *the reason given (the premise) merely repeats the proposition to be proved (the conclusion), but in different words.* The argument has the following form :

P is true.

because P' is true.

Here P' is a synonym of P. That is, it has the same meaning as P.

The following arguments commit this fallacy :

i) Opium produces sleep, because it has a soporific property.

Here the word "soporific" means "sleep producing". Thus, the premise is the same as the conclusion. So the fallacy of hysteron proteron is committed.

ii) The soul is immortal, because it never dies.

Here "immortal" and "that which does not die" have the same meaning. So the argument commits the *fallacy of hysteron proteron.*

The fallacy of hysteron proteron is involved when we believe the conclusion to be different from the premise. But we may not be deceived. That is, we may consider the conclusion to be the same as the premise. In that case, there is no fallacy.

ii) Arguing in a circle (or Vicious Circle) : Generally, in the fallacy of petitio principii, the premise, that is assumed, is not the conclusion itself. But it is something whose proofs depends upon the conclusion. This variety of the fallacy is called "arguing in a circle". The fallacy of "arguing in a circle" has the following form :

P is true, because Q is true.

And Q is true, because P is true.

Let us take an example.

> The actress 'S' is in Hollywood, because she is famous. We know that everyone who is in Hollywood is famous.

The reason why the actress is in Hollywood is that she is famous. But being famous is stated to be a characteristic of Hollywood actresses (including 'S'). Thus, the premise (S is famous) follows from the conclusion. So the argument is circular. When we state it in the following way, its circularity becomes obvious.

'S' is famous. Therefore, she is in Hollywood.

'S' is in Hollywood. Therefore, she is famous.

iii) Sometimes a **general principle is assumed** as the basis for the conclusion; but the principle itself requires to be proved. This also involves the fallacy of Petitio Principii; e.g. *"Knowledge of Logic is not useful, for it does not teach matters of business."* In this argument the general principle "All useful things teach matters of business" is assumed. This principle itself requires to be proved.

5. False Cause (Non causa pro causa) : This fallacy consists in rejecting a proposition because of the falsity of some other proposition, which is not its consequent, though it may appear to be so. To take an example, *"It is ridiculous to suppose that the earth is flat; for a flat world would be infinite, and an infinite world could not be circumnavigated, as this has been."* According to these premises, the reason why the world could not be circumnavigated is the infinity of the world, and not its flatness.

6. Fallacy of Post hoc ergo propter hoc : This fallacy consists in identifying any antecedent with the cause. To say that one thing follows another and, therefore, the earlier is the cause of the later is to commit this fallacy. To take an example, *"After working in the hot sun all the afternoon, I drank a cup of coffee and fell ill.*

Therefore, taking a cup of coffee, after working in hot sun, is the cause of my illness." Here an antecedent is considered to be the cause.

7. Many Questions : This fallacy consists in putting questions in such a form that any answer involves an admission. In the simplest form of this fallacy an answer 'yes' or 'no' is demanded to a question, which cannot be so answered. This kind of fallacy is common in courts of law, where a witness is not allowed to give a full answer. To take examples :

i) Father to son : "When did you stop telling lies?"

Any answer to this question would imply that the son had been telling lies.

This fallacy is also involved in a question that asks for the reason of something which has not been admitted to be true.

ii) *Why are white men more intelligent than black men?*

Any answer to this question would imply that white men are more intelligent than black men.

SUMMARY

Formal and non-formal fallacies : An argument is said to commit a *fallacy* when it appears to establish a conclusion, but does not really do so. Non-formal fallacies arise either when words are used ambiguously or when some relevant feature of the argument is ignored.

Fallacies of Equivocation, Amphiboly, Accent and Figure of speech are due to ambiguities of language. **The fallacy of division** is committed when we argue that what is true of the group (class) is also true of its members, or what is true of a whole is true of its parts too. In the **fallacy of composition,** the argument proceeds in the opposite way.

In the **fallacy of accident,** we argue wrongly from a general rule. That is, what is true, in general, is considered to be true in a special case too. In the **converse fallacy of accident,** we proceed in the opposite way. Here it is argued that what is true in a special case is true in general too.

Ignoratio Elenchi is a group of fallacies in which the argument is beside the point. In *argumentum ad baculum,* there is appeal to force. In *argumentum ad hominem,* the opponent's character, reputation, circumstances, or past beliefs, are given as the ground for rejecting his views. The fallacy of *argumentum ad populum* involves appeal to feelings and emotions. In *argumentum ad misericordiam,* there is appeal to the feeling of pity. When we quote improper authority, or accept anything due to our feeling of respect for famous people, we commit the fallacy of *argumentum ad verecundium*. In *argumentum ad ignoratiam,* absence of evidence (or reasons) for a belief is taken as the ground for holding the opposite view.

Petitio principii (or begging the question) is a fallacy of proof. Here the conclusion somehow forms a part of the evidence stated in the premises. There are three ways in which this fallacy is committed. In *hysteron properon,* the proposition to be proved is repeated in different words. In the variety *"arguing in a circle",* the truth of the conclusion depends upon the premise, and the truth of the premise depends upon the conclusion. We also commit this fallacy when we assume a general principle which itself requires proof.

Fallacies of **post hoc ergo propter hoc** and **false cause** are causal fallacies, while the fallacy of **many questions** consists in putting questions in such a way that any answer involves an admission.

TEST QUESTIONS

1. Define the following terms :
   1. Fallacy
   2. Fallacy of Petitio Principii
   3. Fallacy of Division
   4. Fallacy of Composition
   5. Fallacy of Accident
   6. Hysteron proteron
2. Give reasons for the following in one or two sentences :
   1. Why is the expression "Might is right" said to describe the fallacy of argumentum ad baculum?
   2. Why is the fallacy of ignoratio elenchi said to involve "ignorance of argument"?
   3. Why are fallacies of Division and Composition said to be opposites of each other?
   4. Why are the fallacy of Accident and the converse fallacy of Accident said to be opposites of each other?
   5. Why is the fallacy of hysteron proteron said to be a form of the fallacy of petitio principii?
3. Give technical terms used in Logic for each of the following groups of words :
   1. The fallacy in which a quality which is possessed by members is taken to be possessed by the class.
   2. The fallacy in which what is true in general is taken to be true in a special case.
   3. The fallacy in which there is appeal to force.
   4. The fallacy in which we appeal to feelings and emotions for supporting the conclusion.
   5. The fallacy in which we appeal to improper authority for supporting our statement.
   6. The fallacy in which the premise merely repeats the conclusion that is to be proved, but in different words.
4. Fill in the blanks with suitable word/words in the following statements :
   1. An argument in which what is true of a class is taken to be true of its members commits the fallacy of _______.
   2. In the fallacy of ______, what is true in a special case is regarded as true in general.
   3. In the fallacy of _______, there is an irrelevant appeal to the feeling of pity.
   4. In the fallacy of _______, the absence of disproof for a view is regarded as the proof for it.
5. Find out the fallacies, if any, in the following and give reasons for the same :
   1. Our hockey team must be very good. For, look, you don't find even a single bad player in it.
   2. Since Nietzsche died insane, there is no point in studying his philosophy.
   3. I decided that he must be the best candidate when the Statesman came out in support of him.
   4. Everybody in this city pays his taxes. It is, therefore, obvious that the city pays its taxes.
   5. Adam was the happiest man on earth, because he had no mother-in-law.
   6. Forgery is committed by a man who knows to write. So teaching to write is clearly dangerous.

7. Schools and colleges have every right to forbid mini-skirts. It is against the Indian culture and makes our girls look cheap.
8. Don't you believe that atheists (persons who do not believe in God) are immoral? Then read what that atheist has written. His words are clearly immoral, and we can see from his writing that he is an atheist.
9. You admit that anyone who takes property from another is a thief. Then, you must agree that if the government takes over textile mills, it is committing a theft.
10. The women of this country are completely opposed to this proposal. Hence, our ladies' representative will vote against it. Is she not a woman?
11. Should a person slap his enemy with his right hand or his left hand?
12. "Of course, he did it, the dirty Red!"
13. Mr. Truman wanted to introduce the scheme for national medical care in America. This met with opposition. One of the speakers argued against it thus : The question comes to simply this. Shall our great nation slavishly imitate England, or shall we give our citizens the right to choose their doctors freely?
14. Science has proved many things, but it has not been able to give any argument to show that the soul dies. Therefore, we are right in believing that soul does not die.
15. We should not speak ill of our *friends*.
16. This plan, said a member of the Municipal Corporation, should not be accepted. It is suitable for some cities, but not for other cities. Our city is one of those for which it is not suitable.
17. "Friends", said a speaker at an election meeting, "How can my opponent ask the labour to vote for him? It was only last year that he supported the capitalist viewpoint in the Parliament. "
18. It is meaningless to argue in favour of democracy when we know that Aristotle was against it.
19. Americans do not believe in destiny. Since he is an American, he does not believe in it.
20. You admit that every man has a right to his private judgment. From this it logically follows that an examiner is free to pass or fail candidates as he desires.
21. We cannot hold a man responsible for what he did more than ten years ago. Each cell of his body is renewed within ten years. Therefore, no man is the same after ten years.
22 Classical music is better than light music, for the best critics say so. Now, we know that those who like classical music are the best critics of such matters.
23. Mr. P comes from a noble family. What he says must be true.
24. An election speech: Can my opponent be the working man's candidate? Of course, not. He lives in an aristocratic locality, is driven around in a Cadilac by a chauffeur, and hasn't ever done a thing with his own hands.
25. This is the finest orchestra in Bombay. Therefor, every man in it must be a good instrumentalist.
26. The bill before the house will raise the level of education, because the general standard of instruction will go up.
27. Man refuses to give up biting dog.
28. "This idea must be true, for it is beautiful." What do you mean by saying that it is beautiful? I mean that it expresses the truth so perfectly.

29. Our visitor, who is an Australian, claims to be an intellectual. But I do not believe him , for we know that Australia is not a nation of intellectuals.
30. Attorney to the Jury : "If you don't declare him guilty, he may kill one of you the next time."
31. I am not sure that this medicine is doing me any good. Yet I am taking it, for my doctor prescribed it.
32. When Mr. N's doctor suspected that he was suffering from a heart disease, he advised him to stop taking long walks. Now that suspicion has been removed. But Mr. N believes that long walks are bad for his health; and he has decided to lead a less active life. Everyone will agree that this is a sensible decision.
33. Ladies and Gentlemen of the Jury, think of this poor boy's sorrowing mother. See her weeping there, her white head bowed, because her only son is in danger. You can clearly see the sacred love in her heart as she prays to God for her baby boy. Nobody with such a mother could be guilty.
34. You admit that any profitable undertaking increases incomes. Then you have to accept that studying logic increases income, for it is a profitable undertaking.

CHAPTER – 12

REDUCTION

DO YOU KNOW THAT ......

* *For Aristotle, the first figure is the perfect figure?*
* *With two exceptions, the names of moods contain instructions for their direct reduction?*
* *Indirect reduction proves a mood to be true by showing that it is impossible for its conclusion to be false?*

1. DICTUM DE OMNI ET NULLO AND THE FIRST FIGURE

Aristotle distinguished between syllogisms which are only valid and those which are valid as well as perfect. He considered the syllogisms in the first figure to be perfect, while those in the second figure and the third figure to be only valid. As we have pointed out in the last chapter, the fourth figure was not recognized by Aristotle.

Though the syllogisms in the second and the third figure are valid, their validity has to be proved. This is done by transforming them into the first figure. *The transformation of arguments into the first figure is called reduction.*

According to Aristotle, the first figure is the perfect figure, because the principle behind it is clear and self-evident. This principle is the *dictum de omni et nullo* (also called *"Aristotle's dictum"*).

The *dictum de omni et nullo* is stated thus : *"Whatever is predicated, whether affirmatively or negatively, of a term distributed may be predicated, in like manner of everything contained under it."* The dictum applies to a term distributed. Now, a term is said to be distributed when it is taken in its entire denotation. Thus, the dictum lays down that the major premise be universal. It also lays down that the predication be about that which is contained in the class. The expression "contained in the class" shows that the minor premise is affirmative; because only affirmative propositions express the relation of inclusion.

The statement of the dictum makes it clear that the dictum is applicable to the first figure only. We have seen earlier that only in the first figure the major premise is universal and the minor premise is affirmative.

The moods **Barbara** and **Darii** express the inclusion of one class in another class, while the moods **Celarent** and **Ferio** express the exclusion of one class from another class. The mood Barbara expresses the relation of total inclusion, and the mood Celarent that of total exclusion. On the other hand, the mood Darii expresses the relation of partial inclusion, and the mood Ferio that of partial exclusion.

2. REDUCTION

Reduction is the process of transforming the moods of the imperfect figures into those of the first figure. But this is the *narrower sense of reduction.* The term 'reduction' is also used in a wider sense. In the wider sense, reduction is the process by which an argument in a given mood is expressed in some other mood. In this sense, reduction would either reveal the equivalence of the various syllogistic forms or it would show that some syllogistic forms imply other syllogistic forms. Now, many syllogisms are equivalent to one another; they are merely different ways of saying the same thing. For instance, the mood 'EIO' is a valid mood in all the figures. The mood 'EIO' of any figure can be transformed into the mood 'EIO' of any other figure. This is done by conversion of one or both the premises. However, we are not concerned with reduction in this wider sense. *We are concerned with reduction in the narrower sense of transforming the moods of the imperfect figures into the moods of the perfect figure.*

There are two **kinds of reduction.** These are direct reduction and indirect reduction. The traditional logicians used direct reduction for transforming all the moods of the imperfect figures, except Baroco of the second figure and Bocardo of the third figure. However, later on, it was shown that the moods Baroco and Bocardo could also be reduced directly.

3. DIRECT REDUCTION

Direct reduction consists in transforming the moods of the imperfect figures into the moods of the first figure by conversion, obversion or transposition of premises.

In the Middle Ages, logicians worked out the process of direct reduction carefully. They expressed the various *instructions for direct reduction* in the name of the mood. The first letter of the mood name shows the mood in the first figure to which it will be reduced. Those moods which begin with the letter 'B' (except Baroco and Bocardo) are to be reduced to Barbara; those beginning with the letter 'C' to Celarent, those beginning with 'D' to Darii, and those beginning with 'F' to Ferio.

The letter 's' in the middle of the mood name indicates simple conversion. The proposition after which it occurs is to be converted simply. The letter 'p' in the middle of the mood name indicates conversion per accidents. The proposition after which it occurs is to be converted per accidens. The letter 'm' in the mood name shows that the premises have to be transposed. That is, the major premise will become the minor premise, and the minor premise will become the major premise. The letter 'c' in the mood name shows that the mood is to be reduced indirectly. This letter occurs in the moods Baroco and Bocardo. But these moods also can be reduced directly by changing their names. For direct reduction, the mood *'Baroco'* will be named *'Faksoko';* and the mood *'Bocardo' will* be named *'Doksamosk* . In these new names for the moods 'Baroco' and 'Bocardo', the letter 'k' stands for obversion.

When the letters indicating the above processes occur after the third vowel, the processes are to be applied to the conclusion obtained in the first figure.

We shall now proceed with direct reduction of the moods of the imperfect figures.

Reduction of the moods of Fig. II : The **mood 'Cesare'** is symbolized thus:

E No P is M.

A All S is M

E ∴ No S is P.

The letter 's' after the first vowel shows simple conversion of the major premise. By carrying out this process, we shall get the mood Celarent of the first figure as follows:

E No M is P.

A All S is M.

E ∴ No S is P.

	Camestres		*Reduced to Celarent*
A	All P is M.	E	No M is S.
E	No S is M.	A	All P is M.
E	∴ No S is P.	E	∴ No P is S.
	By simple conversion		No S is P.

The letter 's' after the second vowel indicates 'simple conversion' of the minor premise. The letter 'm' indicates transposition of premises. The letter 's' at the end of the mood name indicates simple conversion of the conclusion of the mood (Celarent) of the first figure.

Baroco

A All P is M.

O Some S is not M.

O ∴ Some S is not P.

The mood 'Baroco' can be reduced directly by changing its name to *'Faksoko'*. In the word 'Faksoko', we find 'ks' after the first vowel. This indicates partial contraposition (first obverse, then converse) of the major premise. The letter 'k' occurs after the second vowel. This indicates obversion of the minor premise. After carrying out these processes, we get the mood *Ferio* of the first figure as follows :

E No *non-M is P.*

I Some S is *non-M.*

O ∴ Some S is not P.

This is mood Ferio of the first figure. Here the middle term is 'non-M'.

	Festino		*Reduced to Ferio*
E	No P is M. ®	E	No M is P.
I	Some S is M.	I	Some S is M.
O	∴ Some S is not P.	O	∴ Some S is not P.

Reduction of the Moods of the Third Figure :

	Darapti		*Reduced to Darii*
A	All M is P.	A	All M is P.
A	All M is S. ®	I	Some S is M.
I	\ Some S is P.	I	∴ Some S is P.

	Disamis		*Reduced to Darii*
I	Some M is P.	A	All M is S.
A	All M is S.	I	Some P is M.
I	∴ Some S is P.	I	∴ Some P is S.
	By simple conversion		Some S is P.

	Datisi		*Reduced to Darii*
A	All M is P.	A	All M is P.
A	All M is S. ®	I	Some S is M.
I	∴ Some S is P.	I	∴ Some S is P.

Felapton		*Reduced to Ferio*	
E	No M is P.	E	All M is P.
A	All M is S. ®	I	Some S is M.
O	∴ Some S is not P.	O	∴ Some S is not P.

Bacardo

O	Some M is not P.
A	All M is S.
O	∴ Some S is not P.

The mood *'Bocardo'* can be reduced directly by changing its name to *'Doksamosk'*. In this word, 'ks' occurring after the first vowel indicates partial contraposition of the major premise. The letter 'm' indicates transposition of premises. The mood will be reduced to 'Darii', thus :

A	All M is S.
I	Some non-P is M.
I	∴ Some non-P is S.

By first converting and then obverting the conclusion of the mood 'Darii', the conclusion will be 'Some S is not P'. In this way, the conclusion of 'Bocardo' is shown to be equivalent to the conclusion of 'Darii'.

Ferison		*Reduced to Ferio*	
E	No M is P.	E	No M is P.
I	Some M is S. ®	I	Some S is M.
O	∴ Some S is not P.	O	∴ Some S is not P.

Reduction of the moods of the Fourth Figure :

Bramantip		*Reduced to Barbara*	
A	All P is M.	A	All M is S.
A	All M is S.	A	All P is M.
I	∴ Some S is P.	A	∴ All P is S.
	By conversion per accidens		Some S is P.

Camenes		*Reduced to Celarent*	
A	All P is M.	E	No M is S.
E	No M is S.	A	All P is M.
E	∴ No S is P.	E	∴ No P is S.
	By simple conversion		No S is P.

Dimaris		*Reduced to Darii*	
I	Some P is M.	A	All M is S.
A	All M is S.	I	Some P is M.
I	∴ Some S is P.	I	∴ Some P is S.
	By simple conversion		Some S is P.

Fesapo		*Reduced to Ferio*	
E	No P is M. ®.	E	No M is P.
A	All M is S. ®	I	Some S is M.
O	∴ Some S is not P.	O	∴ Some S is not P.

Fresison		*Reduced to Ferio*	
E	No P is M. ®	E	No M is P.
I	Some M is S. ®	I	Some S is M.
O	∴ Some S is not P.	O	∴ Some S is not P.

4. INDIRECT REDUCTION

A proposition is proved indirectly by showing that its contradictory is false. This is done by showing that if the contradictory is assumed to be true, it leads to self-contradiction. This method of indirect proof is applied to reduction also.

Indirect reduction consists in proving that the contradictory of the conclusion of the given mood is false, and thus the conclusion of the given mood is true. This is done with the help of the first figure.

In indirect reduction, the contradictory of the conclusion is assumed to be true. This is combined with one of the premises, so as to form a mood in the first figure. The conclusion of the mood in the first figure is proved to be false, by showing that it contradicts one of the premises of the original syllogism. The new syllogism is a mood of the first figure (and, therefore, perfect). Since one of the premises (of the syllogism in the first figure) is the original premise, the other premise is proved to be false. This (false) premise is the contradictory of the original conclusion. Thus, the original conclusion is proved to be true.

This process is called reduction, because syllogisms in the first figure are the means of testing the validity of the moods of the imperfect figures. Like the method of direct reduction, indirect reduction also depends upon certain implications and equivalences between syllogisms.

The method of indirect reduction was originally applied for the reduction of Baroco and Bocardo. However, any mood can be reduced indirectly. We shall reduce some of the moods by this method.

Indirect reduction of Baroco (Fig. II) :

A All P is M.
O Some S is not M.
O ∴ Some S is not P.

Suppose this conclusion is false, then its contradictory "All S is P" will be true. Combining the contradictory of the conclusion with the original major premise, we get a syllogism in the first figure. Now, 'P' is the middle term.

A All *P* is M.
A All S is *P*.
A ∴ All S is M.

The conclusion of this syllogism (which is mood Barbara of the first figure) is the contradictory of the original minor premise. The original minor premise being true, the new conclusion must be false. The falsity of the conclusion of the mood Barbara cannot be due to the process of reasoning, because Barbara is a mood of the perfect figure. The new major premise is the same as the original major premise. Therefore, the new minor premise (of Barbara) must be false. The new minor premise is the contradictory of the conclusion of Baroco. Hence the conclusion of Baroco is true.

Indirect reduction of 'Bocardo' (Fig. III) :

O Some M is not P.
A All M is S.
O ∴ Some S is not P.

Suppose this conclusion is false, then its contradictory "All S is P" will be true. Combining the contradictory of the conclusion with the original minor premise, we get a syllogism in the first figure. Now 'S' is the middle term.

A All *S* is P.
A All M is *S*.
A ∴ All M is P.

The conclusion of this syllogism (mood Barbara) is the contradictory of the original major premise. The original major premise being true, the conclusion of the mood Barbara must be false. Barbara being a mood of the first figure, the process of reasoning is valid. The minor premise is the original minor premise. Therefore, the new major premise (of the mood Barbara) must be false. Since the major premise of the mood Barbara is false, its contradictory, which is the original conclusion, must be true.

Indirect reduction of 'Bramantip' (Fig. IV) :

A All P is M.
A All M is S.
I ∴ Some S is P.

Suppose this conclusion is false, then its contradictory "*No S is P*" will be true. Combining the contradictory of the conclusion with the original minor premise, we get a mood in the first figure. *(We cannot combine the contradictory of the conclusion with the major premise, because that would give us an invalid mood. In that mood, the major premise will be 'A' and the minor premise will be 'E'. AE is not a valid mood of the first figure. In the first figure the minor premise must be affirmative.)*

The mood in the first figure will be :

E No *S* is P.
A All M is *S*.
E ∴ No M is P.

The conclusion of this syllogism (mood Celarent) is the contradictory of the converse[1] of the original major premise. (The converse of the major premise is "Some M is P".) The original major premise being true (the major premise being true, its converse will be true), the conclusion of the mood Celarent must be false. Celarent being a mood of the first figure, the process of reasoning is valid. The minor premise is the original minor premise. Therefore, the new major premise (of the mood Celarent) must be false. Since the major premise of Celarent is false, its contradictory, the original conclusion, must be true.

Indirect reduction of 'Fesapo' (Fig. IV) :

E No P is M.
A All M is S.
O ∴ Some S is not P.

Suppose this conclusion is false, then its contradictory "All S is P"
will be true. Combining the contradictory of the conclusion with the original minor[2] premise, we get a syllogism in the first figure as follows:

A All *S* is P.
A All M is *S*.
A ∴ All M is P.

The conclusion of this syllogism (mood Barbara) is the contrary of converse of the original major premise. (The converse of the major premise is "No M is P".) The original major premise being true (the major premise being true, its converse will be true), the conclusion of the mood Barbara must be false. Barbara being a mood of the

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[1] In indirect reduction of the moods of the fourth figure, the conclusion of the first figure will not have direct relation of opposition. The conclusion of the mood in the first figure will have the direct relation of opposition to the converse of one of the premises of the original syllogism. In Bramantip, Camenes, Dimaris and Fresison, the conclusion of the mood in the first figure will be contradictory of the converse of one of the premises. In Fesapo, it will be either contrary or contradictory of converse.

[2] In the mood Fesapo (as well as in Fresison) we can combine the contradictory of the conclusion either with the major premise or with the minor premise.

first figure, the process of reasoning is valid. The minor premise is the original minor premise. Therefore, the new major premise must be false. Since the major premise of Barbara is false, its contradictory, the original conclusion, must be true.

5. INDIRECT REDUCTION OF SOME ARGUMENTS

So far we have used symbols to explain the process of reduction. Now we shall take some arguments, and reduce them indirectly.

A All gentlemen are *polite.*

E No gamblers are *polite.*

E ∴ No gamblers are gentlemen.

This argument is in mood "Camestres" of the Second Figure. (Naming the mood is not necessary.)

Suppose its conclusion is false, then the contradictory of the conclusion *"Some gamblers are gentlemen" will* be true. Combining the contradictory of the conclusion with the original major premise, we get a mood in the first figure as follows :

A All *gentlemen* are polite.

I Some gamblers are *gentlemen.*

I ∴ Some gamblers are polite.

This conclusion is the contradictory of the original minor premise. The original minor premise being true, this conclusion must be false. Now, the process of reasoning is mood Darii of the first figure, and hence it is perfect. (Naming the mood of the first figure is not necessary.) The major premise is the original major. Therefore, the minor premise of this mood (Darii) must be false. Since the minor premise of this mood is false, its contradictory, which is the conclusion of the given mood (Camestres), must be true.

2. Not every truth is directly useful, but every truth is worthy of being known. Therefore, not everything that is worthy of being known is directly useful.

This argument is expressed in its strict logical form thus :

O Some *truths* are not directly useful.

A *All truths* are worthy of being known.

O ∴ Some things worthy of being known are not directly useful.

Suppose the conclusion of this mood is false, then its contradictory *"All things worthy of being known are directly* useful" will be true. Combining the contradictory of the conclusion with the original minor premise, we get a mood in the first figure as follows :

A All *things worthy of being known* are directly useful.

A All truths are *worthy of being known.*

A ∴ All truths are directly useful.

This conclusion is the contradictory of the original major premise. The original major premise being true, this conclusion must be false. Now, the process of reasoning is a mood of the first figure (mood Barbara), Hence it is perfect. The minor premise is the original minor. Therefore, the major premise of this mood (Barbara) must be false. Since the major premise of this mood is false, its contradictory, the conclusion of the given mood in the Third Figure, must be true.

3. Every truly moral act is done from a right motive. Some acts which benefit others are not done from a right motive. Therefore, some acts which benefit others are not truly moral.

Expressed in its logical form it will be :

A All moral acts are *those done from a right motive.*

O Some acts which benefit others are *those done from right motive.*

O ∴ Some acts which benefit others are not truly moral.

Suppose the conclusion of this mood is false, then its contradictory "All *acts which benefit others are truly moral*" will be true. Combining the contradictory of the conclusion with the original major premise, we get a mood in the first figure as follows :

A All *truly moral acts* are those done from a right motive.

A All acts which benefit others are *truly moral*.

A ∴ All acts which benefit others are those done from a right motive.

This conclusion is the contradictory of the original minor premise. The original minor premise being true, this conclusion must be false. Now, the process of reasoning is a mood the first figure; and hence it is perfect. The major premise is the original major. Therefore, the minor premise of the mood in the first figure must be false. Since this minor premise is false, its contradictory, the conclusion of the given mood, must be true.

SUMMARY

Aristotle's dictum: Aristotle considered syllogisms directly based upon the dictum de omni et nullo as perfect. The dictum demands that the major premise be universal and the minor premise be affirmative. Since these requirements are fulfilled by the first figure, the first figure is the perfect figure.

Reduction is the process of transforming the moods of the imperfect figures into the moods of the first figure. Direct reduction involves the processes of conversion, obversion or transposition of premises. Indirect reduction, on the other hand, consists in showing that the conclusion of an imperfect mood is true, by proving that its contradictory is false.

TEST QUESTIONS

1. What is reduction? Distinguish between direct and indirect reduction.
2. Explain the *dictum de omni et nullo*. Show how the dictum applies to the moods of the first figure.
3. Why is the first figure considered to be the perfect figure?
4. State whether the following statements are true or false :
   1. The dictum *de omni et nullo* requires that the major premise be affirmative.
   2. The *dictum de omni et nullo* requires that the major premise be universal.
   3. Aristotle's dictum is directly applicable to those syllogisms in which the minor premise is universal.
   4. Aristotle's dictum is directly applicable to those syllogisms in which the minor premise is affirmative.
   5. The first figure is the perfect figure, because it proves 'A' proposition as its conclusion.
   6. Reduction shows that certain syllogistic forms are equivalent to, or implied by, certain other syllogistic forms.
   7. The mood Baroco of the second figure cannot be reduced directly.
   8. The mood Bocardo of the third figure can be reduced only indirectly.
5. Bring the following arguments into their logical form and reduce them indirectly :
   1. Some imperfect beings are not honest, for all men are imperfect and some men are not honest.
   2. All axioms are self-evident propositions. Since every axiom is a scientific principle, it follows that some scientific principles are self-evident.

3. Many rich men are not wise, for many rich men take unnecessary risks and no wise man takes unnecessary risks.
4. All dacoits are courageous and a few dacoits are resourceful. Therefore, some courageous persons are resourceful.
5. Since every adventurer is brave and some politicians are not brave, it follows that some politicians are not adventurers.
6. Diamond rings are always expensive. Therefore, some things given as marriage gifts are expensive, for sometimes diamond rings are given as marriage gifts.
7. No burglar is a poltergeist, because no burglar is noisy and every poltergeist is noisy.
8. Every good diplomat is cautious and a cautious person is never impulsive. Therefore, an impulsive person is never a good diplomat.
9. Few sensitive persons are miserly, because all great artists are sensitive and few great artists are miserly.
10. All truly religious men exercise self-control and all persons who exercise self-control have moral courage. Therefore, some men who have moral courage are truly religious.
11. All crimes are punishable. Since some immoral acts are not punishable, they are not crimes.
12. Some informative things are not boring, for no historical romance is boring and some historical romances are informative.
13. Some physicists are mathematicians. Since all mathematicians are good at counting, some persons good at counting are physicists.

CHAPTER – 13

HYPOTHETICAL & DISJUNCTIVE ARGUMENTS – DILEMMA

DO YOU KNOW THAT .....

- *Even if the consequent is true, the antecedent need not be true?*
- *By denying one of the alternatives, you can affirm the other?*
- *If you are lucky to have mutually exclusive options, you can accept any one of them and reject the other?*
- *You can free yourself from the horns of a dilemma by making your opponent face the music?*
- *You can escape between the horns of the dilemma if you can show that the alternatives are not exhaustive?*

So far we have been dealing with those syllogisms whose constituents are categorical propositions. But there are certain other forms of argument to which the term "syllogism" has been extended. These are hypothetical and disjunctive arguments. It is doubtful whether the term 'syllogism' can be rightly applied to them. However, it makes no difference to us whether we call these arguments syllogisms or not.

1. HYPOTHETICAL ARGUMENTS

Hypothetical arguments are divided into *pure hypothetical* arguments and *mixed hypothetical* arguments. In a pure hypothetical argument all the three constituent propositions (the major premise, the minor premise and the conclusion) are hypothetical. However, here we are concerned with mixed hypothetical arguments only.

A mixed hypothetical argument (also called hypothetical-categorical argument) is one in which the major premise is a hypothetical proposition, while the minor premise and the conclusion are categorical propositions. To take an example :

If the soul is simple, it is indestructible.
The soul is simple.
∴ The soul is indestructible.

There are two *valid forms of mixed hypothetical argument*. These are (i) the argument in the *modus ponens* or Constructive mixed hypothetical argument and (ii) the argument in the *modus tollens* or Destructive mixed hypothetical argument.[1]

A **constructive** hypothetical argument is one in which the minor premise affirms the antecedent and the conclusion affirms the consequent. This argument is said to be in the *modus ponens*. It is symbolically represented by the modern logicians thus :

$p \supset q$

p

$\therefore\ q$

The traditional logicians symbolized it thus :

If A is B, C is D.

A is B.

∴ C is D.

However, the traditional symbolism is not preferred. This is because the traditional symbols give the impression that the antecedent and the consequent consist of terms.

The example taken above is that of a constructive hypothetical argument. In the minor premise the antecedent *"Soul is simple" is* affirmed; in the conclusion the consequent *"Soul is indestructible"* is affirmed.

A **destructive** hypothetical argument is one in which the minor premise denies the consequent and the conclusion denies the antecedent. This argument is said to be in the *modus tollens*. It is symbolically represented thus :

Modern symbolization	**Traditional symbolization**
$p \supset q$	If A is B, C is D.
$\sim q$	C is not D.
$\therefore \sim p$	∴ A is not B.

To take an example :

If matter is indestructible, it is uncreated.

Matter is not uncreated.

∴ Matter is not indestructible.

2. RULES OF HYPOTHETICAL ARGUMENTS

The constructive and destructive hypothetical arguments are sometimes expressed in the form of rules. When so expressed, they are stated thus :

1. *By affirming the antecedent in the minor premise, the consequent can be affirmed in the conclusion, but not conversely.*

An argument in accordance with this rule is said to be **constructive** or in the *modus ponens*.

An argument in which the minor premise affirms the consequent and the conclusion affirms the antecedent is fallacious. It commits the **fallacy of Affirming the Consequent.** This fallacy is symbolized thus :

Modern symbolization	**Traditional symbolization**
$p \supset q$	If A is B, C is D.
q	C is D.
$\therefore p$	∴ A is B.

[1] We shall deal with the Rules of Modus Ponens and Modus Tollens in Chapter 12 also.

To take an example :

If it rains, roads will be wet.

Roads are wet.

∴ It has rained.

The reason why the above argument is fallacious lies in the nature of hypothetical proposition. The condition expressed in the antecedent may not be the only condition from which the consequent follows. Let us explain with the help of the above example. The roads, for instance, may be wet due to the leakage of drainage pipes.

2. *By denying the consequent in the minor premise, the antecedent can be denied in the conclusion, but not conversely.*

An argument in accordance with this rule is said to be **destructive** or in the *modus tollens.* This rule will be violated if the minor premise denies the antecedent and the conclusion denies the consequent. In that case, the argument will commit the **fallacy of Denying the Antecedent.** This fallacy is symbolized thus :

Modern symbolization	**Traditional symbolization**
$p \supset q$	If A is B, C is D.
$\sim p$	A is not B.
$\therefore \sim q$	∴ C is not D.

To take an example :

If you eat too much ice cream, you will vomit.

You have not eaten too much ice cream.

∴ You will not vomit.

As in the case of the fallacy of Affirming the Consequent, the reason for this fallacy lies in the nature of hypothetical proposition. As we have explained above, we cannot rule out the possibility of alternative conditions leading to the same consequence. Let us illustrate this point by reference to the above example. A person may vomit, because, say, he has eaten too many chocolates.

We may state here that in a hypothetical argument the antecedent may be the only condition from which the consequent follows. In that case the argument will not be fallacious. It will neither commit the fallacy of affirming the consequent nor that of denying the antecedent. **The expression "if and only if", before the antecedent, indicates that the condition stated in the antecedent is the only condition.**[2]

To take an example :

If and only if the government is defeated on the floor of the Assembly, it will be sent out of office.

The Congress government in Bihar has been sent out of office.

∴ It had been defeated on the floor of the Assembly.

This argument is valid, because the condition stated in the antecedent is the only condition. Therefore, if the consequent is affirmed in the minor premise, the antecedent can be affirmed in the conclusion.

In a hypothetical argument, either the antecedent or the consequent, or both of them, may be negative. When the negative antecedent is affirmed, it will remain negative; and when it is denied, it will become affirmative. Similarly about the consequent. However, the form of the argument will remain the same.

We find that the minor premise may not affirm or deny either the antecedent or the consequent. It may affirm or deny a **special case** falling under either the antecedent or the consequent. To take examples :

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[2] In this case, the modern logicians will say that the first promise is an equivalent proposition.

1. If a member of Parliament is declared bankrupt, he loses his seat.
   Mr. A has not lost his seat.
   ∴ Mr. A has not been declared bankrupt.

This is a *destructive hypothetical argument*. (It is in the Modus Tollens.)

2. If one is guilty, one trembles with fear.
   The accused is trembling with fear.
   ∴ The accused is guilty.

This argument commits the *fallacy of affirming the consequent*. Here "the accused" is a special case of guilty person.

3. DISJUNCTIVE ARGUMENTS

A disjunctive argument (also called disjunctive-categorical argument) is one in which the major premise is a disjunctive proposition, while the minor premise and the conclusion are categorical propositions. To take an example :

He is either careless or dishonest.
He is not careless.
∴ He is dishonest.

A disjunctive proposition states alternatives. These alternatives may or may not be exclusive. A disjunctive proposition merely asserts that at least one of the alternatives is true. However, traditional logicians maintain that a disjunctive proposition may express exclusive alternatives.[3]

The minor premise of a disjunctive argument may either affirm one of the alternatives or deny it. On this basis, there are two forms of disjunctive arguments. These are *modus ponendo tollens* and *modus tollendo ponens*. These forms are often expressed as rules of disjunctive arguments.

4. RULES OF DISJUNCTIVE ARGUMENTS

1. *By denying one of the alternatives in the minor premise, the other alternative can be affirmed in the conclusion.*

Now there are two[4] alternatives in the minor premise. Since either of these alternatives may be denied, by applying this rule, we get *two forms* of disjunctive arguments.[5] These are symbolically expressed thus :

i)		ii)	
	$p \vee q$		$p \vee q$
	$\sim p$		$\sim q$
∴	q	∴	p

To take examples :

i) Students are either intelligent or hardworking.
   John is not intelligent.
   ∴ John is hardworking.

ii) Students are either intelligent or hardworking.
   John is not hardworking.
   ∴ John is intelligent.

The disjunctive arguments which obey this rule are said to be in the *modus tollendo ponens*. These arguments (i.e. all arguments in the *modus tollendo ponens*) are valid. It does not matter whether the alternatives are exclusive or not.

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[3] The modern logicians do not hold that a disjunctive proposition has exclusive alternatives.

[4] There may be more than two alternatives. However, we shall not deal with disjunctive arguments with more than two alternatives.

[5] Modern logic recognizes only form (i).

2. *By affirming one of the alternatives in the minor premise, the other alternative can be denied in the conclusion, provided the alternatives are exclusive.*

On the basis of this rule also, there are two forms. These are symbolically expressed thus :

i) $p \vee q$	ii) $p \vee q$
p	q
$\therefore \sim q$	$\therefore \sim p$

To take examples :

i) Either he violated the law or he was arrested unjustly.
He violated the law.
∴ He was not arrested unjustly.

ii) Either he violated the law or he was arrested unjustly.
He was arrested unjustly.
∴ He did not violate the law.

The disjunctive arguments on the basis of this rule are said to be in the *modus ponendo tollens*. These arguments are valid, only if the alternatives are exclusive; otherwise, they are invalid.

It is clear from the above that disjunctive arguments in the *modus tollendo ponens* are valid. On the other hand, arguments in the *modus ponendo tollens* may be valid or invalid. They are valid when the alternatives are exclusive; and they are invalid when the alternatives are exclusive. *When the alternatives are exclusive, the disjunctive arguments may be symbolically expressed by using '^'. This symbol stands for the exclusive sense of "or".*

We shall symbolically express the **arguments in which the alternatives are exclusive.**

Rule 1 (Modus tollendo ponens)

i) $p \vee q$	ii) $p \vee q$
$\sim p$	$\sim q$
$\therefore q$	$\therefore p$

Rule 2 (Modus ponendo tollens)

i) $p \vee q$	ii) $p \vee q$
p	q
$\therefore \sim q$	$\therefore \sim p$

To take examples :

i) He is either honest or dishonest.
He is honest.
∴ He is not dishonest.

ii) He is either honest or dishonest.
He is dishonest.
∴ He is not honest.

If the alternatives are exclusive, all kinds of disjunctive arguments are valid.

5. WHAT IS A DILEMMA?

Dilemma also is considered to be a mixed syllogism. As in the case of hypothetical and disjunctive arguments, in dilemmas too the propositions are not of the same relation. However, a dilemma is more complex than hypothetical and disjunctive arguments.

A dilemma combines, into one argument, hypothetical and disjunctive reasoning. It may be defined as *an argument in which the major premise is formed by the conjunction of two (or more)*[6] *hypothetical propositions, the minor premise is a disjunctive proposition, which either affirms the antecedents or denies the consequents, and the conclusion is either categorical or disjunctive.* To take an example :

> If men are morally perfect, it is unnecessary to preach socialism; and if they are not morally perfect, it is impossible to preach it.
>
> Either men are morally perfect or not.
>
> ∴ Either it is unnecessary to preach socialism or it is impossible to preach it.

In the above dilemma the major premise is formed by the conjunction of two hypothetical propositions. The minor premise affirms the antecedents of the hypothetical major premise, while the conclusion affirms the consequents. The conclusion is a disjunctive proposition.

6. KINDS OF DILEMMA

Like mixed hypothetical arguments, dilemmas may also be either constructive or destructive. A *constructive* dilemma is one in which the minor premise, which is a disjunctive proposition, affirms the antecedents; and the conclusion affirms the consequents. A *destructive* dilemma is one in which the minor premise denies the consequents, and the conclusion denies the antecedents.

The antecedents and the consequents in the major premise may be different propositions or they may be common. When either the antecedents or the consequents are common, the dilemma is called a *simple* dilemma. When they are separate, it is called a *complex* dilemma.[7]

On the above basis, the traditional logic classifies dilemmas into *four forms.* These are :

1. Simple Constructive dilemma : In this kind of dilemma the minor premise affirms the antecedents; and the consequents in the major premise are identical (common). This kind of dilemma is symbolically expressed thus :

Modern symbols	*Traditional symbols*
$(p \supset q) . (r \supset q)$	If A is B, C is D; and if E is F, C is D.
$p \vee r$	Either A is B or E is F.
$\therefore q$	∴ C is D.

To take an example :

> If you are fated to live, medicine is unnecessary; and if you are fated to die, medicine is unnecessary.
>
> Either you are fated to live or you are fated to die.
>
> ∴ Medicine is unnecessary.

2. Complex Constructive dilemma : A complex constructive dilemma is one in which the minor premise affirms the antecedents; and the antecedents as well as the consequents in the major premise are separate propositions. It is symbolically represented thus :

Modern symbols	*Traditional symbols*
$(p \supset q) . (r \supset s)$	If A is B, C is D; and if E is F, G is H.
$p \vee r$	Either A is B or E is F.
$\therefore q \vee s$	∴ Either C is D or G is H.

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[6] We shall not deal with dilemmas which have more than two hypothetical propositions.

[7] Modern logic does not recognize the distinction between simple and complex dilemmas. So, the conclusion of a Simple Constructive Dilemma is symbolized as "q v q", and that of a Simple Destructive Dilemma as "~p v ~p".

To take an example :

If compulsory legislation against prohibition is obeyed willingly, it is mischievous; and if it is obeyed unwillingly, it is useless.

Either compulsory legislation against prohibition is obeyed willingly or it is obeyed unwillingly.

∴ Either compulsory legislation against prohibition is mischievous or useless.

3. Simple Destructive dilemma : In this form of dilemma the minor premise denies the consequents, and the antecedents in the major premise are identical (common). To represent it symbolically :

Modern symbols	*Traditional symbols*
$(p \supset q) \cdot (p \supset r)$	If A is B, C is D; and if A is B, E is F.
$\sim q \vee \sim r$	Either C is not D or E is not F.
$\therefore \sim p$	∴ A is not B.

To take an example :

If you go to Kashmir, you must pay for the ticket; and if you go to Kashmir, you must pay for the hotel bill.

Either you cannot pay for the ticket or you cannot pay for the hotel bill.

∴ You cannot go to Kashmir.

4. Complex Destructive dilemma : In this kind of dilemma the minor premise denies the consequents; and the antecedents as well as the consequents in the major premise are separate propositions. It is symbolically represented thus :

Modern symbols	*Traditional symbols*
$(p \supset q) \cdot (r \supset s)$	If A is B, C is D; and if E is F, G is H.
$\sim q \vee \sim s$	Either C is not D or G is not H.
$\therefore \sim p \vee \sim r$	∴ Either A is not B or E is not F.

To take an example :

If we are to have a peaceful society, we must not encourage competitive behaviour; and if we are to have a progressive society, we must not discourage competitive behaviour.

Either we must encourage competitive behaviour or we must discourage it.

∴ Either we are not to have a peaceful society or we are not to have a progressive society.

It will be observed that the consequents in the major premise are negative. Therefore, while denying them in the minor premise, they will become affirmative.

7. REBUTTAL OF DILEMMA

There are two ways of meeting the argument presented by a dilemma. Firstly, we may prove that the argument is false. Secondly, we may present the opponent with an argument which proves the opposite conclusion. The former is called refutation of a dilemma; the latter is called its rebuttal. We shall deal with rebuttal first.

The rebuttal of a dilemma consists in presenting a counter-dilemma which proves the opposite conclusion. The process of rebuttal of a complex constructive dilemma is this: The major premise of the counter dilemma is formed by transposing the consequents of the two hypothetical propositions. The quality of the consequents is also changed.

Thus, the *rebuttal of a complex constructive dilemma* will be symbolically expressed as :

$(p \supset \sim s) \cdot (r \supset \sim q)$

$p \vee r$

$\therefore \sim s \vee \sim q$

Let us take a complex constructive dilemma and rebut it.

If poetry is true, it is disguised history; and if poetry is false, it is misleading.

Either poetry is true or false.

∴ Either it is disguised history or it is misleading.

Rebuttal :

If poetry is true, it is not misleading; and if it is false, it is not disguised history.

Either poetry is true or false.

∴ Either poetry is not misleading or it is not disguised history.

The same method is applicable to the rebuttal of a complex destructive dilemma. By negating the antecedents and transposing them, a complex destructive dilemma can he rebutted.[8]

Thus, the *rebuttal of a complex destructive dilemma* will be symbolized as :

$(\sim r \supset q) \cdot (\sim p \supset s)$

$\sim q \vee \sim s$

$\therefore r \vee p$

To take an example :

If he is clever, he will see his mistake; and if he is honest, he will acknowledge it.

Either he does not see his mistake or he does not acknowledge it.

∴ Either he is not clever or he is not honest.

Its rebuttal :

If he is not honest, he will see his mistake; and if he is not clever, he will acknowledge it.

Either he does not see his mistake or he does not acknowledge it.

∴ Either he is honest or he is clever.

The rebuttal of a complex destructive dilemma has no force. Rebuttal has force when we accept the antecedents and show (by transposing and negating the consequents) that the stated consequents need not follow. Therefore, rebuttal is more natural in the case of complex constructive dilemmas. But if we consider the formal aspect of argument, rebuttal of a complex destructive dilemma has as much value as that of a complex constructive dilemma.

8. REFUTATION

The force of a dilemma consists in the fact that, generally speaking, dilemmas are formally valid. Though it is possible that a dilemma may involve a formal fallacy, such formal fallacies are rare. However, the formal fallacies of a dilemma are : (i) the fallacy of Affirming the Consequents and (ii) the fallacy of Denying the Antecedents. These are, in fact, the fallacies of a mixed hypothetical argument. Now, the formal fallacies of dilemma are the same as those of mixed hypothetical argument, because dilemma is a combination of mixed hypothetical arguments.

Apart from the above formal fallacies, dilemmas are refuted by pointing out defects in the premises. Dilemma is no more powerful than its weakest premise. Now, the major premise of a dilemma is formed by the conjunction of two hypothetical propositions. In a dilemma it is assumed that the consequents necessarily follow from the antecedents. If it is shown that either of the consequents does not follow from its antecedent, the major premise is fallacious. This fallacy is called the fallacy of *"Taking*

[8] Joseph, *An Introduction to Logic*, p. 363.

the dilemma by the horns". Taking the symbolic expression of complex constructive dilemma, this fallacy may be represented thus :

$$\{p \supset q\ (?)\}\ .\ \{r \supset s(?)\}$$
$$(p \vee r)$$
$$\therefore (q v s)\ ?$$

The minor premise of a dilemma is a disjunctive proposition. Dilemma proceeds on the assumption that the alternatives are exhaustive. This means that in the situation referred to by the dilemma, there are no other alternatives. When the alternatives in a dilemma are not exhaustive, the dilemma commits the fallacy of *"Escaping between the horns of the dilemma"*. Taking the symbolic expression of a complex constructive dilemma, this fallacy may be represented thus :

$$(p \supset q)\ .\ (r \supset s)$$
$$p \vee r\ (\vee t)$$
$$\therefore (q \vee s)?$$

It must be stated here that refutation is possible only on examining the argument materially. That is why, Eaton points out that when a dilemma is fallacious it may be said to fail, or be unsuccessful, rather than be formally fallacious.[9]

There is a reason behind the peculiar names of the fallacies. A dilemma is compared to a bull, and a bull has horns. The horns of a dilemma are the unpleasant consequences. When the minor premise is shown to be defective, one escapes the unpleasant consequences. Therefore, the fallacy is named *"Escaping between the horns of the dilemma"*. When the major premise is fallacious, it is shown that the consequents do not follow from the antecedents. In this way the dilemma is shown to be powerless. Since a dilemma is compared to a bull, showing that the consequents do not follow is *taking the dilemma (bull) by the horns* (horns being the dangerous consequences).

We shall now take some dilemmatic arguments and refute them.

1. If economic conditions are unfavourable, the law is sure to fail; and if economic conditions are favourable, no legislation is necessary.
   Either economic conditions are unfavourable or favourable

   ∴ Either the law is sure to fail or no legislation is necessary.

In this dilemma both the premises are fallacious. The consequents in the major premise do not follow from the antecedents. Even when economic conditions are unfavourable, the law may not fail. Similarly, even in favourable economic conditions, legislation may be necessary. Therefore, the dilemma commits the fallacy of *"Taking the dilemma by the horns"*. The dilemma also commits the fallacy of *"Escaping between the horns of the dilemma'*. Economic conditions may be neither favourable nor unfavourable. (Favourable and unfavourable are not contradictory terms.) Therefore, the alternatives are not exhaustive.

2. If he were clever, he would see his mistake, and if he were honest, he would acknowledge it. But either he does not see it or he will not acknowledge it. Therefore, either he is not clever or he is not honest.

This dilemma will be brought to its logical from thus :

If he is clever, he will see his mistake; and if he is honest, he would acknowledge it.

Either he does not see his mistake or he does not acknowledge it.

∴ Either he is not clever or he is not honest.

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[9] *General Logic*, p. 197.

This dilemma commits the fallacies of *"Taking the dilemma by the horns"* and *"Escaping between the horns of the dilemma"*. In the major premise the consequents do not follow from the antecedents. A person may be clever, and yet he may not see his mistake. Similarly, a person may be honest, and yet he may not acknowledge his mistake (because he may not know it). The alternatives are not exhaustive. A person may see his mistake, but he may not acknowledge it.

SUMMARY

Hypothetical arguments may be pure or mixed. In a mixed hypothetical argument the major premise is hypothetical, while the minor premise and the conclusion are categorical. Valid forms of mixed hypothetical argument are (i) Constructive hypothetical argument, and (ii) Destructive hypothetical argument. Its fallacies are those of (i) Affirming the Consequent and (ii) Denying the Antecedent. Hypothetical arguments in which the antecedent is the only condition (as shown by "if and only if") are always valid.

In a disjunctive argument the major premise is disjunctive, while the minor premise and the conclusion are categorical. In a disjunctive argument the alternatives may or may not be exclusive. If they are exclusive, then by denying one of them the other can be affirmed, and by affirming one of them the other can be denied. If the alternatives are not exclusive, then by affirming one of them the other cannot be denied.

Dilemma is a form of argument in which the major premise is formed by the conjunction of two (or more) hypothetical propositions, the minor premise is disjunctive, and the conclusion is either categorical or disjunctive. There are four kinds of dilemma. These are : (*i*) Simple Constructive, (*ii*) Complex Constructive, (*iii*) Simple Destructive and (*iv*) Complex Destructive dilemmas.

Rebuttal and refutation : There are two ways of meeting the argument presented by a dilemma. These are rebuttal and refutation. Rebuttal consists in presenting a counter dilemma, while refutation consists in proving the falsity of the dilemma. Usually, dilemmas are formally valid. As such, rebuttal is done by finding out material defects. The two material fallacies of dilemma are those of *"Taking the dilemma by the horns"* and *"Escaping between the horns of the dilemma"*.

TEST QUESTIONS

1. What is a hypothetical argument? Explain its rules and fallacies.
2. What is a disjunctive argument? Explain its rules and fallacies.
3. Explain the moods of a disjunctive argument. What are the invalid forms of disjunctive arguments?
4. Explain the reasons for the following :
   i) In a hypothetical argument the minor premise can affirm the antecedent, but not the consequent.
   ii) The minor premise of a hypothetical argument can deny the consequent, but not the antecedent.

   Is there any exception to the above?
5. "To affirm one of the alternatives is to deny the other." When is this rule applicable to a disjunctive argument? Illustrate your answer.
6. What is a dilemma? State and explain its forms.
7. Explain the statement : "Rebuttal of a dilemma is not the same as its refutation." Can all dilemmas be rebutted?
8. Take an example of dilemma and rebut it.

9. Do you agree with the following statements? Give reasons for you answer.
   i) The conclusion of a dilemma presents alternatives, all of which are either unpleasant or unacceptable.
   ii) It is always possible to escape between the horns of a dilemma.
   iii) A dilemma and its rebuttal may lead to conclusions that are consistent with each other.
10. Indicate appropriate alternative in the following :
    1. A valid hypothetical argument in which the minor premise affirms the antecedent is said to be _____. (constructive/destructive)
    2. An invalid hypothetical argument in which the minor the conclusion denies the consequent commits the fallacy of _____. (affirming the consequent/denying the antecedent)
    3. If the conclusion of a hypothetical argument affirms the consequent when its minor premise has denied the antecedent, the argument is _____. (valid/invalid)
    4. If the minor premise of a hypothetical argument affirms the antecedent and its conclusion denies the consequent, the argument is _____. (valid/invalid)
    5. If the antecedent of a hypothetical argument is the only condition for the consequent; and its minor premise denies the consequent, while its conclusion denies the antecedent, the argument, is _____. (valid/invalid)
    6. If the minor premise of a disjunctive argument affirms the first alternative, while its conclusion affirms the second alternative, the argument is _____. (valid/invalid)
    7. If the conclusion of a disjunctive argument denies the first alternative and its minor premise denies the second alternative, the argument is _____. (valid/invalid)
    8. In a disjunctive argument with exclusive alternatives, if the minor premise affirms the second alternative and the conclusion denies the first alternative, the argument is _____. (valid/invalid)
    9. Suppose we do not know whether the alternatives in a disjunctive argument are exclusive; the minor premise affirms the first alternative, while the conclusion denies the second alternative, the argument is _____. (valid/invalid)
    10. In a disjunctive argument with non-exclusive alternatives, if the minor premise denies the second alternative and the conclusion affirms the first alternative, the argument is _____. (valid/invalid)
    11. A valid dilemma whose conclusion affirms the consequent is _____. (constructive/destructive)
    12. The rebuttal of a dilemma _____ that the given dilemma is fallacious. (proves/does not prove)
    13. The refutation of a dilemma _____ that the given dilemma is fallacious. (proves/does not prove)
    14. When the consequences in the major premise do not follow from the antecedents, the dilemma commits the fallacy of
        i) escaping between the horns of the dilemma;
        ii) taking the dilemma by the horns.
    15. If a dilemma commits the fallacy of "taking the dilemma by the horns", it _____ commit the fallacy of "escaping between the horns of the dilemma". (can/cannot)
    16. In the rebutted dilemma the minor premise is _____ the minor premise in the original dilemma. (the same as/different from)

11. Examine the validity of the following arguments :
    1. Dinesh could not have been drowned, because he could not drown unless he had water in his lungs. But the most-mortem showed that there was no water in his lungs.
    2. The corpuscular theory of light was either right or wrong. We know it was proved wrong.
    3. If and only if the research is completed can the thesis be written. Mr. T has written the thesis, and so he must have completed the research.
    4. If the wholesale prices drop, food shortages do not continue. But food shortages continue in India.
    5. Either he is distracted or he does not care. But he cares. Therefore, he is not distracted.
    6. There is lipstick on this cigarette. So it must have been smoked by a woman.
    7. Shakespeare was either a supreme poet or a clever wit. He must not have been a clever wit, since we know that he was a supreme poet.
    8. If the argument is correct, then no error of inference has been made. But the argument is not correct.
    9. A heavenly body is a star if it twinkles. The heavenly body 'H' does not twinkle. Therefore, it is not a star.
    10. Rev. Robert Richards is either a poet or an athlete. Since he is not a poet, he must be an athlete.
    11. Mr. P was born either in November or in December. His horoscope shows that he was born in December.
    12. Either P is true or Q is true. It is already known that P is true. Therefore, we can infer that Q is false.
    13. An action anticipates a desired result, provided it is rational. Since this action anticipates a desired result, it is rational.
    14. To be admitted to this club one must either be a member or be accompanied by a member. Mr. P was accompanied by a member. Hence he is not himself a member.
    15. If and only if a dog has good ears, he makes a good watch dog. This dog does not have good ears and, hence, he will not make a good watch dog
    16. A person cannot expect to be promoted, in case he neglects work. Ramesh has not neglected his work, and so he should expect a promotion.
    17. Either he answers all the questions or he will fail. As he answered all the questions, he will not fail.
    18. If a number is divisible by four, it is even. This number is not even. Therefore, it is not divisible by four.
    19. Fallacies would be excusable, if they are unavoidable; most fallacies are avoidable; therefore, they are inexcusable. [When expressed in its logical form, this argument will be :

        If fallacies were unavoidable, they would be excusable.

        Some fallacies are not unavoidable.

        ∴ Some fallacies are not excusable.]
    20. Unless the manuscript is accompanied by return postage, it will not be returned. Mr. M's manuscript was not accompanied by return postage. Therefore, he will not get it back.
12. Put the following in the form of dilemma and rebut and refute them :
    a) If a man goes to temple regularly, he is a hypocrite; but if he does not go to temple regularly, he is a sinner. Therefore, every man is either a hypocrite or a sinner.

b) If a man is in politics, he is corrupt; and if he takes no interest in politics, he is an undesirable citizen. Either a man is in politics or takes no interest in it. In either case, his position is awkward indeed.

c) If a man keeps money, he is a miser; and if he spends it, he is extravagant.

13. Construct a dilemma with the following premise and rebut it :

a) If a lecturer reads from notes, he is a bore; if he speaks without notes, his lecture is not to the point.

b) If a man goes after money, he is money-mad; but if he is indifferent to money, he lacks ambition.

c) If we are aggressive, we are accused of hostile acts; while if we are passive, we are threatened by disaster.

14. Construct a complex destructive dilemma from the following premise and rebut it : "If a man is poor, he has no sense; and if he is rich, he is dishonest."

15. Put the following in the form of dilemma and refute them :

i) If a girl is beautiful, she does not have to worry about a husband. Similarly, if a girl is rich, then she does not have to worry about a husband.

ii) If a politician is punished, he is not a clever politician; and if he is punished, his lawyer is not clever.

iii) If a book is full of obscure references, it is tiresome to read it; if it deals with insignificant details, then also we find it tiresome to read.

iv) If the decision is made in ignorance, it is costly. So also it is costly if it is made on poor judgment.

v) If a scientist is honest, then he will make true statements and will also indicate evidence opposed to his theory. (Bring this to the form of a simple destructive dilemma. The antecedent of both the hypothetical propositions is the same, but their consequents are different.)

CHAPTER – 14

RELATIONS AND RELATIONAL ARGUMENTS

DO YOU KNOW THAT .....
* *Even if "Maya is the sister of Meena", logic does not permit us to say that "Meena is the sister of Maya"?*
* *Though "A and C are different from each other" and "A is different from B", "B may not be different from C"?*
* *A term can have a relation to its own self?*
* *Inference by simple conversion is based on the property of symmetry?*

All kinds of deductive arguments depend upon certain formal properties of relations. Therefore, the theory of relations occupies an important place in logic.

1. RELATIONS – DOMAIN, CONVERSE DOMAIN AND FIELD

The term 'relation' is one of those concepts which can be easily understood, but which are difficult to define. We shall explain this concept with he help of certain common sense notions. We usually make a distinction between a thing, its qualities and relations. A thing has qualities, and stands in a certain relation to other things. *"This table"* is a thing. It has certain qualities like *being wooden* and *having a smooth surface*. It stands in a certain relation to other things. For instance, "this table" is bigger than certain objects, and smaller than other objects. Also, it has similarities to some objects. Now, though the property of *'being smaller than'* or *'being bigger than'* is possessed by this table, these properties differ from properties like being wooden or having a smooth surface. The difference consists in this. The property of *having a smooth surface* or the property *of being wooden* does not involve a necessary reference to any other object. But the property of being *bigger than* or being *smaller than* involves a reference to other objects. **Those properties which involve an explicit reference to other objects are called relations.** Thus, relations are those characteristics of an object which belong to it, when the object is considered with reference to some other object or objects.

While dealing with relational propositions (in Chapter 4), we explained the **sense or direction of relation.** In the proposition "Ram is older than Laxman", 'Ram' is the referent, and 'Laxman' is the relatum. This proposition is symbolized thus :

x R y

Now the relation "older than" does not relate merely the individuals 'Ram' and 'Laxman'. It relates many other individuals also. That is to say, there are many objects which are the referents of this relation. Similarly, there are many objects which are its relata. The class of terms which are the referents of a relation form the **'domain'** of relation; and the class of terms which are the relata of a relation form its **'converse domain'.** Both the referents and the relata, taken together, form the **field of relation.** In the above example, the relation 'R' proceeds from 'x' to 'y'. The domain of the relation 'R' will be the class of referents 'x'; its converse domain will be the class of relata 'y'.

The domain and the converse domain may overlap. That is to say, those terms which are included in the domain may also be included in the converse domain. To take an example, in the relation of "being equal to", the referents and the relata are the same. Because each term will have this relation to itself. On the other hand, in the relation of "being older than", a part of the class of referents and a part of the class of relata will be common. This is because 'A' may be older than 'B', 'B' may be older than 'C', and so on. So, 'B' will be included in the referents as well as in the relata. Thus, we find that the domain and the converse domain may overlap. In other words, what belongs to the domain may also belong to the converse domain. In fact, we shall see later that reflexive relations hold between a term and itself. In reflexive relations referents and relata are the same terms.

We shall now deal with some important properties of relations.

2. CLASSIFICATION OF RELATIONS ACCORDING TO THE NUMBER OF TERMS

The simplest classification of relations is on the basis of the number of terms of relation.

A **dyadic** relation is one which requires *two terms* to complete its sense. "Loving" is a dyadic relation. In the proposition *"Romeo loved Julliet"*, the terms of relation are 'Romeo' and Juliet'. A **triadic** relation *is a three-termed* relation. *"Giving" is* a triadic relation. In the proposition "Borgia gave poison to his guest", the terms connected by the relation of 'giving' are (*i*) 'Borgia', (*ii*) 'poison' and (*iii*) 'guest'. A **tetradic** relation *is a four-termed* relation. In the proposition "He presented a watch to me on my birthday", the relation of 'giving present' or 'presenting' is tetradic. A **pentadic** relation is a *five-termed* relation. A relation involving *more than five terms* is called *polyadic* relation. (*It is sometimes called a multiple relation.*) Pentadic and polyadic relations are of rare occurrence.

In the following sections we shall be concerned with dyadic relations only.

3. RELATIONS AND THEIR CONVERSE

Every relation has a converse. The converse of a relation is obtained by changing the direction of relation. Instead of the relation proceeding from 'x' to 'y', the relation will proceed from 'y' to 'x'. The relation may or may not remain the same. The converse of relation may be symbolized thus : "$y\ R^C\ x$". The converse of the relation of "being married to" is the same. But the converse of the relation of 'older than' is 'younger than'.

4. SYMMETRY

The property of symmetry has to do with whether the direction of relation can be changed. On this basis, relations are classified into symmetrical, asymmetrical and non-symmetrical.

A **symmetrical** relation is such that if it holds between the terms 'x' and 'y', it also holds between 'y' and 'x'. It may also be explained thus. *A symmetrical relation is such that if one individual has that relation to a second individual, then the second individual must have that relation to the first one.* Thus if "x R y", then always "y R x". 'Married to', 'equal to', 'different from' and 'cousin of' are examples of symmetrical relations.

It will be observed that in a symmetrical relation the direction of relation can be changed, without changing the relation.

Asymmetrical relations are such that if they hold between 'x' and 'y', they never hold between 'y' and 'x'. Thus if "xRy", then never "yRx". *In asymmetrical relations if one individual has a relation to a second individual, then the second individual cannot have that relation to the first one.* 'Father of', 'older than', 'husband of' and 'greater than' are asymmetrical relations.

There are some relations which are neither symmetrical nor asymmetrical. These are called **non-symmetrical** relations. In a non-symmetrical relation, if one individual has a relation to another individual, the second individual may or may not have that relation to the first individual. Thus if "xRy", then "sometimes yRx and sometimes not yRx". The relations "loves" and "hates" are non-symmetrical.

5. TRANSITIVITY

The property of transitivity has to do with pairs of objects with reference to a given relation. On the basis of this property, relations are classified into transitive, intransitive and non-transitive.

Transitive relations are such that if they hold between x and y and between y and z, they always hold between x and z. Thus if "xRy" and "yRz", then always "xRz". The relations "equal to", "greater than", "less than" and "older than" are transitive.

Intransitive relations are such that if they hold between x and y and between y and z, they never hold between x and z. Thus, if *"x R y" and "y R z"*, then never *"x R z"*. "Father of" and "married to" are examples of intransitive relations.

Non-transitive relations are such that if they hold between x and y and between y and z, they sometimes do and sometimes do not hold between x and z. Thus if *"x R y" and "y R z"*, then "sometimes *x R z* and sometimes not *x R z*". "Different from" and "friend of" are examples of non-transitive relations.

6. REFLEXIVITY AND ALIORELATIVENESS

The property of reflexivity has reference to the relation of a term to itself. On this basis, relations are classified into reflexive, irreflexive and non-reflexive.

Reflexivity may be distinguished from total reflexivity. A relation *is totally reflexive*, if every individual has that relation to itself. The relation "being identical with" is totally reflexive. On the other hand, a relation is said to be **reflexive,** if an individual has that relation to itself, when that individual has the relation to some other individual or when some other individual has relation to it. The relations "has the same colour as" and "is the same age as" are reflexive relations.

Irreflexive relations are such that no individual has the given relation to itself. Examples of irreflexive relations are "married to" and "parent of".

Relations which are neither reflexive nor irreflexive are called **non-reflexive.** "Hates", "loves" and "criticizes" are examples of non-reflexive relations. An individual may or may not have these relations to itself.

Aliorelative relations : A relation that has the properties of both transitivity and asymmetry is said to have the property of aliorelativeness. A relation is aliorelative when it is such that no term has the given relation to itself. The examples of such relations are "greater than" and "successor of".

7. CONNEXITY

Two terms that are included within the field of a relation may not have that relation, or the converse of that relation, to one another. The relation of "being a parent of", in the field of 'human beings', need not hold between any two given terms. But when in a field of relation all the terms are related either by 'R' or by 'R^C', the relation is said to be connected. The relation of "being greater than", within the field of natural numbers, has the property of connexity.

8. LOGICAL PROPERTIES OF RELATIONS IN SOME COMMON TYPES OF ARGUMENTS

Now we are in a position to raise the question : What are the properties on which the validity of the different kinds of arguments depends? We shall consider this with reference to immediate and mediate inferences.

One of the common forms of argument is **inference by conversion.** This kind of immediate inference depends upon the property of symmetry. The simple conversion of 'E' and 'I' propositions is valid, because the relations expressed by these propositions are symmetrical. 'E' proposition expresses the relation of total exclusion of one class from another class. The relation of total exclusion is symmetrical. 'I' proposition expresses the relation of partial inclusion. This relation also is symmetrical. On the other hand, simple conversion of 'A' proposition is not possible, because the relation of total inclusion of one class in another class is not symmetrical.

Inference by converse relation : We have dealt with the inference by converse relation in chapter 8. In this type of inference, if the relation in the conclusion is the same as that in the premise, the validity is to be determined by reference to the property of symmetry. If the relation is symmetrical, the inference is valid; otherwise, it is invalid. On the other hand, if the relation in the conclusion changes, we have to find out whether it is replaced by its converse. If so, the inference is valid. To take examples :

1. A is married to B.
   ∴ B is married to A.
2. A loves B.
   ∴ B loves A.
3. A is the husband of B.
   ∴ B is the wife of A.
4. A is the father of B.
   ∴ B is the son of A.

In the first argument, the relation is symmetrical, and so the inference is valid. On the other hand, in the second argument, the relation is non-symmetrical; and, therefore, the inference is invalid. Now the third argument is valid, because the relation is replaced by its converse, but the fourth argument is invalid, because "son of " is not the converse of "father of".

SUMMARY

Relations are those characteristics which involve an explicit reference to other objects. A relation proceeds from the referent to the relatum. The class of referents is called *domain,* and that of relata *converse domain*. Domain and converse domain, together, constitute the *field of relation*.

There are many **classifications** of relations. On the basis of the number of terms, relations are classified into dyadic, triadic, tetradic, pentadic and polyadic. From the point of view of the change in the direction of relation, we get the classification of relations into symmetrical, asymmetrical and non-symmetrical. The classification into transitive, intransitive and non-transitive relations has reference to pairs of terms. Lastly, the classification into reflexive, irreflexive and non-reflexive relations is based upon whether a term has the relation to itself.

Immediate inferences depend upon the property of symmetry.

TEST QUESTIONS

1. What is a relation? Explain, with examples, domain, converse domain and field of relation.
2. How are relations classified on the basis of the properties of symmetry and transitivity? Illustrate your answer.
3. Explain, with examples, the classification of relations into reflexive, irreflexive and non-reflexive.
4. What is meant by aliorelativeness and connexity?
5. Indicate the appropriate alternative in the following :
   1. An individual that is included in the domain of a relation _____ be included in its converse domain. (can/cannot)
   2. An individual that is included in the converse domain of a relation _____ be included in its domain. (may/must/cannot)
   3. The field of a relation includes _____. (its referents/its relata/both its referents and relata)
   4. A relation in which the direction of relation can be changed, without changing the relation, is _____. (symmetrical/asymmetrical/non-symmetrical)
   5. The relation of total class-inclusion is
      i) symmetrical transitive;
      ii) asymmetrical transitive,
      iii) symmetrical intransitive;
      iv) asymmetrical intransitive.
   6. If a relation is such that an individual cannot have the relation to itself, the relation is _____. (reflexive/irreflexive/non-reflexive)
   7. Every reflexive relation is _____. (symmetrical transitive/asymmetrical transitive/asymmetrical intransitive)
   8. _____ irreflexive relations are transitive. (All/Some/No)
   9. _____ transitive relations are reflexive. (All/Some/No)
   10. The validity of an inference by converse relation, in which the relation in the conclusion is the same as that in the premise, depends upon the property of _____. (symmetry/transitivity/reflexivity)

7. Give a concrete example of the following and state the logical properties of symmetry and transitivity in each case :

1. greater than	2. borrow from
3. son of	4. partner of
5. different from	6. married to

8. Classify the following relations from the point of view of symmetry and transitivity :

1. south of	2. next to
3. grandmother of	4. brother of
5. nearest neighbour of	6. parallel to
7. has affection for	8. praises
9. believes	10. classmate of

9. Determine the properties of relations involved in the following propositions, with reference to symmetry, transitivity and reflexivity :
   1. Radha is angry with her sister.
   2. Einstein wrote to Sommerfeld.
   3. Water is heavier than red wine.
   4. Houn Ohara is the author of "Houn Ohara —The Creative Tradition".
   5. Nikhil Banerjee's music is more satisfying than that of other sitarists today.
   6. Banerjee's style of play resembles that of Ravi Shanker.
   7. Meena is the sister of Shyam.
   8. John is not taller than himself.
   9. A is not different from B.
10. Test the validity of the following relational arguments :

    Note : Immediate inferences depend upon the property of symmetry, while mediate inferences depend upon that of transitivity.
   1. Pathetique is Beethoven's greatest sonata till 1799. Beethoven's greatest sonata till 1799 is the first modern sonata. Therefore, Pathetique must be the first modern sonata.
   2. If A hires B and B hires C, does A hire C?
   3. L cooperated with M and M cooperated with N. So, L must have cooperated with N.
   4. Men dislike sharks and sharks dislike whales. Therefore, men dislike whales.
   5. If a cat eats a rat and the rat has eaten cheese, does the cat eat cheese?
   6. Bombay University Cricket team beat Poona University team, while Poona team beat Shivaji University team. So it follows that in a cricket match between Bombay University and Shivaji University, Bombay University beat Shivaji University.
   7. India exports to America. Can we say that America also must be exporting to India?
   8. Africans distrust Americans. Therefore, they must distrust Chinese, for Americans distrust Chinese.
   9. My hand touches the note book and the note book touches the table. Must my hand touch the table?
   10. This house is made from bricks, while bricks are made from clay. Hence this house is made from clay.

11. Hitler met Churchill. Therefore, Churchill met Hitler.
12. A is near to B. B is near to C. Therefore, C is near to A.
13. Plato was a pupil of Socrates, while Aristotle was a pupil of Plato. Therefore, Aristotle was a pupil of Socrates.
14. The line AB is parallel to the line CD; and the line CD is parallel to the line GH. Therefore, HG is parallel to AB.
15. If a dog bites a man and the man is biting his fingernails, surely the dog is biting the man's fingernails.
16. If France defeats Germany in war and Germany defeats Russia, can it be said that France defeats Russia?
17. Beethoven praised Goethe, and so Goethe must have praised Beethoven.
18. If Stella trusts her husband, does it follow that her husband trusts her?
19. Rajabai Tower is within sight of Churchgate railway station. Since Esso is within sight of Churchgate railway station, Eros must be within sight of Rajabai Tower.
20. Two cars were approaching each other before the collusion and the collusion occured before the occupants were taken to the hospital. Therefore, the occupants were taken to the hospital after the two cars were approaching each other.

12. Consider the relation of "father of", and indicate whether all human beings belong to the domain of this relation. Do all human beings belong to its converse domain?

CHAPTER – 15

THE LAWS OF THOUGHT

DO YOU KNOW THAT ......
* *The laws of thought are not sufficient to enable us to draw inferences?* * *The law of Excluded middle robs us of extra alternatives?* * *If the law of Excluded middle does not hold, the law of Double Negation fails?* * *The law of Contradiction expresses the significance of negation?* * *The law of Identity merely demands that propositions be unambiguous?*

The traditional logicians defined logic as the science of the principles of valid reasoning. They maintained that valid reasoning is based upon certain principles. These principles are called the laws of thought.

According to the traditional logicians, the three laws of thought *were considered to be the necessary and sufficient conditions for valid thinking.*

1. TWO INTERPRETATIONS OF THE LAWS OF THOUGHT

There are *two main formulations* of the laws of thought. On one interpretation, the laws of thought *refer to propositions.* On the other interpretation, they *refer to things.* A third interpretation is also given, according to which the laws of thought *refer to terms.* However, terms have no existence apart from the propositions in which they occur. As such, we shall not discuss the third interpretation.

Let us now come to the view that the laws of thought refer to things. We do not deny that truth or falsity of a proposition can be judged only with regard to the nature of things. (A fact has reference to the nature of things.) But logic is concerned with truth or falsity as properties of a proposition. Therefore, if we take the position that the three laws of thought are the fundamental principles of inference, we have to interpret them as referring to propositions. Let us deal with the statements of the three laws on this interpretation.

2. THE LAWS OF THOUGHT AS APPLIED TO PROPOSITIONS

1. The law of Identity : The law of Identity states that if any proposition is true, it is true. That is to say, if a proposition is once true, it is always true. This law requires that a proposition be unambiguous. Only when the meaning of a proposition remains the same, it is possible for us to draw inferences from it. If a proposition were to mean one thing now and something else at some other time, valid inference would be impossible. Then a thinker can accept the original proposition and deny the inference that follows from it. Now, for the modern logicians, logic is the science of patterns of implication. Therefore, the modern logicians would express this point somewhat differently. They would say that if the meaning of a proposition were not to remain fixed, it would be possible to accept the proposition and deny its implications. Once the law of Identity is interpreted in this way, it can be accepted as a principle which permits valid inferences.

We may consider **an objection to the law of Identity.** It is said that a proposition may be true at one time and false at another. To take an example, the proposition *"Maharashtra has Shiv Sena government"* can be considered to be true as well as false. It is true with reference to the present time, but it may be false with reference to a later date. This objection is based upon a misunderstanding. The above proposition is not stated fully. If we state it fully, it would be: "Maharashtra has Shiv Sena government in July 1995." When it is expressed in this way, we see that it cannot be considered to be true at one time and false at some other time.

In fact, a proposition whose truth-value (truth or falsity) appears to change with time is incompletely expressed. Now logic is concerned with propositions which are fully expressed; and the law of Identity refers to such propositions.

2. The law of Contradiction : The law of Contradiction states that no proposition can be both true and false. Though every proposition claims to be true, we cannot assert its truth without implying that some other proposition is false. Thus, when we assert that the proposition "Vimla is intelligent" is true, we imply that the proposition "Vimla is not intelligent" is false. *This relation between a proposition and its negation is explicitly stated by the laws of Contradiction and Excluded Middle.* The law of Contradiction states that two contradictory propositions cannot be true, while the law of Excluded Middle states that both of them cannot be false.

On the above interpretation, it is clear that the law of Contradiction expresses the significance of negation. For the validity of inference, it is necessary to refute false propositions. But the refutation of a proposition would not be possible, if two contradictory propositions could be true together.

Objections to the law of Contradiction have also been raised. These are due to the same misunderstanding as in the case of the law of Identity. It is said that contradictory propositions, e.g. *"This wall is white"* and *"This wall is not white"*, may both be true. But when it is understood that a proposition refers to a definite object at a given time, it becomes clear that the above two propositions cannot be true together. The objection called "The Sophism of 'the Liar' " is also raised. But this objection is trivial and, therefore, will not be considered here.[1]

3. The law of Excluded Middle : The law of Excluded Middle states that two contradictory propositions cannot both be false. If one of them is false, the other must be true. If the proposition "This rose is red" is false, then its contradictory "This rose is not red" must be true.

Both the law of Contradiction and the law of Excluded Middle, taken together, express the significance of contradictory propositions.

[1] Those who wish to know about this objection may refer to Keynes (*Formal Logic*, pp. 457-58).

The universality of the law of Excluded Middle has been challenged more often than that of the other two laws. The objections raised are due to the failure to distinguish between contradictory opposition and contrary opposition. Let us understand this objection with the help of examples.

i) He is taller than his brother.

ii) He is shorter than his brother.

It is pointed out that both these propositions may be false, for there is another alternative, namely, "He is as tall as his brother." It is obvious that this objection is due to a confusion. The law of Excluded Middle does not apply to contrary propositions. It applies to contra-dictory propositions. (For contrary and contradictory propositions, see Chapter 7.) The above two propositions are contraries. Now, the contradictory of the proposition *"He is taller than his brother" is "He is not taller than his brother"* If we state the two propositions in this way it would be clear that they would not be false together.

Mill objects to the law of Excluded Middle on a different ground. He says that between the true and the false there is a third possibility, the unmeaning. This objection arises from a misconception of what a proposition is. While dealing with propositions, we have stated that a proposition is either true or false. A meaningless expression is not a proposition. Therefore, this objection is worthless.

Russell presents the following argument in **defence of the law of Excluded Middle.** If the law of Excluded Middle does not hold, the law of double negation also fails. Then the denial of the falsity of a proposition would not involve the assertion that it is true.

3. THE LAWS OF THOUGHT AS APPLIED TO THINGS

Let us now consider the second interpretation of the laws of thought. It is said that the laws of thought refer to the nature of things. When the laws of thought are considered in this way, they are stated somewhat differently. The law of Identity states that "A *is A" or "Everything is what it is"*. The law of Contradiction states that *"Nothing is both A and not-A."* The law of Excluded Middle states that *"Everything is A or not-A."* We may mention here that this way of stating the laws is more common; but it does not bring out their essential nature.

When the laws of thought are interpreted as referring to things, they are understood thus: The law of Identity asserts that, in spite of change of properties, the subject remains the same. The law of Contradiction refers to the fact that the same thing cannot possess two contradictory qualities. The law of Excluded Middle is given the interpretation that everything must possess either of the two contradictory qualities.

As stated in an earlier section, for logic, the laws of thought are to be interpreted as referring to propositions, rather than to things. This can be clearly seen from the fact that the laws of thought do not give us any material knowledge. The formulae "A is A", "A is not not-A" and "Everything is either A or not-A" do not tell us about the nature of things.

4. THE FUNCTION OF THE LAWS OF-THOUGHT

The laws of thought, as Dr. Keynes points out, perform a negative function.[2] In this sense, they are the foundation of all reasoning. Consistent thinking would be impossible unless we accept them. However, all valid inferences cannot be shown to depend upon the laws of thought. Modern logicians have realized this. They point out that the three laws of thought are no doubt true principles. But these principles are no

[2] *Formal Logic*, p 450.

more fundamental than other principles. Moreover, they are not sufficient for enabling us to draw inferences. To mention only a few other principles, ordinary reasoning is based upon the Principle of Syllogism, the Principle of Deduction and the Applicative Principle (or the Principle of Substitution).

SUMMARY

There are three interpretations of the laws of thought. These are : the laws of thought refer to (i) propositions, (ii) things and (iii) terms. Proposition is the fundamental unit of logic. Therefore, we accept the view that the laws of thought apply to propositions.

As referring to propositions, the law of Identity states that if a proposition is once true, it is always true. The law of Contradiction asserts that no proposition can be both true and false. The law of Excluded Middle states that two contradictory propositions cannot both be false.

The laws of thought perform a negative function. An inference would not be valid if it violates these laws. However, the laws of thought are not sufficient for enabling us to draw inferences.

TEST QUESTIONS

1. Do the laws of thought apply to things or to propositions? Give reasons in support of your answer.
2. Explain the three laws of thought. In what sense do the laws of Contradiction and Excluded Middle express the nature of negation?
3. Write notes on :
   a) The law of Identity.
   b) The law of Contradiction.
   c) The law of Excluded Middle.

PART – II

INDUCTION

&

METHODOLOGY OF SCIENCE

CHAPTER – 16

DEFINITION

DO YOU KNOW THAT.....

- *By defining words, disputes can sometimes be settled?*
- *Definitions attempt to fix boundaries of words?*
- *The same word may have more than one definition?*
- *When you say that Dimple Kapadia, Hema Malini and Saira Banu are actresses, you are giving a definition of "actress"?*
- *Animals in a zoo serve as definitions of their names on the cages?*

1. WHAT IS DEFINITION ?

Definition is the explanation of the meaning of a word, phrase or symbol (i.e. non-verbal symbol). What is defined may be the name of a concept or class; or it may be a symbol. Thus, we may define words (or phrases) standing for concepts, e.g. 'good' and 'beautiful', or for classes like 'man' and 'monkey'. We may also define symbols like "+" and "~". While doing so, we are explaining their meanings.

Definition consists of two parts. These are (i) what is defined and (ii) the words by means of which it is defined. The word, phrase or symbol which is defined is called *definiendum*. The word, or words, used to define it is called *definiens*. Thus, in the definition. "Triangle is a plane figure bounded by three straight lines", the definiendum is 'triangle'. The definiens is "a plane figure bounded by three straight lines".

When a definition is given, the definiendum is placed to the left, and the definiens to the right. The definition should be stated thus :

X means Y

Here 'X' is the definiendum, 'Y' is the definiens, and the word 'means' indicates that the statement is a definition. However, the word "means" is rarely used. From the context it becomes clear whether the statement is a definition.

It will be observed that the *definiens is generally a longer expression than the definiendum;* because the definiendum is the word whose meaning is to be explained.

And it is easier to explain the meaning if the definiens is more fully expressed. However, the definiens may even be a single word if it can clarify the meaning of the definiendum. We shall see later that, in biverbal definitions of words, definiens is a single word.

This brings us to the problem of **relativity of definition.** The need for definition arises when the listener (or reader) does not understand the meaning of a word. Therefore, the purpose of defining is served only if the given definition is clear to the receiver of definition. The definition of soft drink as "a carbonated non-intoxicating beverage" is a good definition; but a common man will find it difficult to understand. Obviously, what is clear to a scientist may not be clear to a common man. Therefore, the same word may have to be defined differently for different persons. This shows that definition is relative to the person for whom it is meant.

2. PURPOSES OF DEFINITION

Definitions are required for making communication possible as well as clear. These functions can be analyzed into five purposes of definition. These are :

1. To increase vocabulary : By explaining the meaning of new words, definition increases vocabulary. One way of clarifying the meaning of a word is by using it. But sometimes the context does not clarify the meaning. In that case, the meaning has to be deliberately explained. Deliberate explanation of meaning involves definition. Let us understand this. Imagine the situation when a share broker tells his client that the market is "bull market". If the client does not understand the expression 'bull market', the share broker will have to define it. He will tell his client that the 'bull market' is one in which the prices of shares are rising. This example shows that definitions of new words increase vocabulary. The share broker's client will have learnt a new word.

2. To eliminate ambiguity : The chief defect of everyday language is that many words in it are equivocal, ambiguous, or vague.

An *equivocal word* is one which can be interpreted in two or more ways. Every language contains a number of equivocal words. Usually this causes no trouble. Their meanings become clear from the context. To take an example, the word 'pound' is equivocal. It may mean "a measure of weight" (sixteen ounces), or "a unit of money" (twenty shillings). Now, when I say, "I bought a pound of cheese", everyone will understand what I am referring to. Thus, in the case of equivocal words no difficulty arises.

There are words whose meanings do not become clear from the context. Such words are said to be *ambiguous*. Consider the following sentence :

Industry should be encouraged.

Here we are not sure whether "industry" means 'hard work' or 'industrial organizations'. This is due to the ambiguity of the word "industry".

Sometimes disputes arise, because people are arguing from different points of view. In such cases, by clarifying the different meanings of the ambiguous word, a dispute can be resolved. Thus, definition serves the purpose of eliminating ambiguity. The following example illustrates how a verbal dispute can be resolved by defining an ambiguous word :

Some years ago I (the author) was involved in a purely verbal argument. The argument arose about the meaning of 'atom.'[1] The argument proceeded on more or less the following lines :

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[1] This was while discussing the defining properties of gold with a colleague.

A. What is an atom?

B. An atom is the smallest particle of a substance.

A. An atom cannot be the smallest particle, since it consists of electrons, protons and neutrons.

B. Though an atom consists of electrons, protons and neutrons, these fundamental particles cannot exist separately.

A. Whether electrons, protons or neutrons can exist separately or not, they are certainly smaller than an atom.

Now, there was no disagreement about facts. Both of us recognized that an atom consists of electrons, protons and neutrons. The argument arose due to the ambiguity of the word 'substance'. 'A' was taking substance to mean "matter" (not referring to any particular kind of matter); 'B' was taking substance to means a "particular kind of matter" (e.g. gold, silver, wood, etc.) The disagreement was finally resolved when 'A' realized that he was using the word 'substance' in a different sense from 'B'. However, when there is a genuine difference of opinion, clarifying the meanings of words will not resolve the argument.

3. To reduce the vagueness of words : A word is vague when the type of things to which it applies is not definite. A large number of words in any language are vague. They do not have exact boundaries. In such cases, vagueness may lead to difference of opinion. Definition helps in resolving differences by reducing the vagueness of words. Let us take two examples.

a) Is cashew dry nut or vegetable? This problem arose when the Government of India budget for 1969-70 levied ten per cent duty on vegetable products. The Central Excise authorities classified cashew as vegetable. The Cashew Export Promotion Council disagreed with this view. In this case, the definition of "vegetable" will resolve the dispute by reducing the vagueness of that term.

b) The Government exempts from the entertainment tax those films which are in the national interest, which promote Indian culture, or which have educational value. The expressions "national interest", "promoting Indian culture", and "having educational value" are vague. Due to this, it is difficult to determine which films are to be exempted. If these expressions are defined, their vagueness will be reduced. And then it will become easier to determine their application.

The vagueness of a word should not be confused with its ambi-guity. A word is ambiguous when, in a given context, it can be interpreted in two or more ways. It is vague when it is difficult to decide to what cases it applies. However, a word may be both vague and ambiguous.

4. To explain a word theoretically : Sometimes definition gives a theoretical explanation of a word. When a student of physics asks, "What is heat?" or "What is light?", he does not want the dictionary meaning of these words. He wants to know the theory which explains 'heat' and 'light'. In such cases, definition explains a theory. To take examples of theoretical definition :

i) Digestion is the transformation of complex and insoluble food substances into simple and soluble food substances.

This is the biologist's definition of 'digestion'. It explains the nature of digestion.

ii) Tax is a revenue-earning asset for a statutory body.

This definition serves the purpose of explaining the nature of 'tax'.

A large number of definitions of scientific terms serve the purpose of theoretical explanation.

5. To influence attitudes : Lastly, definitions are sometimes given with the intention of influencing attitudes.

Certain words have emotional appeal. Some of them stand for what is desirable, while others for what is undesirable. Words like "unscientific" and "accidental" arouse an unfavourable reaction. While defining a word, a writer or speaker may use such words. In this way, he may influence our attitudes. To take an example :

"There is no meaning in planning one's family. For planning consists in bothering about the best method of achieving an accidental result."[2]

The expression "accidental result" arouses an unfavourable reaction. By using this expression in the definition of "family planning", our attitude towards family planning is being influenced.

A definition whose purpose is to influence attitudes is called **persuasive definition**. Since a persuasive definition does not explain the meaning of a word, we shall not deal with it.

3. REAL AND NOMINAL DEFINITIONS

The traditional logicians believed that we define things. But modern logic does not accept this view. According to the modern logicians, words have meanings; things do not. Since definition explains meaning, the definiendum is a word (or some other symbol). To illustrate, when we define 'dog' we do not explain the nature of a certain kind of animal. Rather, we indicate what the English speaking people understand by this word.

To define a thing is to state the qualities which it really possesses. **So a definition which claims to state the nature of a thing is called real definition.** As distinguished from this, a definition which explains the meaning of a word is called nominal definition.

A nominal (or verbal) definition explains the meaning of a word, phrase or symbol. It may do this in various ways. Some of these are :

i) pointing out an object (or objects) to which the definiendum applies;

ii) giving examples of the definiendum;

iii) stating another word which has the same meaning as the definiendum.

The purpose of a nominal definition may be to state how a word is to be used. Or it may be to report how people actually use it.

The modern logicians give various reasons for holding the view that definitions are nominal, and not real. Let us state some of these. Firstly, some words are not names of real things. So we cannot state their essential nature. Words like 'fairy' and 'ghost' are of this kind. Secondly, the technical terms of a science do not name real objects. So these too can have only nominal definitions. Thirdly, a real definition can be given if the nature of a thing were to remain fixed, and if we could know it. But we do not know what the essential nature of a thing is.

4. KINDS OF DEFINITIONS - MODERN

There are two ways of classifying definitions. One of these is the method of definition; and the other is the purpose of definition. On the basis of the method of defining terms, we get four main kinds of definitions. These are :

1. Ostensive definition
2. Extensive definition

[2] This definition of "planning" is a slight modification of one given by Ambrose Bierce in *"Devil's Dictionary"*.

3. Biverbal definition
4. Per genus et differentiam definition

On the basis of the purpose, there are two main kinds of defini-tions. These are :

5. Stipulative definition
6. Lexical definition

From another point of view, definitions may be classified into denotative and cannotative. A *denotative definition* indicates the things to which the definiendum applies. A *connotative definition* states properties. Ostensive and extensive definitions are denotative. They indicate the things to which a word applies. Biverbal and per genus et differentiam definitions are connotative. They define a word by stating its properties. On the other hand, lexical and stipulative definitions may be either denotative or connotative.

1. Ostensive definition : An ostensive definition consists in pointing out an object (or objects) to which the definiendum applies. Ostensive definition of the word "table" would consist in pointing to one or more tables, thus :

The word "table" means this.

In an ostensive definition, the word "this" is accompanied by pointing to the object. However, the word 'this" need not be used. If a person merely utters the word "table" and points out an object, it would be an ostensive definition.

Familiar examples of understanding meanings of words ostensively are the name-plates over the cages of animals in a zoo. The name-plate over the cage of a tiger defines the word 'tiger' in this way. It serves the purpose of saying : *Tiger is this.*

Ostensive definition is the best method of defining words in certain cases. It is the first (or primary) method of explaining meanings of new words. Ostensive definitions are absolutely necessary for defining those words which are names of sensations, feelings and desires. For instance, we can define the word 'green' (which stands for a colour), only by pointing out a green thing.

A foreigner who does not understand the native language, or a child who is beginning to learn a language, needs ostensive definitions. That is why, baby books explain the meanings of words through pictures or objects. The picture of a bird in a baby book seems to say : "Bird is this (i.e. the object represented by this picture").

Ostensive definitions have many **limitations.** An object has many qualities. From an ostensive definition, we do not know which one of them is being pointed out. Let us say, we want to define the word "dog" ostensively. From the gesture, it may not be clear whether the word means size, colour, or body structure of the animal.

It is not possible to give ostensive definitions for words which do not name real things. Words like "fairy" and "ghost" are names of imaginary beings. So they cannot be defined ostensively. Further, even if a word stands for something real, it may not be possible to define it ostensively. This is the case with scientific concepts like "gravitation" and "electron".

However, these limitations are not very serious. Only when a person has developed a large vocabulary, he needs definitions of such words. After all, ostensive and extensive definitions do not claim to serve the purpose that other kinds of definitions serve. They merely show how a word is to be applied. When we are interested in under-standing properties, other types of definitions have to be given.

2. Extensive definition : Like ostensive definition, extensive definition explains how a word is to be applied. *Extensive definition (also called definition by type) consists in giving examples of the definiendum.*

Examples can be given in two ways. We may give examples of the individual objects (included in the class) to which the word applies. Or we may give examples of the sub-classes. The following definitions adopt the first method :

i) City means Bombay, Calcutta, Delhi, Madras, London, Washington and Peking.

ii) Ocean means Arctic, Antarctic, Atlantic, Indian and Pacific.

There is an obvious limitation to this way of giving examples. We can give a satisfactory extensive definition when the definiendum applies to a limited number of objects. There are only a few oceans. Therefore, the word 'ocean' can be defined extensively. But we cannot define words such as 'bird', 'building' and 'boat' in this manner. However, they can be defined extensively by taking examples of sub-classes. This is because the number of sub-classes included in a class is more or less limited.

The following extensive definitions take examples of sub-classes :

i) Ornament means things like necklaces, earrings, bangles and nose-rings.

ii) Insect means bees, ants, wasps, cockroaches, etc.

An extensive definition may not be complete. We may neither be able to state all the individuals, nor all the sub-classes. Therefore, the only way is to state **paradigm examples.** *A paradigm example is a clear-cut or typical case.* It is such a case about which there is no dispute. If the definition consists of many typical examples, extensive definition will be satisfactory.

3. Biverbal definition : Certain words and phrases have the same meaning. When they are used to explain the meaning of one another, we get biverbal definition. *Thus, biverbal definition is the explanation of the meaning of one word by another word; or of one phrase by another phrase, when they have the same meaning.* To take examples of biverbal definitions of words :

Valour means courage.

In this case, the words "valour" and "courage" have the same meaning. Therefore, "courage" can be used to define "valour".

Biverbal definition of a phrase will consist in explaining its meaning by another phrase. To take an example :

To think better of the matter means to give it further consideration.

In this case the definiens has the same meaning as the definiendum.

Sometimes a part of a phrase is not understood, and its definition is required. In that case, the definition would explain the meaning of that part. To take an example :

Between two **fires** means between two **dangers**.

In the definition "between two fires", the part printed in black type requires explanation.

The definition of one word by another word, having the same meaning, has received a distinct name. It is called **synonymous definition.** This is because words having the same meaning are called synonyms. This shows that synonymous definition is a sub-class under biverbal definition. We have already taken examples of synonymous definitions. To take two more examples :

i) Apparition means ghost.

ii) Sloth means laziness.

In a biverbal definition, the definiendum and the definiens have the same meaning. Therefore, either one of them can be used to define the other. Let us illustrate this with the help of the synonyms "sloth" and "laziness". We may define "sloth" by giving its synonym, or we may define "laziness" by giving its synonym, as follows :

i) Sloth means laziness.

ii) Laziness means sloth.

Which of the two synonyms becomes the definiendum depends upon which word is not understood.

4. Definition per genus et differentiam : Certain words are names of classes. Members of a class have certain qualities in common. A definition may state these. When it does so, it is an analytical definition. The most commonly used analytical definition is per genus et differentiam definition. **In a per genus et differentiam definition, the definiendum is analyzed by stating its genus and differentia.** Let us see what genus and differentia are.

One of the relations between classes is that of inclusion. That is to say, one class may be included in another class. To take an example, the class of bees is included in the class of insects. Similarly, the class of chairs is included in that of furniture. In the first example, 'bee' is a narrower class in relation to 'insect'. Conversely, the class of insects is wider than that of bees. *The wider class is called 'genus'; the narrower class included in it is called 'species'.* Since the class of bees is included in the class of insects, 'bee' is a species of 'insect'. On the other hand, 'insect' is the genus of 'bee'.

The genus 'insect' includes the species 'bee', 'ant', 'mosquito', 'cockroach', etc. T*he various species included in a genus differ from one another. The quality, or qualities, in which one species differs from the other species is called its differentia.* The differentia of bee is 'producing wax and honey'. This distinguishes bees from other insects.

As we shall see, the traditional logicians recognized only this method of defining terms. But, as we have seen, a term may also be defined by ostensive, extensive, and biverbal methods.

The four types of definitions dealt with so far are the methods of defining words. The two types that we shall discuss now are based on the purpose of definition. If the purpose is to give one's own definition of a word, the definition is stipulative. If it is to report the commonly accepted meaning, the definition is lexical.

5. Stipulative definition : Sometimes a word does not have exact meaning. This may be because different people apply the same word to different things; or they may understand by it different qualities. Also, the word may be a new one. In all such cases, stipulative definitions are helpful.

A writer or speaker is free to use a word (or phrase) in any sense he likes. The word will mean what the writer or speaker wants it to mean. Such definitions are called stipulative definitions. *In a stipulative definition we deliberately assign meaning to a word or words.* To take examples :

i) Whitehead means by 'zero', the class of all empty classes.

ii) Aristotle means by citizen a person who is qualified to exercise deliberative and judicial functions.

Stipulative definitions are of the form : *"I mean by X what Y means".* Here 'X' is the definiendum, and 'Y' is the definiens. The words "I mean" (or any similar expression) shows that the definition is stipulated by the speaker or writer. However, in most cases, the expression "I mean" is omitted. From the context we can make out whether the definition is stipulative.

In a stipulative definition the writer says that the word shall have such and such meaning. The definition does not say how the word is actually used. Therefore, stipulative definitions are neither true or false. However, they may be useful or misleading. If they help in communicating ideas, they are useful. But if they confuse the listeners, they are misleading.

A writer is free to define words in any manner he likes. But having done so, he must stick to his own definition. That is why it is said that a stipulative definition is a kind of promise by the speaker to use the word in the stated sense.

The technical terms of every branch of knowledge are defined stipulatively. Of course, if a stipulative definition is commonly accepted, it does not remain stipulative. It becomes reported or lexical definition.

6. Lexical (or reported) definition : *A definition which reports the meaning of a word or phrase, as actually used by people, is called lexical definition.* Lexical definitions report how people actually use words. To take examples :

i) Billion is one thousand millions.

iv) By belladonna, Italians mean a beautiful lady. (This definition reports how Italians use the word 'belladonna'.)

Dictionaries report how people use words. Therefore, they contain lexical definitions.

Generally, lexical definitions use the analytical method. But they also use the biverbal, ostensive, and extensive methods. When a dictionary gives the picture of an object, it is using the ostensive method. When it clarifies meaning by taking examples, the extensive method is being used. In both the examples taken above, the analytical method is used.

Dictionaries give various meanings of a word. From this it follows that **the same word may have more than one lexical definition.** However, while actually defining a word, there is some restriction. The context in which a word is used shows which meaning is intended. Take the following dictionary meaning of "bee" :

i) four-winged stinging social insect producing wax and honey;

ii) busy worker.

While defining the word "bee" in the second sense, we will have to show that we are applying the word to a man. This can be shown thus :

Bee (as referring to persons) means a busy worker.

When a word has clear meaning, only lexical definition can be given. A stipulative definition for such a word is likely to cause confusion.

A lexical definition is either true or false. But truth or falsity depends upon whether the definition agrees with the actual use of a word. If it does, it is true. If not, it is false.

5. TRADITIONAL VIEW OF DEFINITION

Aristotle recognized only real definition. According to him, the only purpose of definition is to bring out the essence (or the essential nature) of a thing. To state the essential nature of a thing, we must point out its similarities to and differences from other things. The qualities which a thing has in common with other things are expressed by its *genus.* Its differences from other thing are included in its *differentia.* A definition which states the genus and the differentia of the definiendum is called per genus et differentiam definition. We may state here that the traditional logicians recognized only per genus et differentiam definition. Hence, they simply called it definition.

We have already dealt with per genus et differentiam definition in Section 4.

Let us take two more examples of per genus et differentiam definition.

i) Pentagon is a five-sided rectilinear plane figure.

The genus of pentagon is 'rectilinear plane figure'. Its differentia is being five-sided.

ii) Baby is a very young child.

'Child' is the genus of baby, while being 'very young' is its differentia.

6. RULES OF PER GENUS ET DIFFERENTIAM DEFINITION

The traditional logicians have framed certain rules which a definition (of this kind) must follow. These rules will help in constructing good per genus et differentiam definitions.

1. *A definition must be applicable to everything included in the species defined, and to nothing else.*

This rule is applicable not only to this kind of definition, but also to most of the definitions recognized by the modern logicians. *This is the rule of substitution.* In any statement the definiens may be stated in place of the definiendum, without changing the information that the statement expresses.

This rule is violated[3] either when the definiens is applicable only to a part of the definiendum, or when it is applicable to other classes also. In the former case, the definition is said to commit the fallacy of Too Narrow definition. In the latter case, it is said to commit the fallacy of Too Wide definition. We shall now take examples.

Too Narrow definition

i) A spinster is a young unmarried female.

This definition does not apply to all spinsters. A spinster may be old.

ii) A pump is a water-raising machine worked by handle.

This definition does not apply to all pumps. A pump may be worked by some other means, such as electricity.

Too Wide definition

i) Square is a our-sided plane figure.

This definition applies to other figures (e.g. rectangle) also.

ii) Knife is an instrument for self-defence.

This definition applies to other things, like swords, axes and guns also.

Sometimes a definition has both the faults of being too narrow and too wide at the same time. This happens when the definiens does not apply to the whole class represented by the definiendum, and when it applies to other classes too. To take an example :

Story is an imaginary narrative.

This definition is too narrow, because it does not apply to all kinds of stories. Some of them are narratives of actual incidents. It is also too wide, because it applies to dramas and novels too.

2. *A definition must not, directly or indirectly, define the thing by itself.*

This rule lays down that the definition must not state the term defined or its synonym. When the definiens contains the word defined, the definition fails in its purpose. As for stating a synonym in the definiens, it is to be noted that this condition is applicable to definition as understood by the traditional logicians. (The modern

[3] The first two rules that Joseph mentions are: (l) A definition must give the essence of that which is defined. (2) A definition must be per genus et differentiam. (*Introduction to Logic*, pp. 111-112))
These rules were necessary when the definition was merely called 'logical definition'. Since it is now called per genus et differentiam definition and since it is pointed out that this is what is meant by real definition, it is not necessary to state these two rules.

logicians admit synonymous definition.) According to the traditional logicians, the definiens is an analysis of the definiendum. If the definiens is merely a synonym of the definiendum, the idea represented by the definiendum is not analyzed.

The violation of this rule leads to **the fallacies of Synonymous** and **Circular** definitions. When the definiens contains the term defined, the definition is circular; and when the definiens is a synonym of the definiendum, it is synonymous. To take examples :

Circular definition

i) Murder is an act committed by a murderer.

ii) A star is a stellar body seen in the heaven at night.

Synonymous definition

i) An adage is a proverb.

ii) An apparition is a ghost.

While classifying a definition as Circular, we have to be careful. There are terms which cannot be defined without some repetition. To take examples of valid definitions involving repetition :

Houseboat is a boat fitted for living in on water.

This definition is not circular, though the word boat occurs in the definiens. What we are interested in is to know what kind of boat houseboat is.

3. *A definition should not be in obscure or figurative language.*

The purpose of definition is to explain meaning. If the definition is expressed in obscure language, this purpose will not be served. However, what may be obscure for the common man may not be obscure for the scientist. To take an example, *"Electrical potential " is defined as "an amount of work done in bringing a unit charge from infinity to a given point"*. This definition will be clear to a scientist. Therefore, this rule expresses the relativity of definition. If a definition is expressed in figurative language, it does not serve the purpose of directly expressing the definiendum. Moreover, there is the danger that the meaning conveyed by such language may not be intended. To take examples :

Obscure definition

i) Gipsy is a person who is willing to tell you your fortune for a small portion of it.

This definition does not clarify the meaning of gipsy. The definiens is more difficult to understand than the definiendum.

ii) Diagnosis is the physician's art of determining the condition of the patient's purse, in order to find out how sick to make him.

Figurative definition

i) Envelope is the coffin of a document.

Here an envelope is compared to a coffin. As a dead body is placed in a coffin for burial, so a document is placed in an envelope for sending it.

ii) Water is a medicine for thirst.

As a medicine is helpful in curing disease, so water is helpful in quenching thirst.

4. *A definition must not be negative if it can be in positive terms.*

The reason for this rule is that a negative expression may not be definite. Therefore, it may not help in distinguishing the term defined from other terms. To take some examples of **fallacious negative definitions :**

i) A genius is one who cannot earn his own living.

ii) Wisdom is the avoidance of folly.

However, if a term stands for a negative concept, it can only be defined negatively. In such a case, the negative definition is not faulty. To take an *example of negative definition which is permissible :*

An orphan is one who has no parents living.

This is a good definition. "Orphan" is a negative concept.

SUMMARY

Definition explains the meaning of a word, phrase or symbol. The word which is defined is called definiendum; and the word, or words, by means of which it is defined is called definiens.

Purposes : Definition increase vocabulary. it eliminates ambiguity and reduces vagueness. It may also provide theoretical explanation. Sometimes definitions are used for influencing attitudes; and in such cases they are said to be persuasive.

Real and nominal definitions : The traditional logicians said that we define things, while the modern logicians hold that we define words. A definition which expresses the nature of a thing is called real definition. On the other hand, a definition which explains the meaning of a word is called nominal (or verbal) definition.

Kinds of definitions : There are six main kinds of definitions. Of these, ostensive, biverbal and per genus et differentiam definitions are the methods of defining words. On the other hand, definitions are classified into stipulative and lexical on the basis of the speaker's purpose.

Ostensive definition consists in pointing out an object, while in extensive definition examples are given. *Biverbal definition* consists in stating a word or phrase which has the same meaning as the definiendum. In a *per genus et differentiam definition,* the definiendum is analyzed by stating its genus and differentia.

Stipulative definition is a writer's or speaker's own meaning of the term defined. On the other hand, *lexical definition* reports the meaning of the definiendum as it is commonly used by people.

Traditional definition : Aristotle recognized only real definition. A real definition brings out the essential nature of a thing. Thus, the traditional logicians recognized, what is now called, per genus et differentiam definition only. They framed rules which will ensure that the definition is good. Too narrow, too wide, circular, synonymous, obscure, figurative and negative definitions are regarded as fallacious.

TEST QUESTIONS

1. What is definition? Why are definitions said to be relative?
2. Explain the purposes of definition. What purpose do ostensive and extensive definitions serve?
3. Distinguish between ostensive and extensive definitions. What are their limitations?
4. Explain the difference between lexical and stipulative definitions. Can these definitions be considered to be either true or false?
5. It is often said that a speaker has complete freedom in defining his terms. Do you agree?
6. What is per genus et differentiam definition? Is negative definition always fallacious?

7. Define the following terms :

   i) Definition
   ii) Definiens
   iii) Definiendum
   iv) Ostensive definition
   v) Extensive definition
   vi) Biverbal definition
   vii) Synonymous definition
   viii) Lexical definition
   ix) Stipulative definition
   x) Persuasive definition
   xi) Genus
   xii) Species

8. Distinguish between the following :
   1. Ostensive and extensive definition.
   2. Biverbal and synonymous definition.
   3. Biverbal and per genus et differentiam definition.
   4. Lexical and stipulative definition.
   5. Genus and species.

9. Give reasons for the following in one or two sentences :
   1. Why is the definiens generally a longer expression than the definiendum?
   2. Why is biverbal definition wider than synonymous definition?
   3. Why is definition said to be relative?
   4. Why is ostensive definition denotative?
   5. Why is biverbal definition connotative?
   6. Why are ostensive definitions of imaginary objects not possible?
   7. Why does extensive definition use paradigm examples?
   8. Why does a stipulative definition offer greater freedom than a lexical definition?
   9. Why does lexical definition have wider scope than per genue et differentiam definition?

10. Give technical terms used in Logic for each of the following groups of words :
    1. The word or phrase which is defined.
    2. The word, or words, which are used to define a word.
    3. The explanation of the meaning of a word, phrase or symbol.
    4. A definition whose purpose is to influence attitudes.
    5. A definition which gives examples of the definiendum.
    6. A definition which deliberately assigns meaning to a word.
    7. A definition which reports the meaning of a word or phrase.

11. State whether the following statements are true or false :
    1. The words which are names of imaginary objects cannot be defined.
    2. By defining words, purely verbal disputes can be eliminated.
    3. Every word cannot be defined ostensively.
    4. The same word can have many stipulative definitions.
    5. If a definition is stipulative, it can never become lexical.
    6. Every biverbal definition is synonymous.
    7. All dictionary definitions are lexical.
    8. All dictionary definitions are per genus et differentiam definitions.

12. Indicate the alternative applicable in the following :
    1. ____ definition cannot be given in the absence of the objects to which the definiendum applies. (Stipulative/Lexical/Ostensive/Biverbal)
    2. ____ definition always indicates things to which the definiendum applies. (Per genus et differentiam/Biverbal/Lexical/Ostensive)
    3. Every ____ definition states the qualities of the definiendum. (Per genus et differentiam/Ostensive/ Extensive/Lexical)
    4. A dictionary contains ____ definitions. (Stipulative/Lexical)
    5. A stipulative definition is ____ (either true or false/either clear or confused)
    6. We can give synonymous definitions of ____. (words only/phrases only/both words and phrases)
13. Recognize , with reasons, the types of definitions involved in the following :
    1. Diamondback is another name for rattlesnake.
    2. In modern usage, anecdote means an interesting incident or striking event.
    3. The term tax is used for levies such as income-tax, excise duty, estate duty and entertainment tax.
    4. Physician is a legally qualified medical practitioner.
    5. My neighbour's child did not understand what tower means. His father showed him the picture of the Leaning Tower of Pisa, and the child was satisfied.
    6. Red is the colour of this rose and that hydrant.
    7. When I told my friends that I am in high spirits, they didn't understand. So I told them that I feel cheerful.
    8. Pain is what you felt when I pinched you.
    9. Pedestrain is a traveller on foot.
    10. The word pest stands for such insects as cockroach.
    11. As used by Americans, baron means a great merchant in a commodity.
    12. In Italian, belladonna is a beautiful lady; while in English, it is a deadly poison.
    13. Virture stands for such qualities as charity, piety and justice.
    14. In English 'howler' is a blunder.
    15. Mr. M's daughter wanted to know what mammal means. He took her to a zoo, and showed her a monkey, an elephant and a tiger. Ad she understood the meaning of mammal.
    16. I told Mr. M that he is a wet blanket. Since he did not understand it, I told him that he is discouraging.
    17. Marshall says that Economics is a study of mankind in the ordinary business of life.
    18. A novelist is a person such as C.S. Forester.
    19. J.M. Keynes' view of interest is this : "Price paid for parting with liquidity."
    20. Camera is an apparatus for photography.
    21. Date is a U.S. colloquial word meaning appointment.
    22. Issue is result or outcome.
    23. In Marshall's view, rent is income derived from free gifts of nature.

24. A natty person is one who is trim.
25. Rocker and nut are slang words which mean head.

14. Examine the following per genus et differentiam definitions :
    1. Competition is perfect when there is no monopoly.
    2. Interest is the reward for waiting.
    3. Manure is a substance used for fertilizing soil.
    4. Ballot paper is a paper used in voting by ballot; voting by ballot is secret voting.
    5. Bedlam is a madhouse.
    6. Chauffeur is a motor-car driver.
    7. Work is the salt of life.
    8. Lecturer is a person who has tongue in your ear and faith in your patience.
    9. Honeymoon is a holiday of married couple.
    10. An effect is something that is produced by a cause, and a cause is something that produces an effect.
    11. Kite is a child's papered frame flown in wind by means of attached string.
    12. Circus is a place where horses, ponies and elephants are permitted to see men, women and children acting the fool.
    13. Oceanography is physical geography of the ocean.
    14. Peace is freedom from way.
    15. Love is the union of hearts.
    16. Wedding is a ceremony in which two persons undertake to become one; one undertakes to become nothing; and nothing undertakes to become supportable.
    17. Reception is a formal welcome on the occasion of wedding.
    18. Rolly-polly child is one who is plump.
    19. Credit is the bond of society.
    20. Rational life is one lives according to the dictates of reason.

CHAPTER – 17

DIVISION

DO YOU KNOW THAT.....
* *Rules of division merely express the ideal of the logician?*
* *Division seeks to give us knowledge of the denotative meaning of a term?*
* *Division of bees into busy workers and honey-producing insects is faulty?*
* *Division by dichotomy is based on the principles of Contradiction and Excluded Middle?*

While dealing with per genus et differentiam definition, we have seen that it consists in stating genus and differentia. Now, a genus consists of a number of species. The genus "rectilinear plane figure" (rectilinear means bounded by straight lines) includes the species 'triangle', 'quadrilateral' (four-sided figure), 'pentagon' (five-sided figure), 'hexagon' (six-sided figure), 'octagon' (eight-sided figure), etc., We can know the various species, either by defining them or by showing that they belong to the same genus. The first method is adopted in definition, and the second in division.

1. WHAT IS LOGICAL DIVISION?

Logical division sets forth the smaller groups which are included in the extension (denotation) of a given term. It is the process of splitting up (or separation) of a genus into its constituent species. To take examples :

i) Triangles into equilateral, isosceles and scalene triangles.

ii) Candidates into successful and unsuccessful.

The genus which is divided is called *totum divisum* and the species into which it is divided are called *membra dividentia.* In the first example 'triangle' is the totum divisum; equilateral, isosceles and scalene triangles are the membra dividentia.

When we divide a genus (class) into its species (sub-classes), we have a certain *basis for division.* The basis on which a class is divided into its sub-classes is called *fundamentum divisionis* (or principle of division). **Fundamentum divisionis is either an attribute which varies among the members of the class divided or**

it is an attribute which is possessed by some members of the class, but not by others. In the above division of triangles, the fundamentum divisionis is the equality or inequality of sides. This attribute (viz. equality or inequality of sides) is present in different ways in the different sub-classes. In the sub-class "equilateral triangle" all the sides are equal, in "isosceles triangle" two of the sides are equal, and in "scalene triangle" none of the sides is equal. Thus, in the division of triangles, the fundamentum divisionis is an attribute which varies among triangles. This is not so in the division of candidates into successful and unsuccessful. Here the attribute of being successful (which is the fundamentum divisionis) is present in some members and absent in others. Later on we shall see that in division by dichotomy too, the fundamentum divisionis is of the latter kind.

We must not make the mistake of supposing that there is only one way of dividing a class into its sub-classes. In fact, there are various ways in which the same class (genus) may be `divided into its sub-classes (species). Thus the class 'triangle' may also be divided into its subclasses "obtuse angled" (obtuse angle is more than 90°), "right angled" and "acute angled" (acute angle is less than 90°) triangles. In this case the basis of division is the size of the largest angle. In fact, we may say that there will be as many divisions of a genus as there are principles of division. The different divisions of the same class (or genus) are called **co-divisions.** The two divisions of triangles that we have dealt with are co-divisions.

2. LOGICAL DIVISION AND OTHER PROCESSES

Logical division is to be distinguished from certain other processes. These are :

1. **Enumeration of individuals :** *This consists in stating the individual things included in a class.* Thus, enumeration of individuals is the process of showing that certain individuals are members of a class. For instance, continents are divided into Asia, Africa, Australia, Europe, North America and South America.

Enumeration of individuals is the same as extensive definition of a word (when the examples are those of individuals, and not of sub-classes). The only difference is that in enumeration of individuals we consider the class (which is divided), but in extensive definition we consider the word which is defined.

There is hardly any similarity between logical division and enumeration of individuals. In logical division, a class is divided into its sub-classes, while in the enumeration of individuals we state the individuals which are included in a class. Secondly, logical division is based upon a fundamentum divisionis. But the enumeration of individuals is not based upon any principle.

Physical division : *This is the division of an individual thing into its parts.* Thus, the division of bicycle into handle, bars, wheels, chain and seat is physical division. Since the physical division consists in stating the parts of a thing, it is also called **Partition.** We may mention here that the analysis of any chemical compound involves physical division. For instance, the analysis of a molecule of water into two atoms of hydrogen and one atom of oxygen is physical division.

In logical division the name of the class divided is applicable to every sub-class in the same sense. When we divide triangles into equilateral, isosceles and scalene, all the sub-classes are called triangles. But this is not the case in physical division. We cannot say that hydrogen or oxygen is water.

Metaphysical division : This is the division of a thing into its *separate qualities.* To take examples :

a) Stone into colour, solidity, weight and extention.

b) Gold into yellowness, preciousness and heaviness.

Metaphysical division can be carried out in thought only. In the metaphysical division of gold, we cannot separate yellowness, preciousness and heaviness from gold. On the other hand, in physical division parts of an individual can be actually separated. We can actually separate the handle or the chain from a bicycle.

Verbal division : In the preceding chapter we have dealt with equivocal and ambiguous words. Now, when an equivocal or ambiguous word is divided into its *different meanings*, such a division is called verbal division. To take an example, the division of *"watch into time-piece and guard"* is such a division. Here two different meanings of "watch" are stated.

3. RULES OF LOGICAL DIVISION

Logical division has to observe certain rules. The purpose of these rules is to ensure that all the species are stated, and that the species are mutually exclusive.

1. *Each distinct act of division must have, at a time, only one fundamentum divisionis (principle of division).*

In an orderly division, the different bases of division will be kept separate. We may divide men into Hindus, Christians, Jews, Parsees, Muslims, Jains and Buddhists. Similarly, we may divide men into rich, poor and middle class. The basis of the first division is religion; and that of the second division is wealth. But in the same division we cannot use both these principles. If we do so, the division will be fallacious. A division which proceeds on the basis of more than one principle is called **Cross** division. To take examples :

i) Music into classical, vocal, instrumental and film music.

In this division there are three principles. These are (*a*) being classical, (*b*) being vocal or instrumental and (*c*) whether used in films or not.

ii) Cloth into cotton, silk, rayon, nylon, and costly.

There are two principles, viz. kind of cloth and its price.

2. *The sub-classes into which a class is divided must be mutually exclusive.*

When the sub-classes are not mutually exclusive, some of the members may be included in more than one sub-class. Thus if we divide *Hindus into rich, poor, tall and short*, an individual may be both rich and short, rich and tall, poor and tall, or poor and short. This leads to **overlapping** of the sub-classes.

This rule is generally violated when the division proceeds on more than one basis (i.e. when it is Cross). The above division of "Hindus into rich, poor, tall and short" is also Cross division. It is based upon two principles. These are wealth and stature (height).

Even when a division is Cross, it is not necessary that the sub-classes must overlap. For instance, the division of "triangles into equiangular, scalene and isosceles" is Cross. It is based upon two principles, viz. equality of angles and equality (or inequality) of sides. The sub-class "equiangular triangles" is based upon the type of angles, while in the sub-classes isosceles and scalene triangles the basis is the type of sides. But the sub-classes do not overlap.

3. *The sub-classes into which a class is divided must be co-extensive with the class divided.*

This rule lays down that everything included in the denotation of a genus must belong to one of the species. The violation of this rule occurs under two conditions. These are : (i) when some of the species belonging to the genus are omitted; and (ii) when the division states a sub-class which is not a species of the genus. In the former case, the division is said to be **Too Narrow.** In the latter case, it is said to be **Too Wide.** To take examples :

Too Narrow division

i) Educational institutions into schools and colleges.

This division omits some of the sub-classes, e.g. universities.

ii) Literature into poetry, novel, short story and drama.

This division omits some of the sub-classes of literature. For instance, it omits biography.

Too Wide division

i) Furniture into tables, chairs, cupboards and blackboards.

This division states the class of blackboards which is not a kind of furniture.

ii) Sportsmen into cricketers, hockey-players, foot-ballers and chess-players.

The class of chess-players is not a species of sportsmen. (Chess is a game, and not a sport.)

It will be noticed that *the same division may be both Too Narrow and Too Wide.* In fact, both the above examples of Too Wide division are also cases of Too Narrow division. The division of furniture does not state all the sub-classes of furniture. For instance, stools and desks are omitted. Similarly, the division of sportsmen does not include all the sub-classes of sportsmen. It omits sub-classes like volley-ball players, boxers and wrestlers.

The logical division of a class will be defective if it violates this rule. But, in practice, this rule is difficult to obey. It is difficult to know whether all the species are stated. Because, generally, our knowledge of the species included in a genus is incomplete. Also, we cannot rule out the possibility of new species arising at some future date. In view of these difficulties, this rule can be theoretically laid down as a goal, but a scientist cannot be certain that it is followed in practice.

4. *If the division involves more then one step, it should proceed gradually and continuously from the highest genus to the lowest species. That is to say, the division must not take a leap.*

This rule is also expressed by saying **"diviso non faciat saltum".** The expression means that a *division must not take a leap.* The purpose of this rule is to ensure that the intermediate classes are not omitted. If a genus is not divided into its proximate (or immediate) species, it is possible that some of the species be omitted. In that case, the division will be Too Narrow. To take an example, the division of *living beings into moral and immoral* involves a leap. The species 'moral' and 'immoral' are species of 'man'. Therefore, the division omits plants as well as other animals. Valid division in this case would involve three stages. At the first stage, living beings will be divided into animals and plants. At the second stage, animals will be divided into men and other animals (i.e. the other species of the genus animal). Then men will be divided into moral and immoral. As the above division (of living beings into moral and immoral) involves a leap, several intermediate classes are omitted. Therefore, the division commits the fallacy of Too Narrow division.

If we examine the above rules, we shall find that they express the ideal of the logician. They cannot be followed in practice. No doubt, the aim of logical division is to achieve precision and order in knowledge. But this aim cannot be realized. Nature is complex, and the sub-classes are not as clear as we get in logical division.

4. DIVISION BY DICHOTOMY

We have seen that the chief defects of logical division are that the sub-classes may not be exclusive and they may not be exhaustive. In view of these difficulties, some logicians have suggested a method of division which is free from these defects. This is Division by Dichotomy or dichotomous division.

Division by dichotomy is the division of a class, with reference to the presence or absence of a given attribute (or a group of attributes). In this kind of division, a *class is divided into two sub-classes, which are the corresponding positive and negative terms*. In other words, the sub-classes are contradictories of one another. The division of *cars into those driven by the owner and those not driven by the owner* is division by dichotomy. Division by dichotomy is a *purely formal process*. It does not presume that we know the contents of the class.

When the division by dichotomy is a continuous one, at each step, the class to he divided will be split up into two sub-classes.

The division by dichotomy does not represent the actual procedure followed in dividing a genus into its constituent species. When a genus has more than two species, there is no reason why this method of division be followed. For instance, when we wish to divide men according to religion, there is no need for us to divide them into Hindus and non-Hindus, and then divide these sub-classes.

Further, in division by dichotomy, we may get null classes. (A null class has no members.) In the division of the class of ghosts into spirits and non-spirits, the class of ghosts which are non-spirits is a null-class.

If we admit that the value of division consists in increasing our knowledge, then we have to reject all dichotomous divisions. The logical laws (of contradiction and excluded middle) would not help us in deciding what may be included in the negative class. In the absence of such knowledge, dichotomous division would become merely a theoretical method of arranging things into classes and sub-classes. This shows that the practical value of dichotomous division would depend upon our ability to find some positive content for the negative sub-classes.

But objections have been raised even against the formal character of division by dichotomy. To divide a class into two sub-classes, we must have a basis of division. How are we to know the fundamentum divisionis? If we do not know the contents of the genus, how can we know the attributes which will become principles of division? In fact, in the absence of such knowledge, we may get such an absurd division as that of *triangles into moral and immoral*. However, division by dichotomy can be regarded as a formal process under two conditions. Firstly, the principle of division, as well as the genus to be divided, is given. Secondly, the division should not be understood to refer to the actual existence of members in the sub-classes. This is because the sub-classes may be null (or empty).

In spite of these defects, division by dichotomy is useful in certain cases. In actual scientific inquiry, it is sometimes used as a means of identifying species. This is done by applying the principle that everything must either possess a certain character or not. When a scientist knows that a species does not possess a given character, he looks for the characteristics of the other classes. This search goes on, till he (scientist) has eliminated all classes, except one, under which the species may be included.

5. DIVISION AND DEFINITION

There are two ways of explaining the meaning of a word. One of these is to indicate the things or the kinds of things to which it is applied. The other is to state the attributes it implies. The former is its denotative meaning, while the latter is its connotative meaning. The modern logicians include both these meanings under the head of definition.

In the preceding chapter, we have seen that one of the ways of explaining the denotative meaning of a word is to show the kinds (or sub-classes) to which it applies. This is called extensive definition. The extensive definition of a word is possible only when it (the word which is defined) is the name of a class of things. Now, if we consider the class which the word represents, we may say that extensive definition through sub-classes is the same as division. Thus, on the modern view, division is identical with one kind of definition (namely, extensive definition).

On the traditional view of definition, the relation between definition and division is quite different. We may recall that the traditional logicians recognized only per genus et differentiam definition. In per genus et differentiam definition, we define a term (which stands for a species) by stating its genus and differentia. Now, a genus may include a number of species. Each of these will be defined by stating its differentia. When we define these species, we consider them by themselves. Though they are species under the same genus, we may not realize that they are coordinate species of one another. Now, we shall understand the nature of these terms (standing for classes) better, if we know that they are species under the same genus. Division provides us this knowledge by showing the various species included in a genus. In view of this, we may say that, to understand the meaning of a term completely, we require both definition and division. That is, we need to know the denotative meaning as well as the connotative meaning. The denotative meaning, which is provided by extensive definition in modern logic, is provided by logical division in traditional logic. The connotative meaning is supplied by (per genus et differentiam) definition.

Leaving aside the above, we may also point out that *division and definition depend upon one another*. In order to divide a class, we must know the fundamentum divisionis; and the differentia of its species may suggest the fundamentum divisionis. The differentia of triangle is 'three sidedness'. This suggests that when we divide the genus 'rectilinear plane figure', the number of sides can be the principle of division. Not only this, when we divide the genus 'rectilinear plane figure', how are we to know what members are to be included in its different species? We can know what members are included in 'quadrilateral', 'pentagon', 'hexagon', 'octagon', etc. from their definitions.

Let us see how definition depends upon division. The definition of a term includes its differentia. The differentia can be understood by comparing the species within the same genus. And logical division gives us knowledge of the species that are included in a genus.

The above discussion clearly shows that if by definition we understand per genus et differentiam definition, the relation between logical division and definition is intimate. Both processes, taken together, contribute to the better understanding of the meaning of a term.

SUMMARY

Logical division is the process of splitting up of a genus into its species. The splitting up is based upon a principle, called fundamentum divisionis. *Fundamentum divisionis* is either an attribute which varies among the members of the class divided, or it is an attribute which is possessed by some members of a class, but not by others. Logical division is to be distinguished from enumeration of individuals, physical division, metaphysical division and verbal division.

Logicians have set forth certain *rules* for logical division. The purpose of these rules is to see that a division is based upon a single fundamentum divisionis, the sub-classes are exclusive as well as exhaustive, and the division does not involve a leap. A division which is not in accordance with these rules is fallacious. The fallacies of division are those of Cross, Overlapping, Too Narrow and Too Wide division.

To ensure that the rules of division are obeyed, logicians have suggested a formal process of division. This is called **division by dichotomy.**

For the modern logicians, division is the same as extensive definition of a word. But the traditional logicians consider the relation between them to be intimate. Definition gives knowledge of the connotative meaning of a word, and division that of its denotative meaning.

TEST QUESTIONS

1. What is logical division? How does it differ from enumeration of individuals, physical division, metaphysical division and verbal division?
2. Discuss the relation between definition and division, both on modern and traditional views of definition.
3. "Since every term has both denotation and connotation, definition and division are closely related." Discuss.
4. What is division by dichotomy? What is its value?
5. Explain the rules of logical division. Give examples of division which violate these rules.
6. Define the following terms :
   1) Division
   2) Fundamentum divisionis
   3) Metaphysical division
   4) Verbal division
   5) Physical division
   6) Division by dichotomy
7. Indicate the alternative applicable in the following cases :
   1. In a logical division if the sub-classes are exclusive, the division cannot be _____. (cross/overlapping/too narrow)
   2. _____ division consists in stating the different meanings. (Logical/Verbal/Physical/Metaphysical)
   3. The fallacies of too narrow and too wide division are _____ found together. (always/never/sometimes)
   4. A dichotomous division _____ be a logically valid division. (must/may/cannot)
   5. If a division commits the fallacy of cross division, it _____ commit the fallacy of overlapping division. (must/may/cannot)
   6. The logical division _____ proceed to the individuals. (can/cannot/may)
8. Examine the following divisions :
   1. Pickpockets into those who pick the pockets of gents and those who perform the same office for the ladies.
   2. Criminals into murderers, thieves, dacoits, robbers, confidence-tricksters, blackmarketers, smugglers, etc.
   3. Cities into well-planned and badly-planned.
   4. Umbrellas into rod, handle, spokes and cloth.
   5. Bees into busy workers and four-winged social insects.
   6. Music into vocal and instrumental.
   7. Race horses into insured, non-insured, pedigreed and non-pedigreed.
   8. Educated men into well-educated, ill-educated and uneducated.
   9. Boxers into heavy-weight and light-weight boxers.

10. Dentists into male, female, costly, cheap, efficient and inefficient.
11. Hindus into those who are religious-minded and those who are not.
12. Propositions into universal, particular, affirmative and negative.
13. Horses into race horses, hunters, mules and ponies.
14. Legendary figures into King Soloman, Birbal, Mulla Nasruddin, etc.
15. Flowers into fragrant and non-fragrant; white and non-white.
16. Christians into those who go to church on Sundays and those who do so on other days.
17. Industrialists into miserly and spendthrift; and spendthrift industrialists into those who prefer to spend money on themselves and those who spend on others.
18. Cobras into poisonous and crawling creatures.
19. Magicians into those who practise black magic and those who hypnotise the audience.
20. Calamities into natural and man-made.

CHAPTER – 18

NATURE AND KINDS OF INDUCTION

DO YOU KNOW THAT ....

- *Simple enumeration is a misnomer; its value does not depend upon numbers?*
- *A scientist's reasonings are more likely to be correct, because he looks before he leaps – he is not foolhardy in jumping to conclusions?*
- *When you visit the same store again and again, you are using analogical argument ?*
- *When the layman concludes that all polar bears are white he stops there, while the scientist starts from there?*
- *In science even one supporting case may be sufficient for establishing a law?*

1. NEED FOR INDUCTION – ITS PROBLEM

Deduction is a formal process. It determines the necessary relations between propositions, irrespective of their contents. As a consequence, the valid argument forms established by deduction can be applied to all fields of inquiry. However, if we depend upon deductive reasoning alone, we would seriously limit our knowledge. The starting point of deduction is certain propositions which are assumed to be true. From these, we can infer the truth of all the propositions that are implied by them. But how are we to determine the truth of propositions offered as evidence for the conclusion ? Deduction does not provide us with a basis for determining the truth of its premises. But a careful thinker is interested in sound arguments; and a sound argument is one which is valid and whose premises are true. This being so, a careful thinker must find out whether, as a matter of fact, the premises of his argument are true.

Let us now consider the different types of propositions that may constitute the premises. If the premises are propositions such as "My uncle is a mal", "Material bodies occupy space" and "All triangles have three angles", there is no difficulty. If we analyze them, we shall know that they are true. Such propositions are called *analytic propositions*. But, in science, as in everyday life, the premises are *synthetic* *propositions*.. A synthetic proposition gives us information about the nature of this world. Examples of synthetic proposition are :

1. All mangoes in this basket are ripe.
2. All continents have large rivers.
3. All crows are black.
4. All metals conduct electricity.
5. Every particle of matter attracts every other particle with a force proportional to the product of the masses and inversely proportional to the square of the distance between them.

The first two propositions make assertions regarding a class of things. However, the classes of "mangoes in basket" and "continents" are restricted classes. It is possible to examine each member of the class, and find out whether the proposition is true. But the task of determining the truth-value of the last three propositions is very difficult. The scope of these propositions is not limited to any given region of space, or period of time. For example, the assertion regarding metals is claimed to be true of metals, wherever they be. If we discover new metals, or metals in new regions, say on Moon or Mars, the proposition will be equally true of them.

It may be said that we can assert the truth of propositions of unrestricted generality (hereafter we shall use the expression "general proposition" for these) if we know the truth of some more general proposition. That means, we can deduce the truth of a (synthetic) general proposition from a proposition of wider generality. In a way, this is what science does. The less general laws are deduced from more general laws. But let us not forget that we can deduce the truth of a less general proposition from a more general one, provided we assert that the more general proposition is true. Once again, we are faced with the problem of determining the truth of a general proposition. However long our chain of reasoning, ultimately, we must come to general propositions whose truth cannot be determined in this manner. We will have to assert their truth on the basis of observation or experiment. **The process involved in establishing (synthetic) general propositions is called induction.**

2. NATURE OF INDUCTION

If we examine the last four propositions above, we shall see that the process of reasoning involved in establishing them is not the same. The propositions like "All crows are black" and "All metals conduct electricity" are clearly different from propositions such as "Every particle of matter attracts every other particle with a force proportional to the product of the masses and inversely proportional to the square of the distances between them." In the former ones, the evidence consists of those particular propositions which contain the same terms as are found in the general propositions. Thus, the evidence for the proposition "All metals conduct electricity" consists of those particular pieces of metals which, on experiment, are found to conduct electricity.

The particular propositions which constitute evidence contain the terms "metal" and "conducting electricity". The general proposition too contains the same terms. On the other hand, the evidence for the last general proposition, which is Newton's law of gravitation, is of a different kind. It is such propositions as express the observable movements of all bodies, of the planets and the sun, of the ebb and flow of tides, etc. In these propositions, we do not find expressions such as "force" and "mass". The general propositions of the former kind (i.e. generalizations) are said to be established by primary induction, while those of the latter kind (called non-instantial hypothesis) by secondary induction.[1]

Primary induction is the process of establishing a generalization on the basis of the observation of some instances. It is an inference in which we proceed from the observation of some instances to a generalization (which includes all instances). *Mill puts it thus: "Induction is the process by which we conclude that what is true of certain individuals of a class is true of the whole class, or that what is true at certain times will be true in similar circumstances .*[2]

It will be noticed that *generalizations depend upon the absence of negative instances.* Because we have not found any exceptions to the electricity-conducting property of metals, we hold that "All metals conduct electricity." In a similar way, since we have not observed any non-black crow, we generalize that "All crows are black."

Let us express the form of primary induction, first with reference to the generalization "All metals conduct electricity" and then symbolically.

Instances $P_1, P_2, P_3 .... P_n$ have the property of conducting electricity.

Instances $P_1, P_2, P_3 .... P_n$ are metals.

....

$\therefore$ All metals have the property of conducting electricity.

We can express this argument symbolically thus:

$P_1, P_3, P_3 .... P_n$ are q.

$P_1, P_2, P_3 .... P_n$ are p.

....

$\therefore$ All p are q.

The symbolic representation clearly brings out three **characteristics of primary induction.** These are :

i) The argument depends upon the observation of instances.

ii) Some instances have been observed, but the generalization (which is stated as the conclusion above) is about all the instances.

iii) The observed instances have a certain similarity. (They are members of the same class.)

Let us now discuss these characteristics :

i) *The primary function of induction is to give us knowledge of facts. That is why observation of facts is an essential feature of induction.* This characteristic distinguishes inductive arguments from deductive ones.

ii) *Inductive inference establishes a synthetic proposition of unrestricted generality.* While dealing with the problem of induction, we have explained how synthetic propositions differ from analytic ones. Induction is neither concerned with analytic propositions (such as "All uncles are males") nor with propositions of restricted generality (like "All mangoes in the basket are ripe"). This is because induction is the process by which sciences establish laws. And laws of sciences are propositions of unrestricted generality.

The process of generalization is risky. We cannot be certain that the unobserved instances possess the same characteristics as the observed ones. Generalizations in science, such as "Lead melts at 327°C" and "All whales are warm-

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[1] Following Nicod, Eaton *(General Logic,* pp. 485-86) and William Kneale *(Probability and Induction,* p. 104) draw a clear distinction between primary and secondary induction.

[2] *System of Logic,* Vol. I., Sixth Edition, p. 321.

blooded", are indeed well-established. It is difficult to doubt their truth. Yet, logically, we cannot rule out the possibility of coming across negative instances. *Therefore, inductive generalizations are said to be probable.* As every generalization is subject to rejection, in the light of new evidence, inductive procedure is risky. And, in view of this risk, the process of generalizing from the observation of instances is said to involve *"leap in the dark"* or *"inductive leap"*. The expression "leap in the dark" is apt. It brings out clearly our inability to find out the nature of unobserved instances.

Let us clarify the notion of probability as applied to inductive generalizations. We are not talking about numerical probability (or relative frequency). We are not saying that the chance of a generalization being true is a certain percentage. Probability in induction merely means that the evidence for the generalization makes it likely that the generalization is true. In this sense, probability is a relative matter. The degree to which it is reasonable to believe a generalization depends upon the weight of evidence. That is why we feel different degrees of confidence in different types of generalizations. For instance, the generalizations of science are more likely to be true that the generalizations in everyday life. The difference between them lies in the nature of evidence in support of the generalization.

iii) *Lastly, induction is based upon resemblances. (The argument from resemblance is called analogy.)* The observed instances resemble one another in being members of the same class. That is why the observed instances, collectively, constitute evidence for the generalization. The generalization includes both observed and unobserved instances. The unobserved instances resemble the observed ones in being members of the same class. Since the observed instances possess a certain property, it is believed that the unobserved instances, being members of the same class, will also possess it. It is on this ground that we are able to generalize. *Mill emphasizes this characteristic when he defines induction thus: "Induction, then, is that operation of the mind, by which we infer that what we know to be true in a particular case or cases, will be true in all cases which resemble the former in certain assignable respects."*[3]

At the very outset, we had made it clear that the term "induction" includes secondary induction. **Secondary induction consists in establishing "non-instantial hypothesis" or "transcendent hypothesis".** In a non-instantial hypothesis the terms used are not the same as those used in the propositions that constitute evidence for it. *Non-instantial hypothesis contains "theoretical" terms.* It expresses relations between such concepts as cannot be observed. Newton's law of gravitation is an example of non-instantial hypothesis. In Newton's law we find expressions such as "force" and "mass". We cannot observe force; nor can we observe mass. The evidence for the law of gravitation is the observable movements of all bodies, of the planets and the sun, of the ebb and flow of tides, etc.

Obviously, the generalizations established by primary induction differ from non-instantial hypotheses. Generalizations are directly based upon the evidence of particular instances covered by them. In the case of the generalization "All metals conduct electricity", we can conduct experiments on representative samples. We can take pieces of different metals, and find out whether they conduct electricity. From these observations we generalize. But not so in the case of non-instantial hypotheses. From a non-instantial hypothesis, by the use of mathematical techniques, the scientist deduces consequences These consequences are propositions in which theoretical terms do not appear. If the deduced consequences occur, they become supporting evidence for the non-instantial hypothesis *The procedure followed in establishing a non-instantial hypothesis is the hypothetico-deductive method.* (We shall discuss the hypothetico-deductive method in Chapter 20.) **We may now define secondary induction more**

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[3] *System of Logic*, Vol. I, p. 321.

fully as the process of establishing a non-instantial hypothesis, by the use of hypothetico-deductive method.

Bacon and Mill maintained that induction is the process of establishing generalizations. This is too restricted a view of induction. On this view, induction will be involved in establishing generalizations, but not in establishing non-instantial hypotheses. We do not accept this view. There are two stages in the development of a science; and there is a continuity between these stages. At the second stage, science establishes non-instantial hypotheses. Since we wish to use the term "induction' for all the generalizations and theories established by science, we shall define induction thus: **"Induction is both the process of establishing generalization from the observation of the particular instances and the process of establishing non-instantial hypothesis."**

3. ARISTOTLE'S VIEW OF INDUCTION

Aristotle attached great importance to the doctrine of syllogism. But, according to his doctrine, every syllogism must have at least one universal premise; and induction is required to establish it. Aristotle means by induction the process of establishing a general proposition by appeal to all the particular instances, or kinds of instances, in which its truth is shown. It *consists in proving a universal proposition by showing empirically that it is true in each particular case or kind of case.* Aristotle suggests that induction may be expressed in the form of syllogism. This is commonly called **Inductive Syllogism.** Aristotle's own example of inductive syllogism is :

Man, the horse, and the mule are long-lived.

Man, the horse, and the mule are bileless.

∴ All bileless animals are long lived.

Aristotle distinguished between syllogism and induction. The principle behind inductive syllogism is that an attribute which is affirmed (or denied) of all the logical parts, may be affirmed (or denied) of the logical whole. The correctness of the argument depends upon whether we have examined every species. With reference to Aristotle's example, it would mean that man, horse, mule, etc. are the only bileless animals. No scientist would hold such a view today. However, Aristotle held this view, because he believed that every genus has a limited number of species.

Even supposing we accept the view that species can be completely enumerated, Aristotle does not indicate how we are to find out the truth of propositions like "Man is bileless". Aristotle does not indicate how we are to ascertain the truth of such generalizations. He assumes that we already know that these generalizations are true. Because, according to him, the nature of a species is essentially the same in all the particulars (i.e. individuals). Our observation of particulars will enable us to see the universal in them. *Thus, for Aristotle, induction does not involve inference from the known to the unknown.*

Thus, it is clear that Aristotle did not regard the process of examining every one of its individual instances as the method for establishing a universal proposition. But his illustration of inductive syllogism contains a suggestion of complete enumeration. The later logicians emphasized this aspect (of complete enumeration), and distinguished generalizations based on the observation of all the instances from those based on the observation of some of the instances. The former were said to be established by perfect induction (or complete enumeration), and the latter by simple enumeration (or incomplete enumeration).

4. PERFECT INDUCTION (COMPLETE ENUMERATION)

When the conclusion is drawn by examining all the objects, or events, which can possibly come under the class, induction is said to be perfect. **Thus, perfect induction consists in asserting or denying of a whole class what has already**

been found true of every member. The requirements of perfect induction can be met only when a class consists of a limited number of members; and we know all of them. Classes such as 'continents' and 'planets' have limited membership. If we examine each and every member of such classes, and find that these possess a certain property, we can assert that property of the class as a whole. By examining Asia, Africa, Australia, Europe, North America and South America, we find that every one of them has large rivers. From this we may establish, by perfect induction, the general proposition: "All continents have large rivers."

The medieval logicians named this process "perfect induction", because its conclusion is certain. However, the expression "perfect induction" is not suitable. For if induction based on the observation of all the instances is called "perfect induction", induction based on the observation of some instances should be called "imperfect". But it would be improper to do so. As we shall see later, generalizations in science are based on the observation of some instances. Since incomplete enumeration is the basis for establishing generalizations in science, it would be awkward to call this process "imperfect induction". In view of this, we should avoid the name "perfect induction". We may call the inference involved in establishing a general proposition by examining all the individuals as "induction by complete enumeration".

Value of induction by complete enumeration : Some logicians, notably Bacon and Mill, find fault with Aristotle for maintaining that universal propositions can be established by complete enumeration. In fact, Mill refused to apply the name "induction" to complete enumeration; and he is right in doing so. Induction by complete enumeration lacks the chief mark of induction, namely, the passage of thought from the known to the unknown.

If the conclusion of an argument involves inductive leap, it cannot be said to be proved. But, for Mill, inductive arguments yield certainty. He said that induction is the operation of proving general propositions. Now the conclusion of an inductive argument can be certain only if it is established by complete enumeration. This clearly shows that if we want induction to yield certainty, we must agree with Aristotle that general propositions are established by complete enumeration. However, no logician would claim today that the conclusions of inductive arguments are certain. Therefore, we cannot attach much value to complete enumeration.

Though complete enumeration is practically useless for science, yet it performs an important function. According to Jevons, complete enumeration is an essential element in all generalizations. It is the basis of incomplete enumeration. To proceed from the observed to the unobserved instances, the scientist must first sum up the results of his observations. The summing up is done by complete enumeration of the observed instances. So the reasoning in science assumes the following form :

All known instances possess the property q.

∴ All instances (known and unknown) possess the property q.

5. PARITY OF REASONING

The term 'induction' is sometimes used for certain processes of reasoning in mathematics. Here a universal proposition is established on the ground that it is proved to be true in one or two instances. This sort of inference occurs in geometry, when we prove something of a particular triangle, or square, and conclude that it is true of any triangle, or square. Mill calls this process 'parity of reasoning'.

Parity of reasoning consists in establishing a general proposition on the ground that, what proves a particular case, will prove every other similar case. Thus, in geometry, we draw a diagram of triangle ABC, and prove that its angles are equal to two right angles. Now, what is proved of the triangle ABC can be proved, in a similar manner, of every other triangle. On this ground, we establish the general proposition "The angles of all triangles are equal to two right angles."

Mill refuses to call this process 'induction'; and rightly so. In induction the generalization is established by observing particulars; but not so in parity of reasoning. We do not measure the angles of some triangles, and then say that what is true of the angles of the observed triangles will be true of the angles of all triangles. *Really speaking, the truth of the generalization does not depend upon the nature of objects and events in this world.*

Let us understand the basis of inference in parity of reasoning. In parity of reasoning we realize the necessary connection between the nature of a triangle and the measurement of its angles. The geometrician's proof brings out this connection. He shows (with the help of a diagram) that the property of 'its angles being equal to two right angles' necessarily follows from the definition of triangle (as a three-sided rectilinear plane figure) and certain assumptions (axioms) regarding the nature of space. The diagram represents all triangles, irrespective of differences in the length of sides, the measurement of the largest angle, etc. It must now be clear that it could not be the case that a figure is a triangle, but its angles are equal to either more or less than two right angles. This is the case in the relation of implication. The definition of triangle (along with the axioms of geometry) implies that the sum of its angles is two right angles. In Chapter 1, we have seen that only (valid) deductive arguments exhibit the relation of implication. **Therefore, we conclude that parity of reasoning is deductive in nature.**

6. COLLIGATION OF FACIS

The term 'induction' has been used in two senses. Firstly, it may mean the inference involved in establishing a generalization from the observation of particulars. Secondly, it may mean the whole process of scientific investigation. In the second sense, colligation of facts can be called 'induction'.

Sometimes a phenomenon consists of parts, and these parts are only capable of being observed separately. To understand the nature of the phenomenon, we must hold the different observations together by means of a suitable notion. The process of binding the observed facts together, with a suitable notion, is called "colligation of facts". **Thus, colligation of facts consists in applying a description to the observed facts, so that they form a single whole.** The example traditionally given is that of a navigator. A navigator sailing in the midst of the ocean discovers land. He cannot say, at first, whether it is an island or a continent. He sails along its coast; and after a few days comes back to the same place. On the basis of this, he says that it is an island. Now, in this case, no single observation of the navigator would have enabled him to call it an island. Every time he saw a different piece of land. Then to describe all his observations, he selected a general expression, namely 'island'. In fact, the notion of island enabled him to understand how he came back to the same place. Obviously, the navigator's conclusion, that the land in question is an island, is not arrived at by inference from the observation of the different parts of the land. The conclusion is the facts themselves.

There was a long controversy between Whewell and Mill about the place of colligation in induction. *Mill maintained that colligation cannot be called induction; it is a process subsidiary to induction.* This is because in colligation there is no inference to the unknown. *Whewell, on the other hand, believed that induction is the art of discovery.* Therefore, he attached greater importance to the discovery of new conceptions for understanding facts than to the act of generalizing. New conceptions colligate the facts in a better way *That is why, for him, colligation of facts, by means of appropriate conceptions, is the essence of induction.* The originality of the scientist consists in his ability to conceive of more appropriate ways of describing facts. Compared to this, the inference involved in generalizing is child's play.

Whether we call colligation 'induction' or not depends upon what we mean by induction. In this connection, let us state what, according to Mill, are the purposes of science. They are description, explanation and prediction of facts. Colligation serves the first purpose. This shows that Mill realizes the importance of colligation in science. But he refuses to call it induction, because he maintains that no inference is involved in describing facts. In an earlier Section, we have maintained that 'induction' stands for the methodology of science. Therefore, we agree with Whewell that colligation is induction.

7. SIMPLE ENUMERATION

Our everyday life beliefs, as well as scientific knowledge, have their roots in experience; but they extend beyond experience. In all spheres of life, we believe that what is true of the observed instances will be true of the unobserved ones. That is to say, we generalize. A generalization is a statement whose scope is wider than the evidence for it. "Fire burns", "Water quenches thirst", "Food nourishes", "Arsenic is poisonous" and "Crows are black" are examples of generalizations.

Generalizations of the common man differ from those of the scientist. The former are arrived at by simple enumeration. The latter are established through the scientific method.

When a generalization is supported by positive instances and no contrary instance has been observed, the method of simple enumeration is said to be used. Thus, simple enumeration consists in arguing that what is true of several instances of a kind is true universally of that kind.[4] Generalizations such as "All crows are black", "White cats with blue eyes are always deaf", and "Every rose has thorns" are arrived at by simple enumeration The form of inference here is :

All observed P's are Q.
(No observed P is non-Q.)

....

∴ All P's are Q.

Generalizations established by simple enumeration have the following characteristics :

Characteristics of Simple Enumeration

Uncontradicted experience	Belief in uniformity	No analysis of properties	Low probability

1. **Uniform (or uncontradicted) experience :** Simple enumeration is based on the tendency to expect that what is true of the observed instances will also be true of the unobserved ones. This shows that the ground of generalization in simple enumeration is uniform (or uncontradicted) experience. Our experience shows that certain properties are found together. Blackness always goes with crows; deafness is a characteristic of white cats with blue eyes; and so on. We have not come across any contrary instance. So we expect that what is true of the cases within our experience will always be true.

2. **Belief in uniformity of nature :** The method of simple enumeration supposes that if there were any contrary instances, we would have come across them.

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[4] Mill puts it thus : Simple enumeration "consists in ascribing the character of general truth to all propositions which are true in every instance that we happen to know of." (*System of Logic*, Part 1, p. 340)

Further, we are inferring certain properties of the unknown cases; because we have found them in the known cases. So the generalization is based on the belief that nature uniform.

3. Lack of analysis of properties : In simple enumeration, we do not analyze the properties of the observed instances. That is, we do not attempt to find out why certain properties go together. In the generalization about crows, we have not cared to find out why the property of blackness goes with crows. in fact, if we were to do so, we would be conducting a scientific investigation.

4. Low degree of probability : A generalization by simple enumeration is based on mere uniform experience. So if we come across any contrary instance, it will be rejected. That is why it is said that, as opposed to generalizations in science, generalizations established through the method of simple enumeration have a low degree of probability.

Value of induction by simple enumeration : Bacon and Mill considered the process of simple enumeration as unreliable; and they were right. However, they held that its value depends upon the number of instances observed. But this is not so. For, even if we observe very many instances, we cannot rely that the next unknown instance would have the same property. In fact, all generalizations by simple enumeration do not have the same value. Let us suppose that every blue-eyed person I have met is untrustworthy. From this I generalize that all blue-eyed persons are untrustworthy. Obviously, this generalization is not as likely to be true as the generalization about crows. There are two reasons.

1. ***Wider experience* :** The generalization about crows is based on much wider experience. The value of observing a larger number of instances is this : If there were any contrary instances (say, non-black crows), the wider the experience, the greater the likelihood of coming across them.
2. ***Resemblance* :** Blue-eyed persons do not have much in common. They resemble one another only in the colour of eyes. We cannot say that this characteristic is important for inferring untrustworthiness. On the other hand, crows have many resemblances. And it is possible that some of these are relevant for possessing black colour.

This second point shows that the value of simple enumeration does not depend upon the number of instances alone. It is also affected by the nature of resemblances among the observed instances. Inference from resemblances is called analogy. However, when we use the method of simple enumeration, we are not conscious of analogy.

Of course, the *number* of instances makes a difference. The value of observing a large number of instances is this : If, in spite of observing a large number of instances, we don't find any contrary instances, it is probable that no such instances exist. But, even for this purpose, we are more interested in the variety of instances, rather than in mere number. To illustrate, observing thousands of crows in the same region does not have as much value as observing a few crows from each region of the earth. Moreover, if we observe different types of instances, we would be able to eliminate unimportant characteristics. By observing crows in different regions, we know that characteristics like belonging to a certain region and availability of a certain type of food have nothing to do with the colour of the crow. Therefore, it is likely that the property of being crow is the reason for its colour.

8. SCIENTIFIC INDUCTION

Science explains and describes facts. It does this by establishing laws. These laws are propositions of unrestricted generality. In the past, logicians, e.g. Bacon and Mill, held that scientific laws are established by a kind of inductive reasoning. They called this process "scientific induction".

Broadly speaking, scientists use two main methods – (i) the hypothetico-deductive method and (ii) scientific induction. Of the two, the first one is more widely used. Scientific induction can be used for establishing only scientific generalizations. It is not suitable for establishing theories.[5] Nor can it be used for establishing the conclusion about a particular case.

According to Bacon and Mill, scientific induction is the process of establishing a generalization which expresses a causal relationship. This process involves four main stages. These are :

i) Some instances are observed, and it is found that these possess certain common properties.
ii) A generalization is framed about all these instances.
iii) The observed instances are analyzed to discover a causal relationship, if any.
iv) Certain methods, called experimental methods, are used to verify and prove the causal relationship.

Let us take a causal law, and show how it can be established by the above process.

i) Finlay observed some yellow fever zones. He found in these a certain kind of mosquito. (Observation)
ii) From these observations he generalized that wherever there is yellow fever epidemic, these mosquitoes are present in greater numbers. (Generalization)
iii) The bite of this mosquito is the cause of yellow fever. (Analysis)
iv) "Camp Lazear" was established. Persons who had not suffered from yellow fever earlier were selected. No one else was allowed to enter the camp. In two months' time ten of these persons got yellow fever through mosquito bite. (Experimental methods were used for verification.) So, it was established that yellow fever is caused by mosquito bite.[6]

We cannot accept Bacon's and Mill's views about scientific induction. There are two reasons for this.

1. All scientific generalizations do not express causal laws. For example, the generalization "All whales are warm-blooded" is not causal. The property of being warm-blooded is not an effect of being a whale
2. The experimental methods (Chapter 21) can provide only direct evidence. The direct evidence consists of those cases which fall within the scope of the generalization. But, in science, a generalization does not stand alone. It is a part of a system. So, it gets support from the other generalizations established in the system. The support from the other generalizations in the system forms indirect evidence for it.

In view of the above, we may now define scientific induction thus: **Scientific induction is the process of establishing a generalization on the basis of both direct and indirect evidence.** The following generalizations have been established by scientific induction:

1. All metals expand when heated.
2. All whales are warm-blooded.

Direct evidence for the generalization about metals consists of those pieces of metal on which experiments have been conducted. But, not only metals, other

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[5] Some of the laws of science are called theories. A theory uses theoretical terms. A theoretical term refers to entities that cannot be directly observed. Newton's law of gravitation is a theory. This theory uses theoretical terms like "mass" and "force".

[6] This is a simplified account of an actual investigation.

material bodies (e.g. gases) too, expand when heated. The generalizations about the other material bodies form indirect evidence for the generalization regarding metals. In a similar way, direct evidence for the proposition, "Whales are warm-blooded" consists of the observed whales. Indirect evidence for it is that other mammals (e.g. cats, lions, sheep and bats) too are known to be warm-blooded.

9. SIMPLE ENUMERATION AND SCIENTIFIC INDUCTION

Both induction per simple enumeration and scientific induction are processes of inductive reasoning. But they differ in certain important characteristics. These are :

1. Evidence : The evidence for a generalization which is established by simple enumeration is purely direct. It consists of those cases which have been observed so far. On the other hand, a scientific generalization occupies a definite position in a scientific system. So the evidence for scientific induction is both direct and indirect.

2. Value : Induction by simple enumeration has greater value if it is supported by a large number of observed instances. This is not the case with scientific induction. Since a scientific generalization is a part of a system, sometimes a single experiment is sufficient to establish it. Let us suppose that a new metal is discovered, and a scientist wants to know whether it conducts electricity. He performs an experiment, and finds that it does. So he generalizes : "All samples of this metal conduct electricity". The scientist is satisfied. He has confidence in his generalization. His confidence is due to the fact that each new element has resemblances with the elements (metals) which are already known.

3. Explanatory power : Generalizations established by simple enumeration merely express uniform (or uncontradicted) experience. They do not attempt to explain the observed facts. But scientific induction explains the observations. To illustrate, it has been observed that electric current passes through a copper wire, an aluminium wire, etc. These observations are explained by the generalization : "All metals conduct electricity."

Since scientific induction explains the observations, scientists can predict the nature of unobserved cases. And this enables them to verify generalizations.

4. Analysis : All inductive generalizations are based upon resemblance (or similarity). But, here again, simple enumeration differs from scientific induction. In simple enumeration, there is no analysis of the observed instances. So, no attempt is made to find out whether the observed instances resemble one another in important characteristics. In scientific induction, observed cases are analyzed, and unimportant resemblances are ignored. Let us illustrate. A bat flies like birds; but it breast-feeds the young ones, as mammals (e.g. cat, dog and lion) do. The latter characteristic (breast-feeding) is a more important one. So, in zoology, the generalization about bats is grouped with generalizations about mammals.

10. ILLICIT (HASTY) GENERALIZATION

Earlier we have defined generalization as the conclusion of an inductive argument whose scope is wider than the evidence for it. From this definition we see that all generalizations, whether in everyday life or in science, depend upon insufficient evidence. But some of them are extremely unreliable. There is very little evidence for them. Such generalizations are called illicit (or hasty) generalizations. **The fallacy of hasty generalization is committed when the scope of the generalization is too wide, compared to the evidence in its support.** Let us take examples :

1. An American novelist spends a few months in Calcutta and, then, generalizes that the Indian youth is violent.
2. An Indian visits Hollywood for a week. While he is there, two divorces take place. If he generalizes that Hollywood marriages end in divorce, he is committing the fallacy of hasty generalization.

It is obvious that in these two cases the evidence is too little. Therefore, we would not hesitate to say that these involve illicit generalization. On the other hand, the generalization "All crows are black" is not illicit. There is a fair amount of evidence for it. The generalization is supported by the experience of mankind over a long period and under many different geographical conditions.

Quite often it is difficult to decide whether a generalization is illicit. Some generalizations in science are based upon just a few, or even one, instance; and yet they are regarded as established. To illustrate, when deuterium, a new chemical substance, was discovered, chemists wanted to find out its properties. One or two carefully conducted experiments were considered sufficient. Now this brings us to the question: *"How are we to distinguish between illicit and well-established generalization?"* Obviously, no clear-cut rules can be laid down, and the judgment has to be that of an expert in the field to which the generalization relates. However, broadly speaking, we may mention two criteria. These are: (i) the nature of facts to which the generalization relates; and (ii) the type of instances chosen. In certain fields of inquiry, experience shows that we may expect uniformities. In chemistry, for instance, the scientist has good grounds for believing that the nature of a chemical substance is the same in all its instances; whereas in biology greater variations are noticed in certain features, say the colour of an animal. Therefore, in biology, a larger number of instances need to be observed, while in physics or chemistry we may safely rely upon an instance or two. In those fields of inquiry where wide variations occur, the types of instances also need to be carefully chosen. In the American novelist's generalization about the Indian youth, the instances observed were not well chosen. Young men in Calcutta are not a fair sample of Indian youth; for the conditions prevailing in Calcutta do not prevail in the rest of India. Therefore, what is true of the young people in Calcutta may not be true of young people all over India.

11. ANALOGY

While analyzing the nature of induction, we have seen that analogy (or resemblance) is the basis of generalization, both in everyday life and in science. Apart from this, analogy is also a distinct form of induction. In this section we are concerned with analogy as a form of inductive argument.

As a form of induction, analogy stands for inference in which the conclusion is drawn on the basis of observed resemblances. In this sense, **it may be defined as an argument from partial resemblance to further resemblance.** That is to say, if two (or more) things resemble each other in certain characteristics, and if one of them possesses a further property, the other is also likely to possess it. The pattern of an analogical argument is as follows:

P_1 is observed to have properties $R_1\ R_2\ R_3 \ldots\ldots R_n + q$.

P_2 is observed to have properties $R_1\ R_2\ R_3 \ldots\ldots R_n$

P_2 is likely to have the property q.

Let us take two analogical arguments – one from our common experiences, and one from science.

1. When Mr. M. stayed at the hotel H_1, he found the service to be very good. This time he is going to stay at the hotel H_2. The charges of both the hotels are similar. The waiters have been trained in the same way. Both the hotels are run by the same management. Therefore, service in hotel H_2 will also be good.
2. **Lowell's analogy about life on Mars :** On the basis of the observed similarities between Earth and Mars, Lowell put forward an analogical argument. Both Earth and Mars are planets. They revolve round the sun. They possess water and are

surrounded by atmosphere. Both of them have moderate temperature. There are living beings on Earth. Therefore, Mars also has living beings.

The logical basis of the argument from analogy is this : We believe that the characteristics which are found together are likely to be connected with one another. In the case of Mars, we have observed certain qualities (in which it resembles Earth). On Earth, these qualities are present; and there are living beings. So it is expected that there is some connection between these qualities and the presence of life. The following illustration brings out this point:

3. Two students have the same height and weight. They belong to the same community, and live in the same locality. One of them is intelligent. Therefore, the other must also be intelligent.

Obviously, this analogical argument is bad. Height, weight, community, and locality have nothing to do with intelligence. So we do not attach any value to the argument.

12. VALUE OF ANALOGY

Some analogical arguments are highly probable, while others are worthless. While determining the value of an analogical argument, we have to keep in mind that probability is a relation between the evidence and the conclusion. The probability of an analogical argument has to be judged in relation to the evidence at the time when it (the argument) is advanced. Moreover, there is no ready means of judging the degree of probability. The judgment has to be that of an expert in the field to which the analogical argument relates.

Mill proposed three criteria – which we cannot accept – for determining the value of analogy. These are (i) the extent of known resemblance, (ii) the extent of known difference and (iii) the extent of unexplored region of unknown properties. He said where the resemblance is very great, the ascertained difference very small and our knowledge of the subject-matter fairly extensive, the argument from analogy has high probability. Now Mill lays emphasis on the number of points of resemblance and difference. But even if two things resemble one another in many properties, the argument may have no value whatsoever. For if the resemblances are in unimportant properties, it would make no difference to the conclusion.

In this connection, we may mention certain concepts used by Keynes. He uses the notions of total positive analogy, known positive analogy, total negative analogy and known negative analogy. All the characteristics – known as well as unknown – in which two (or more) things resemble are the *total positive analogy*. The known resemblances between things are the *known positive analogy*. All the characteristics (known as well as unknown) in which things differ constitute the total *negative analogy*, while the known differences constitute the *known negative analogy*. Thus, positive analogy consists of resemblances; negative analogy consists of differences.

It is obvious that we can neither know all the resemblances nor all the differences. We can only know some of them. *Therefore, while judging the probability of an argument from analogy, we have to depend upon the known positive analogy and the known negative analogy.*

1. *When the known positive analogy (resemblances) consists of important properties, the conclusion of analogy has a high degree of probability.*

We shall compare two analogies with reference to this condition. In the case of the analogy about Earth and Mars, resemblances – atmosphere, water and moderate temperature – are important. This is because these are the essential conditions of life on Earth.

Now consider another analogical argument. The structure of sense organs and nervous system of cats is similar to that of human beings. Since human beings possess ideas, cats also possess them. This argument is clearly weak. Of course, we cannot be sure, at what stage of evolution, consciousness appears. Yet resemblance in sense organs and nervous system cannot be considered as important for inferring consciousness.

2. *When the known negative analogy (differences) consists of important properties, the conclusion of analogy has little probability.*

Moon is alike Earth in the following : being a solid, being nearly spherical, appearing to contain active volcanos, receiving heat and light from the sun in about the same quantity as the Earth, and revolving on its axis. As there are living beings on Earth, there must be living beings on Moon. This analogy is weak. With reference to the presence of life, these resemblances are unimportant. On the other hand, differences are important. Unlike Earth, Moon has no atmosphere. Since air is essential for life, this is an important difference.

The example of moon was deliberately taken. It shows that, in the same argument, both resemblances and differences have to be considered. We have to judge the relative importance of positive analogy and negative analogy. In fact, we never come across analogies in which we are aware of resemblances alone or differences alone.

3. *The conclusion should assert the minimum that is justified by the evidence.*

Resemblances between Earth and Mars justify the inference that there are living beings on Mars. But these do not justify the conclusion that there are human beings on Mars. Merely because Mars is alike Earth in the presence of the basic conditions of life, we cannot infer that life on Mars has developed in a similar manner.

We may sum up the factors on which the value of analogy depends thus: *The argument from analogy is based on the belief that certain properties are found together.* That is why if we know that some properties (known resemblances) are present, we can infer the presence of other properties. Even weak analogies are based on this belief.

13. SOUNDNESS OF ANALOGICAL ARGUMENTS

We have seen that no analogical argument proves its conclusion. However, some analogical arguments are good, while others are bad. A good analogical argument is one whose conclusion is highly probable. Conversely, a bad analogical argument is one whose conclusion has a low probability. To determine the soundness of an analogical argument, we have to consider the nature of evidence and the type of conclusion drawn. We may analyze these into the following factors :

1. Known resemblances : The known resemblances affect the value of an analogical argument only when they are relevant to the conclusion. Now, if the resemblance consists of important properties, the analogical argument has a high probability. Some of the ways in which the resemblances may be said to be important are the following :

a) The resemblance is the cause of the inferred property.
b) The resemblance is the effect of the inferred property.
c) The resemblance is a necessary condition of the inferred property.
d) The resemblance and the inferred property are co-effects of the same cause.

2. Known differences : If the known difference consists of important properties, the analogical argument will have a low probability.

3. The number of things having the observed resemblances and the inferred property : The requirement of an analogical argument is that the resemblances and the inferred property be found together in one instance. Now, if the resemblances and the inferred property have been found together in many instances, the analogical argument has a higher degree of probability.

To take an example, Mars resembles Earth in certain properties. Since Earth has living beings, Mars is expected to have living beings. Let us now suppose that we know another planet (say Pluto or Neptune) which has living beings. In that case, the inference about Mars will be more probable.

4. Nature of the conclusion : The less we infer in the conclusion, the more likely is the conclusion to be true. To illustrate, when we infer that there are human beings on Mars, the conclusion has lower probability than when we infer that there are living beings on Mars.

14. IMPORTANCE OF ANALOGY

Analogy performs many useful functions, both in everyday life and in science. In everyday life, we draw inferences on the basis of observed resemblances. We visit the same store, the same book-shop, the same hair-cutting saloon. We argue that when we visited a certain store on the occasion 'a', we found salesmen to be polite. Therefore, on the occasion 'b' too, we expect the same. Clearly, this is an argument from analogy. The ground of inference is positive analogy (resemblances) between the two visits.

Role of analogies in science : There are three ways in which analogies are used. These are: to illustrate or to explain, to suggest hypotheses, and to draw inferences.

Functions in Science

Explanation	Suggesting hypotheses	Making predictions	Choice between hypotheses

1. As a method of explanation : In science, analogies are sometimes used for explaining phenomena. To illustrate, before the existence of viruses was known, the concept of virus was used to explain the course and development of certain diseases. Viruses are similar to bacteria; and bacteria were known to cause many diseases. In many diseases, bacteria cannot be isolated. So it was proposed that viruses cause such diseases.

2. Suggest hypotheses : All scientific investigations are guided by hypotheses; and analogies have often suggested fruitful hypotheses. This is the most important use of analogies.

Black's experimental discoveries about heat were suggested by his conception of heat as a fluid. (Like a fluid, heat passes from one body to another. It passes from a body of higher temperature to a body of lower temperature.) Huygen's wave theory of light was suggested by the familiar view of sound as a wave phenomenon. The analogy of a falling apple suggested to Newton by a falling moon; and this led to his law of gravitation.

3. Drawing inferences : Analogies are used in arguments for two purposes. These are :

a) Analogies enable us to make predictions : This point is well illustrated by Halley's prediction of the appearance of a comet in 1758. The orbit of a comet is like that of a planet. Since the orbit of a planet can be calculated in a precise way, it follows that the orbit of a comet too can be calculated. It was known that a large comet had appeared at regular intervals in 1305, 1380, 1456, 1531, 1607 and 1682. Therefore, on the analogy of regularity in the movement of comets, Halley inferred that a comet will appear in 1758.

b) ***Choice between alternative hypotheses :*** Analogies also help us to choose between alternative hypotheses. Let us illustrate. When both Copernican and the Ptolemaic system had supporters, analogy helped scientists to choose between the two. By an analogical argument it was shown that the Copernican system provides a better explanation. By the use of his new telescope, Galileo discovered four small satellites of Jupiter. These satellites were seen to revolve round Jupiter in different periods, but in one plane. From this astronomers inferred, by analogy, that what happens on the small scale, in the case of Jupiter, may also happen on the wider scale in the case of the whole planetary system. This analogy suggested that the Copernican system was probably correct.

The importance of analogies for science is so great that **science will never be able to eliminate the need for analogies.** Science aims at systematization of knowledge. So a hypothesis is considered to be satisfactory only when it has certain analogies (resemblances) to well-established theories.

SUMMARY

Deduction has many uses; but it is not a means of gaining knowledge of matters of fact. We hold many beliefs about the nature of things and events, and these beliefs are established by induction.

Nature of induction : By inductive argument, we establish both generalizations and non-instantial hypotheses. However, the nature of argument in the two cases is different. That is why the two processes are named differently. The former is called primary induction, and the latter secondary induction.

Kinds of induction : Induction has had a long history, and the meaning of the term has undergone considerable changes. For Aristotle, induction consists in proving a universal proposition by showing, empirically, that it is true in each particular case, or kind of case. He expressed the argument in the form of syllogism, now called *'inductive syllogism'*.

The later logicians have named the process of establishing a general proposition by appeal to all the particular instances covered by it as *'perfect induction'*. Really, perfect induction is a process of complete enumeration.

Parity of reasoning consists in establishing a universal proposition on the ground that, what proves a particular case, will prove every similar case. Really, this process is deductive in nature. *Colligation of facts* is the process of binding together the observed facts with a suitable notion.

Simple enumeration consists in arguing that, what is true of several instances of a kind, is true universally of that kind. The real ground of generalization by simple enumeration is resemblance or analogy.

Simple enumeration establishes a generalization on the basis of uncontradicted (or uniform) experience. In this kind of inference there is no analysis of the observed instances. It is sometimes said that the value of simple enumeration depends upon the number of instances observed. However, the inference is also affected by the nature of resemblances among the observed instances.

When a generalization is based on very little evidence it is called *illicit generalization.*

Analogy is an argument from known resemblance to further resemblance. Its logical basis is this : We believe that the characteristics which are found together are likely to be connected with one another. The value of analogy depends on three main factors. These are the importance of observed resemblances, the importance of observed differences, and the nature of the conclusion.

Scientific induction is the process of establishing a generalization on the basis of both direct and indirect evidence. The direct evidence for it consists of those cases which fall within its scope. The indirect evidence consists of the support that comes from the other generalizations in the system.

TEST QUESTIONS

1. Explain the nature of induction. Bring out the need for induction.
2. Explain the difference between perfect induction and simple enumeration. Is it proper to use the expression "perfect induction" ?
3. Describe the reasoning involved in Aristotle's inductive syllogism. Does it differ from induction by complete enumeration?
4. Explain Parity of Reasoning and Colligation of Facts. What is their value from the point of view of inductive reasoning?
5. Explain, with illustrations, the nature of primary and secondary inductions.
6. Explain induction by simple enumeration. How does it differ from scientific induction?
7. Define scientific induction and explain its nature.
8. What is analogy? Explain the factors on which its value depends.
9. Write a note on the importance of analogy.
10. State whether the following statements are true or false:
    1. The universal proposition established by perfect induction is one of unrestricted generality.
    2. In simple enumeration the evidence is both direct and indirect.
    3. The value of induction by simple enumeration does not depend upon the kind of instances observed.
    4. The value of analogy depends only upon the nature of observed resemblances.
    5. The value of analogy has nothing to do with the nature of its conclusion.
    6. In illicit generalization, the evidence consists of a large number of instances.
11. Re-write the following statements if they are incorrect :
    (If they are correct, say so.)
    1. Perfect induction sometimes involves inductive leap.
    2. The conclusion of colligation of facts is probable.
    3. In Aristotle's inductive syllogism the evidence consists of the species observed.
    4. The conclusion of colligation of facts is a universal proposition.
    5. In an analogical argument, we consider only two cases.
    6. Simple enumeration is based upon the evidence of some of the observed instances.
    7. The value of induction by simple enumeration depends only upon the number of instances observed.
    8. In scientific induction the evidence is purely indirect
    9. In illicit generalization the evidence is purely direct.
    10. The nature of observed differences does not affect the value of analogy.
    11. If the resemblances are important, the analogy cannot be a bad one.
12. Indicate the appropriate alternative in the following :
    1. The generalizations established by scientific induction are ______ propositions. (analytic/synthetic)
    2. The universal proposition established by parity of reasoning is ______. (probable/certain)

3. Perfect induction consists in ______ of a whole class what has been found true of every member. (affirming/denying/either affirming or denying)
4. ______ is based upon the ground of uncontradicted experience. (Simple enumeration/Scientific induction/Analogy)
5. ______ consists in applying a description to the observed facts, taken as a single whole. (Perfect induction/Parity of reasoning/Colligation of facts)
6. If the resemblances are superficial, the analogical argument is ______. (good/bad)
7. In analogy the evidence consists of the observation of at least ______ individual objects. (one/two/three/four)
8. The universal propositions established by scientific induction are ______. (certain/probable)
9. The value of analogy depends upon the ______ of resemblances. (number/nature)
10. Perfect induction is ______ induction by complete enumeration. (the same as/different from)

13. Test the soundness of the following arguments from analogy :
   1. Two archaeological expeditions were sent to Egypt. The coins dug out by them were similar in certain respects. They were made of the same metal and had similar writing on them. The coins found by the expedition 'A' belonged to approximately 150 A.D. From this, we can infer that the coins found by the expedition 'B' must belong to the same period.
   2. After the last month's accident, the Government has decided to build a wall at the dangerous curve on the road to Khandala. There is no sense in doing it now. It is as useless as locking the barn after the horse is stolen.
   3. The orbit of the planet 'P' is like the orbit of the comet 'C'. The orbit of the planet 'P' can be calculated precisely. Therefore, scientists can calculate the orbit of the comet 'C' too.
   4. Two plants resemble each other in the following points :
      a) They are planted in the same type of pots.
      b) They are planted by the same person.
      c) They grow at the same rate.

      One of them gives juicy fruits. Therefore, the other plant will also give juicy fruits.
   5. The movie I am going to see today is like the last one I saw. In both of them the hero and the villain are interested in the same girl; the hero is an employee of the villain; and the hero is accused of the murder committed by the villain. In the last movie, the hero killed the villain in a gun fight. Therefore, in this movie too, the hero must have killed the villain in a gun fight.
   6. While walking along, I saw birds, whose heads I could not see; otherwise they looked the same. Their bodies were of the same size. Their feathers were of the same colour. Their legs looked alike, and their feet had the same number and type of toes. One of them raised its head, and I saw that it was an ostrich. Therefore, the other must also be an ostrich.
   7. In a Court case, Mr. D. was charged with selling bad beer to Mr. P. He denied the charge; and brought witnesses who said that he had sold good beer to them. Therefore, Mr. D claimed that he had sold good beer to Mr. P too.
   8. I saw two cars. They bore the same name, had body of the same colour, the same type of steering wheel, the same number of doors, and the same design

of handle. I lifted the hood of one car, and found 'X' type of engine. So the other car too must have this kind of engine.

9. The last time I bought a tin of mango jam, I found it to be very tasty. Today also I have bought a tin of the same jam. The label on this tin is of the same type. The tin is of the same size and colour. The name of the manufacturer is also the same. Therefore, this tin too will contain tasty jam.
10. The last time I bought a pair of shoes manufactured by "B", it lasted for two years. Today also I have bought the same company's shoes. The soles of this pair are similar and the leather is of the same quality. But this pair differs from the earlier one in its colour. I expect that this pair too will last for about two years.
11. P is a Public Sector plant, and so are Q and R. All these plants have been making profits; and this year too they have made profits. Q and R have paid 12% bonus to their employees. Therefore, P also will declare 12% bonus.
12. I have read every sea adventure written by C.S. Forester till 1964, and have found every one of them to be highly enjoyable. In 1968, a new sea adventure by C.S. Forester was published. The hero of this novel is the same as that of the earlier books. Therefore, this book too will be enjoyable.
13. Suresh and Kamlesh are equally rich. They have the same social background. They have been educated in the same school. Suresh is well-mannered. Therefore, Kamlesh also is likely to be well-mannered.
14. There are two medicines. Both cure fever. The price of both is the same. One of the medicines produces undesirable reactions on some people. Therefore, the other medicine too would do so.
15. Mr. F bought a flat in the same building as Mr. G had. He paid the same price; and the total area of his flat is the same. Mr. G's flat has three bedrooms. Therefore, Mr. F's flat also must have three bedrooms.

CHAPTER – 19

NOTION OF CAUSE

DO YOU KNOW THAT.....
* ***When you hold that there are many causes for a given effect, you have not done your "home work" properly – you have not analyzed the effect sufficiently?***
* ***Scientifically, a remote factor cannot be the cause of an event?***
* ***When we search for the cause of an occurrence our motive is practical?***
* ***Science does not believe that the cause has the power to produce the effect?***

Even though the scientist, as well as the common man, uses the word 'cause', they do not mean by it the same thing. This is because their search for causes is guided by different motives. The common man's motives are practical. Either he wants to prevent something unpleasant, or he wants to produce a desirable consequence. On the other hand, the scientist's activity is mainly theoretical. He wants to understand phenomena. So we may say that his purpose is to infer the cause when the effect is known; and vice versa.

1. COMMON SENSE NOTION OF CAUSE

There are two ways of looking at causation. We may say that the cause produces the effect, or we may speak of causation as a relation between events. The former is the activity view of cause. The latter is the essence of the scientist's conception of cause.

The main features of the popular notion (or the common sense notion) of cause are as follows :

1. Cause as an agent : The laymen believes that cause is an agent which produces the effect. This is called **the activity view of cause.** In the pre-scientific stage of knowledge, this was the notion of cause. By his effort, man could produce changes; and so he believed that he caused them. If he shot an arrow, and an animal was killed, it was quite natural to say that he was the cause of killing the animal.

Even today, some of our beliefs are an expression of this way of conceiving causes. Many of us believe in the power of prayer, and the ground of this belief is that God can change our destiny. However, with the spread of scientific knowledge, the activity view is no more held. It is realized that causation is a relation between events.

2. Cause determined by practical purposes : The common man's notion of cause is determined by his practical purposes. There are two types of practical purposes. These are : (i) to eliminate something undesirable, and (ii) to produce something desirable.

When the purpose is to eliminate an undesirable consequence, the common man seeks to find out that condition in the absence of which the event would not occur. This is called **necessary condition**. Take the case of a doctor who has to treat a patient for typhoid. He is interested in finding out what bacteria caused the disease. For, in the absence of these bacteria, the person would be free from the disease.

Obviously, a necessary condition is not the whole cause. To pursue the above example, mere presence of a certain kind of bacteria will not cause a disease. Some other conditions are also necessary. For instance, resistance of the body is a relevant condition. However, a doctor is not interested in all these conditions. His purpose is served by considering bacteria (a necessary condition) as the cause of disease.

On the other hand, when the purpose is to produce a desirable effect, it would not be of much help to know a particular condition. He must know all the conditions for the occurrence of the effect. These conditions are called the sufficient condition. Thus, **sufficient condition** is that condition in the presence of which the effect must occur. That is, for producing an effect, sufficient condition is regarded as the cause. To illustrate, oxygen is a necessary condition for lighting a match. For, in its absence, the match would not burn. But this is not the sufficient condition. Other conditions, such as striking a match against the side of the match-box, and dryness of the match and that of the match-box, are also necessary.

3. Most prominent condition as the cause : As we have stated above, when the purpose is to eliminate an undesirable consequence, a necessary condition is regarded as the cause. However, the common man does not consider any necessary condition to be the cause. Rather, he regards the most prominent (or striking) condition (before the occurrence of the effect) as the cause. Bain's definition brings out this aspect of the common sense view of cause. *He says that the cause of an event is some one circumstance, selected from an assemblage of conditions, which is practically the turning point at the moment.*

4. Remote condition as cause : The common man does not always regard the immediately preceding conditions as the cause. Sometimes he considers a remote condition as the cause. A good example of this was provided by a case where the cause of a railway accident had to be determined. The facts of the case were that a workman had quarrelled with his supervisor. And, in anger, he had removed some fishplates from the railway line. This, in turn, had led to the derailment of the train. Here the workman's quarrel will be called a remote condition of the accident. We may mention here that common sense may regard a remote condition as the cause; but science never does. The scientist would regard the immediately preceding conditions as the cause.

5. Belief in plurality of causes : The common man believes that there are many causes for the same event. This is called the doctrine of plurality of causes. In this sense, poisoning and drowning are two of the causes of death.

Science does not believe in the plurality of causes. This belief arises due to insufficient analysis of factors. For example, death by poisoning is different from that by drowning.

2. MILL'S VIEW OF CAUSE

Not only the common man, but the scientist also, has shown interest in finding out the causes of events. Long ago, Hume said that all inferences concerning matters of fact have their basis in causal connections. Science, for him, depends upon establishing causes of events. Mill followed in his footsteps. He too asserted that induction, which is our source of scientific knowledge, establishes causal connections. Hume emphasized certain properties of cause. These are :

i) Cause or causal connection is always between events.

ii) A given cause in similar circumstances always has the same effect.

iii) A given kind of effect is repeatable by the use of similar causal connections in relevantly similar circumstances.

iv) A given cause is always prior to, and contiguous with, the effect.

Mill agreed with Hume that cause is an invariable antecedent. But he wanted to bring out that cause is complex; it consists of many conditions. **So he defined cause as the sum total of the conditions, positive and negative taken together, which is invariable and unconditional antecedent of the effect.** The main points to be noted in Mill's definition are (i) that cause consists of both positive and negative conditions, and (ii) that cause is unconditional.

Cause — a totality of conditions, both positive and negative : Mill asserts that the causal relation seldom holds between a consequent (effect) and a single antecedent. Usually it holds between a consequent and the sum of several antecedents. To take Mill's own example, if a person eats a particular dish and dies, people are likely to say that eating of that dish was the cause of his death. But, really, other conditions are also necessary; as, for instance, a particular bodily constitution, a particular state of present health, and perhaps even a certain state of the atmosphere All of these, taken together, are required for the effect to occur. Now all these are *positive conditions. That is, they must be present so that the effect may follow.* But, in addition, we have to include in cause certain negative conditions; these must be absent so that the effect may occur. *A negative condition, Mill says, is one which prevents the occurrence of the effect.* In the above example, immediate medical aid may prevent death. So the absence of "immediate medical aid" is a negative condition for the occurrence of the effect.

Mill had realized that any invariable antecedent is not the cause. For instance, the sequence of day and night is invariable; we have not found any exceptions to it. But no one would say that night is the cause of day (or vice versa). So, he says, that cause is not merely an invariable antecedent, it is also **unconditional.** In the above example, day would follow from the presence of a sufficiently luminous body (e.g. sun), even if night had not preceded it. Mill's definition of unconditional antecedent is not clear. But it seems that he intended to regard cause as that antecedent which consists of all the necessary conditions, and nothing other than necessary conditions. The scientific notion of cause brings out this feature clearly, when cause is conceived as consisting of necessary and sufficient conditions. So we may say that the scientist's notion of cause is a refinement of Mill's conception.

3. CONCEPT OF CAUSE IN SCIENCE

We have pointed out in an earlier section that the chief interest of science is in understanding the nature of phenomena. Knowledge of causal connections helps the scientist in drawing inferences. The scientist can infer the cause from the effect, and vice versa, only if the causal relation is reciprocal. That is, if C is the cause of E, then E must be the effect of C. The causal relation will be reciprocal if we include in the cause all the necessary conditions, and nothing more than what is necessary. Science meets the requirement of reciprocity by saying that the cause consists of necessary and sufficient conditions. Let us now define the notion of cause as used in science. **From the scientific point of view, cause is a group of conditions, both necessary and sufficient, which invariably and immediately precedes the effect.** This definition reveals the following characteristics of cause :

1. Cause and effect are events. Scientists are interested in finding out, in what way, events are connected. One of the connections between events is that of causal relation. Science is concerned with what is observed. So scientists search for causal relations among the observed events. What scientists can observe is the occurrence of events. They cannot observe any power in the cause to produce the effect. *That is why science does not accept the activity view of cause.* This feature distinguishes the scientist's notion of cause from the common sense one.

There are two properties of cause as an event. These are :

i) **Cause precedes the effect :** In the causal relation, cause is the preceding event; effect is the succeeding event. A scientist searches for the cause of a phenomenon among the preceding conditions. Let us take examples. Suppose a patient dies on the operating table of a surgeon. The surgeon will examine the conditions which preceded this event. For determining the cause, he would ask such questions as "Was there blood-poisoning?", and "Was any organ damaged during the operation?" To take another (and a better) example, every metal has a certain melting point. This melting point is reached when it (metal) is heated to a certain (definite) temperature. In this case, heating of a metal, to a certain temperature, precedes the melting of the metal. Therefore, it will be called the cause of melting.

ii) **Cause is continuous with the effect :** Though the cause precedes the effect, there is no time-gap between the two. Of course, sometimes events which are separated by a certain interval are said to be causally connected. But, in such cases, we assume that there is some causal chain which fills the gaps between the first and the second event. In this causal chain, each link is the cause of the one which follows it. The last link in the chain, i.e. that which is immediately followed by the effect, is the real cause. To take an example, we say that shooting is the cause of death. But between shooting and the bullet hitting the mark, there is a time-interval. This time-interval can be understood only as a chain of events. The first event in the chain is called the cause, and the last (from our point of view) the effect.

2. Cause consists of both necessary and sufficient conditions. We have said that the cause consists of the immediately preceding events. But many conditions that immediately precede the effect are irrelevant. The scientist ignores these. He includes in cause only those conditions that are necessary and sufficient for the occurrence of the effect.

A *necessary condition* is one in the absence of which the effect would not occur. A *sufficient condition* is one in the presence of which the effect must occur. As stated in section 1, oxygen is a necessary condition for lighting a match. But it is not the sufficient condition. On the other hand, a bullet through the heart is the sufficient condition of death by shooting. Nothing more is required for the effect to follow.

A sufficient condition consists of all the necessary conditions. But, usually, it contains more. That is why, for science, cause consists of a group of conditions, each of which is necessary; and all of them, taken together, are sufficient.

Necessary conditions may be either positive or negative. A positive condition is that whose presence is required for the occurrence of the effect. A negative condition is that which must be absent, so that the effect may occur. For example, in the case of death by poisoning, immediate medical treatment may have prevented death. So immediate medical treatment is a negative condition.

3. Causal relation is invariable. Whenever the cause occurs, the effect also occurs. That is, the same cause is always followed by the same effect.

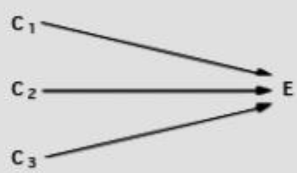
From the property of invariability it follows that the causal relation is between kinds of events, and not between individual events. If cause and effect were to be regarded as individual events, we could never assert that the same cause will be followed by the same effect. We know that events never repeat. Thus, when I throw a ball twice, the second throw is not identical with the first one. There will be some differences.

4. The causal relation is asymmetrical or one-sided. If 'A' is the cause of 'B', 'B' cannot be the cause of 'A'. Thus, the heating of a metal to a certain temperature is the cause of its melting. Its melting is not the cause of its heating.

4. PLURALITY OF CAUSES

We have seen that the cause of a phenomenon is complex. It is a totality of conditions. Now not only the cause, but the effect too, is complex. It has a set of characteristics. For example, when a person dies of poisoning, the effect is not merely death. It is death which has certain properties, such as the presence of the traces of poison in the viscera. On the other hand, when a person is drowned and dies, the effect would have different properties. Here, on post-mortem, water will be found in the lungs. When our purpose is served by ignoring some of the details of the effect, we fix upon the common features of the different effects. In such cases, we believe that there are many different causes of the same effect. **This belief in alternative causes for the same effect is called the doctrine of plurality of causes.**

In the plurality of causes, each cause, on a different occasion, produces a given effect. Each of these causes, by itself, is sufficient to produce the effect. To take examples, heat may be produced by coal, gas, electricity or friction; death may be a result of drowning, poisoning, or heart failure, The plurality of causes may be symbolized thus :



Here C_1, C_2 and C_3 are the alternative causes

While dealing with the scientific notion of cause, we have seen that cause consists of necessary and sufficient conditions. Now, for each kind of effect, there is one definite set of necessary and sufficient conditions. Therefore, the same effect cannot be produced by different causes. This shows that *the belief in plurality of causes is against the spirit of science.*

Sometimes we do not realize the differences between effects, but are able to distinguish between causes. When this happens, we hold that many causes produce the same effect. *But the moment we consider the details of the effects, we see that each cause has a distinct effect.* As we have shown above, death by poisoning is clearly different from death due to drowning. That is why, on post-mortem, the cause of death can be precisely determined. If there were no differences among deaths, it would be impossible to find out the cause of death in a given case.

A sufficient condition, in the usual sense, includes factors that are not necessary. Poisoning or drowning is not the cause of death. It is the cause of a specific kind of death. If we are interested in death in general, rather than in a specific kind of death, then the cause would be what is necessary and sufficient to produce death. Poisoning is not a necessary condition of death in general. (It is a necessary condition of a specific kind of death.) For, even in the absence of poisoning, a person may die. *Thus we see that the necessary and sufficient condition of death is what is common to all the alternative causes of death.* This is the stopping of vital functions (functions concerned with living). Therefore, we may say that stopping of the vital functions is the cause of death.

The belief in plurality of causes arises out of the common man's practical motives. A layman is interested in finding out when a certain kind of effect would occur. So he pays attention to the different causes which may produce it. His purpose will be served even if he ignores the differences among the effects of the different causes. But his purpose will not be served if he ignores the differences among the causes. To illustrate, electricity and coal are different from each other as fuels for cooking. This is why differences among electricity and coal being causes are more noticeable for him. This makes him believe that there are many causes for a given effect.

Since scientists are able to distinguish between the different kinds of effects, they do not believe in plurality of causes.

To conclude, the scientist would not hold that there is plurality of causes, unless clear evidence is found in support of this belief. For belief in the plurality of causes hinders scientific progress. If there were many causes for a given effect, a scientist would not be able to infer the cause when the effect is known. That is why scientists firmly hold on to the view that the causal relation is reciprocal.

5. CONJUNCTION OF CAUSES AND INTERMIXTURE OF EFFECTS

According to Mill, the effects of different causes are not always marked out by boundaries; sometimes they are indistinguishable from one another. In such cases, what we observe is the effect of several causes, acting together. **The combination of causes is called the conjunction (or composition) of causes.** The joint effect due to the conjunction of causes is called **the intermixture of effects**.

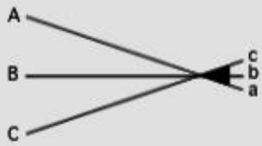
The conjunction of causes takes place in two ways. Therefore, there are two kinds of intermixture of effects. These are homogeneous intermixture of effects and heteropathic (or heterogeneous) intermixture of effects.

In homogeneous intermixture of effects, the joint effect is of the same kind as the separate effects of the combining causes. Here each cause produces its separate effect; but the effects are compounded with one another. Thus, we see that in homogeneous intermixture there is no qualitative difference; the differences are merely quantitative. The joint effect is merely the sum of the separate effects. This kind of effect is seen in mechanics. Each weight of five pounds will produce a certain quantum of pressure. When two such weights are combined, they will produce double the pressure.

In heteropathic intermixture of effects, the joint effect differs in quality from the separate effects of the combining causes. Here the separate effects **cease entirely.** They are succeeded by a phenomenon, which is altogether different from the separate effects. To put it in the common man's language, in heteropathic intermixture we get a different kind of thing. This is seen in chemical combinations. Water is a compound of hydrogen and oxygen; but it does not have the properties of either of them.

The two kinds of intermixture may be represented by the following diagrams :

Homogeneous Intermixture



Heteropathic Intermixture

The diagram for homogeneous intermixture shows that the separate effects (a, b, c) are traceable in the joint effect. On the other hand, in the diagram for heteropathic intermixture we see that an altogether new effect (**J**) arises.

Mill's views on conjunction of causes and intermixture of effects arise out of confusion regarding the meaning of "cause". We have seen earlier that cause and effect are events; and that cause consists of necessary and sufficient conditions. In the case of the so-called intermixture of effects, the necessary and sufficient conditions are the different antecedent factors. These factors cannot be called causes; they are merely conditions. In the example of water (which is Mill's own example), it is misleading to say that hydrogen and oxygen are separate causes of water.

SUMMARY

Commonsense notion of cause : The layman, as well as the scientist, wants to understand how the events in the outer world occur. The notion of causal relation comes to their aid. However, the common man and the scientist approach the problem of causation from different points of view. So their notions of cause differ. One of the chief features of the common sense notion of cause is the belief in the activity view of cause. Further, the common man is motivated by practical considerations. So, when he wants to eliminate an undesirable consequence, for him, cause is any necessary condition, On the other hand, when he wants to produce a desirable consequence, cause is identified with the sufficient condition. Usually, a sufficient condition includes some unnecessary factors too. As a result, the layman believes that there are many causes for the same effect.

Mill's view of cause : The scientific notion of cause arose as a refinement of Mill's notion. Mill realized that cause is a complex event. It consists of conditions, both positive and negative. Moreover, the causal relation is not only invariable, it is also unconditional. *So he defined cause as the sum total of the conditions, positive and negative taken together, which is invariable and unconditional antecedent of the effect.*

Notion of cause in science : From the scientific point of view, cause is a group of conditions, both necessary and sufficient, which invariably and immediately precedes the effect. From this definition we see that cause and effect are events. Cause precedes the effect, but there is no time-gap between the two. Further, the causal relation is invariable and asymmetrical.

Plurality of causes : The doctrine of plurality of causes is the belief that there are alternative causes for the same effect. Each of these causes, by itself, is sufficient to produce the effect. The belief in plurality of causes arises on account of insufficient analysis. The common man's purpose is served by ignoring the details of the effect. But if these details were considered, it would be seen that every cause has an effect of its own. The other way of proving the unsoundness of the belief in plurality of causes is to show that the so-called different causes have something in common. And this common factor is really the cause.

Conjunction of causes and intermixture of effects : According to Mill, certain effects are due to the operation of several causes. The combination of causes is called conjunction (or composition) of causes. The joint effect arising from this is called intermixture of effects. The two kinds of intermixture are : (*i*) homogeneous intermixture of effects and (*ii*) heteropathic (or heterogeneous) intermixture of effects.

TEST QUESTIONS

1. Explain the common sense notion of cause and show why it is defective.
2. Analyze the concept of cause as used in science.
3 Distinguish between necessary and sufficient conditions, and show how the scientific notion of cause requires both types of conditions.
4. Distinguish the scientific notion of cause from the common sense notion.
5. What is plurality of causes? Is the belief in this doctrine justified?
6. Write a note of conjunction of causes and intermixture of effects.
7. State whether the following statements are true or false :
    1. The scientist believes in the activity view of cause.
    2. From the scientific point of view there is some time-gap between the cause and the effect.
    3. The scientist believes that the causal relation is reciprocal.
    4. Sufficient condition never includes conditions that are not necessary.
    5. Plurality of causes means that there are many effects for the same cause.
    6. In the homogeneous intermixture of effects, the joint effect is completely different from the effects of the combining causes.
8. Indicate the alternative applicable in the following :
    1. For producing a desirable consequence, the common man needs to know the ____ condition. (necessary/sufficient)
    2. ____ condition is that in the presence of which the effect must occur. (Necessary/Sufficient)
    3. ____ condition is that in the absence of which the effect cannot occur. (Necessary/Sufficient)
    4. If the joint effect differs in quality from the separate effects of the combining causes, the intermixture is called ____. (homogeneous/heteropathic)
    5. The common man believes that cause is the necessary condition when he wants
        i) to produce a desirable consequence;
        ii) to eliminate an undesirable consequence.

CHAPTER – 20

HYPOTHETICO – DEDUCTIVE METHOD AND HYPOTHESIS

DO YOU KNOW THAT ......
* *Scientific hypothesis must be falsifiable?*
* *Every law was once a hypothesis?*
* *A crucial experiment, like a guide post, points to the better route?*
* *No hypothesis can really be proved?*
* *A great scientist is great, because his mind is ever ready to catch new ideas?*
* *A simpler hypothesis need not be easier to understand?*

1. HYPOTHETICO-DEDUCTIVE METHOD

Scientific method : There are certain common features in the investigations conducted in the different sciences. These may be called the scientific method. *Thus, scientific method is the procedure adopted by scientists in establishing their conclusions.*

Most scientists and philosophers assert that science uses "the method of hypothesis", or the **hypothetico-deductive method.** The hypothetico-deductive method involves certain stages. Before we deal with these stages, we shall recount a few investigations in science.

1. Kon-Tiki expedition (an investigation in Sociology)

It was observed that there are certain similarities between the ancient traditions of natives of the South Sea Islands and the inhabitants of South America. These similarities led a group of sociologists to propose the hypothesis that the natives of the South Sea Islands came from South America. This hypothesis was disputed. It appeared impossible that, thousands of years ago, these primitive people could have undertaken a journey of several months.

From the hypothesis, the scientists deduced that a primitive boat (a loosely constructed raft, with poor facilities for steering, and only a limited space for storing food) must be capable of undertaking such a journey. This consequence was tested.

The scientists undertook a trip in such a boat. The prevailing currents carried them to the destination. They arrived on the islands after a little over hundred days.

2. Discovery of Neptune

Astronomers had calculated the orbit of the planet Uranus, on the basis of the gravitational pull of the then known planets. But, in 1820, Bouvard observed that Uranus does not move in this calculated orbit. The astronomers advanced the hypothesis that there is a planet, beyond Uranus, which is disturbing the gravitational force of Uranus. Two men, Adams in England and Leverrier in France, calculated (on the basis of the law of gravitation) the size and the position of this unknown planet.

The great Berlin telescope was turned on the spot; and there was the planet. This planet was named Neptune.

3. The cause of burning

It was held that burning consists in giving off a substance. This substance was called phlogiston.

Some metals, when heated, leave a powder-like substance on the surface, called calx. The calx is heavier than the metal from which it is formed. This observation cannot be explained on the phlogiston theory. Because, on that theory, the weight of the calx should be less than the weight of the metal. Lavoisier advanced the hypothesis that burning involves absorption of large quantities of air.

From this hypothesis, many consequences were deduced. For example, it was deduced that, in a closed space, there can be only a limited amount of this substance (later named oxygen) in the air. Therefore, when this substance (oxygen) is used up, nothing more can burn until fresh air is let in.

These consequences were tested. Lavoisier conducted experiments with phosphorus. These experiments showed that, in a vessel of limited air capacity, only a part of the phosphorus would burn. It was further seen that the weight of the phosphorous fumes was greater than that of the original phosphorus. Lavoisier performed similar experiments with sulphur. These experiments too confirmed the hypothesis. Lavoisier's later investigations showed that combustion (burning) consists in the combination of the burning substance with the oxygen in the air.

4. Rumford's investigation into the nature of heat

When two bodies of different temperatures are brought into contact, finally, they reach the same temperature. Heat seems to flow from the body of higher temperature to that of lower temperature. But there is no change in their weights. Heat was conceived of as a weightless substance. This weightless heat-substance was called **caloric.**

The caloric theory could not explain some commonly known phenomena, such as the creation of heat by friction, as by rubbing two sticks together.

Count Rumford was engaged in superintending the boring of cannon in the military workshops at Munich. While there, he noticed that a large amount of heat was produced in the boring of the cannon. The metallic chips separated from the cannon, by the borer, gave out much heat, much greater than that of boiling water. Rumford could not understand this phenomenon on the caloric theory of heat. He advanced the hypothesis that **heat is produced and communicated by motion.**

To support this hypothesis, he conducted a number of experiments. In one experiment he placed a brass gun barrel in a wooden box, containing about 19 Ibs. of cold water, used a blunt steel borer, and continued turning the barrel by means of two horses. After two hours, the water in the wooden box boiled. This experiment confirmed his hypothesis.

5. Roentgen's discovery of X-rays

In 1895, Roentgen was experimenting with electrical discharges. He had left some photographic plates near a vacuum tube, through which electrical discharges were passing. He noticed that these plates had become fogged, even though they were covered with black paper.

To explain the shadows on the photographic plates, Roentgen proposed the hypothesis that rays from the tube passed through the covering of the plates.

He reasoned that if such rays were present, then a phosphorescent substance (such as potassium platinocyanide) would show its effects. He found that this substance began to shine. He further reasoned that there would be differences in the shadows thrown by heavier and lighter substances. So he conducted experiments with a thick slab of metal and a piece of aluminum; and his prediction came out true.

Roentgen also reasoned that the shadows of bones would be greater than the shadows of living flesh. This too was confirmed. These rays were named X-rays.

2. STAGES IN THE HYPOTHETICO-DEDUCTIVE METHOD

The hypothetico-deductive method involves four main stages.[1] Before dealing with these stages, we may make three points. Firstly, these stages represent the ideal pattern. That is to say, they represent the pattern of investigation found in the advanced sciences. Secondly, every investigation does not involve all these stages. Thirdly, the importance attached to the different stages varies from investigation to investigation.

Stages in Hypothetico-deductive Method

Hypothesis suggested	Additional facts and possible modification	Deductive development	Testing of hypothesis

Stage 1 – Formulation of hypothesis as a tentative solution : When a familiar solution fails to account for the observations, or when new facts cannot be explained by the known laws, a problem is felt. The scientist puts forward a tentative solution, called hypothesis. This attempts to explain the puzzling situation.

In Kon-Tiki expedition, similarities between the ancient customs of people were the problem. The sociologists asked, "Why should there be similarities in traditions of people who are so far apart?" They attempted to explain these similarities by the hypothesis: "The natives of the South Sea Islands came from South America." In the case of deviation in the orbit of Uranus, the suggested solution was the presence of some planet beyond Uranus. In Lavoisier's investigation, the problem was that the weight of calx is greater than that of the metal from which it is formed. On phlogiston theory, it should have been less. This made Lavoisier guess that burning involves absorption of large quantities of air. In Rumford's investigation, intense heat given off by the metallic chips, separated by the borer, was explained by the supposition that heat could be produced by motion. In Roentgen's investigation fogging of the covered photographic plates presented the difficulty. This led Roentgen to propose that the rays from the tube caused fogging of these plates.

Stage 2 – Collection of additional facts, and modification of the hypothesis if necessary : A hypothesis is a guess. A scientist has to find out

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[1] Sometimes five stages are suggested. When this is done, the first stage is divided into two parts, thus : (i) initial data based on observation and the feeling of problem (ii) formation of hypothesis to explain the observed facts.

whether his guess is supported by facts. So, using the hypothesis as a guide, he observes new facts which are relevant to the problem. The additional facts that are collected may support his hypothesis. In that case, the hypothesis will be retained. If they do not, the hypothesis will be either modified, or a new one will take its place. Only in rare cases the very first hypothesis is the correct solution. The more usual case is that a number of hypotheses are rejected before the correct solution is found.

Scientists usually consider many hypotheses in turn. But in most of the investigations recounted in the first Section, the first hypothesis was the right one. But this is because we have presented the broad features of investigations, and not their details. That is why the second stage is found missing.

Stage 3 – Deductive development of the hypothesis : After a hypothesis is formulated, the scientist predicts certain observed facts from it. These predictions are the consequences deduced from the hypothesis. Let us illustrate. Lavoisier deduced that, in a closed space, when oxygen is used up, nothing more will burn. Rumford predicted that the heat produced was inexhaustible; and so water will boil if something is turned in it. In Roentgen's case, the deduction was that the shadows of denser and heavier metals would be different from those of lighter metals.

All scientific investigations do not involve this stage. Certain kinds of hypotheses can be directly tested. They do not require deductive development. Harvey's hypothesis, that there is only one kind of blood, which circulates throughout the body, can be directly tested.[2] We can directly observe the blood, veins, arteries, etc., and see whether this hypothesis is true. However, Harvey did not test his hypothesis directly. He did not have microscopes with which blood could be seen.

Stage 4 – Testing of the hypothesis : A hypothesis is tested by appeal to facts. If the deduced consequences occur, it is said to be confirmed. If they do not, it is said to be disconfirmed.

A hypothesis may be tested either by observing facts or by conducting experiments. But whenever experiment is possible, it is preferred to simple observation. In the following investigations, confirmation came through experiments : (i) Kon-Tiki expedition, (ii) Lavoisier's hypothesis concerning burning, (iii) Rumford's investigation into heat, and (iv) X-rays hypothesis. On the other hand, the discovery of Neptune was confirmed by observation.

When the consequences of a hypothesis agree with the hypothesis, it (the hypothesis) is confirmed. If the hypothesis is a generalization or a theory, it is said to be well-established only after it has been confirmed under widely differing circumstances, over a period of time. The gap between the formulation of a hypothesis and its confirmation may be a long one. To take an example, the Copernican hypothesis, that planets revolve round the sun, was confirmed only after Galileo invented the telescope.

We have given a simplified account of the method used in scientific investigations. Usually, the scientific procecdure is much more complicated. In this complicated process, a hypothesis may be modified several times. Not only this, the scientist may come across facts which may clash with his hypothesis. In such a case, he will have to reject the hypothesis. He may, then, formulate a new hypothesis.

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[2] Prior to Harvey, it was believed that we have two different kinds of blood. Harvey maintained that we have one kind of blood, and that it circulates. It passes from the arteries, through the capillaries, to the veins.

3. NATURE OF HYPOTHESIS

Observation and experiment furnish the data to science. But science is not interested in the activity of merely collecting and describing facts. Its objective is to explain; and it does this by introducing order into facts.

Order into facts is introduced by formulating hypotheses. **So, hypothesis is an important stage in scientific investigation.** This point was clearly brought out when we dealt with the hypothetico-deductive method in the last Section.

A hypothesis is not formed in a vacuum. It is put forward as a likely solution to a problem. When a problem arises, the scientist puts forward a tentative suggestion. This suggestion is a guess as to what could explain the puzzling situation. Such a tentative suggestion, advanced to explain the observed facts, is called hypothesis. **So we may define hypothesis as a tentative supposition, which is put forward for explaining the facts that cannot be understood without it.**

Hypotheses are a common feature of everyday life as well as that of the scientist's activity. In Section 1, we have taken some examples of hypothesis.

Characteristics of hypothesis : A hypothesis has four main characteristics. These are :

1. Attempt at explanation : Every hypothesis is an attempt at explaining facts. That is, if the hypothesis is established, it will explain the observed facts which have become a problem. Pasteur's hypothesis explained why wines lost their normal taste. The Kon-Tiki hypothesis explained the similarities between the ancient traditions of the natives of the South Sea Islands and those of the inhabitants of South America. Lavoisier's hypothesis explained why calx weighs more than the metal from which it is formed.

2. Provisional : A hypothesis claims to explain facts; but this claim has yet to be tested. So a hypothesis always has a kind of provi-sional character. There is no finality about the solution provided by it. It will be accepted until a better hypothesis take its place. A scientist proposes a hypothesis, and tries to see whether it agrees with facts. If not, he discards it; and we never come to know that the hypothesis was ever formulated. Kepler, for example, is said to have considered nineteen wrong hypotheses before it occurred to him that Mars revolves in elliptical orbit. So when we assert that a hypothesis is a provisional supposition, we mean that, when proposed, it is a possible solution. If, after testing, it is found to be the right solution, it is no more a provisional supposition.

3. Organizing principle : Being an explanation of facts, a hypothesis is an organizing principle. Before it is formulated, each fact stands out separately. It appears unrelated to the other facts. A hypo-thesis introduces order into facts; it shows that facts have a meaningful pattern. Let us take an example. Newton was able to calculate, from the known laws of mechanics, what must be the attractive power of the earth, so that the moon shall move precisely as it does. His hypothesis, of gravitation, correlated the movements of the moon with the fall of an apple (and every other object on the surface of the earth), the orbits of planets, and so on. Prior to this hypothesis, there seemed to be no connection between these facts.

4. Result of rational activity : Different hypotheses order the same facts in different ways. From this it follows that what hypothesis is proposed depends upon the imagination of the investigator. So, we may say that a hypothesis is a result of rational activity. That is, thinking is involved in it. However, a good hypothesis is a happy guess. So the credit for it must go to the creative imagination of the scientist.

4. CONDITIONS OF SOUND HYPOTHESIS

From the start of an investigation to its conclusion, we require hypotheses. But all hypotheses are not equally good. Some are wild guesses, while others are serious attempts at explaining facts. Scientists want to ignore the former. So certain criteria are laid down for distinguishing good hypotheses from bad ones. These are called conditions of good hypothesis.

The main feature of science is faithfulness to facts. Therefore, the criteria for determining whether a hypothesis is good have to be discussed with reference to facts. Jevons emphasizes this point. He says, "Agreement with fact is the sole and sufficient test of a true hypo-thesis."[3] By a true hypothesis, Jevons means one which may be seriously considered. And by agreement with fact, he means that a good hypothesis must be able to account for all the observed facts. This general requirement may be analyzed into the following conditions.

1. Relevance : The function of a hypothesis is to explain the facts which have become a problem. It can serve this purpose, only if it is relevant. By a relevant hypothesis we mean one from which the facts to be explained can be deduced.

Every hypothesis is not relevant. An interesting instance of irrele-vant hypothesis is the one advanced by a follower of Galen for explaining why human thigh bones are straight. Galen (131-201) was prevented by public opinion of his time from dissecting human bodies. For his knowledge of anatomy, he had to rely upon the dissection of apes, dogs, and pigs. He had made many anatomical errors. But these were not realized till the 16th century, when Vesalius (1514-64) discovered about two hundred errors. One of these was about human thigh bones. Galen's anatomy had shown human thigh bones as curved. Vesalius found (by dissecting human bodies) that they are straight.

One of the former teachers of Vesalius was shocked by this lack of respect for Galen. He could not deny that human thigh bones are straight. But he advanced a hypothesis to explain why we find these bones to be straight. His hypothesis was that the narrow trousers of the time were responsible for the straightness of human thigh bones. This hypothesis is clearly irrelevant; it fails to account for the observed facts.

To find out whether a hypothesis is relevant, scientists collect additional facts. Therefore, the condition of relevance can only mean this. In the light of his specialized knowledge, the scientist genuinely believes that the hypothesis is relevant.

The requirement of relevance is sometimes expressed by saying that **a hypothesis must be adequate.** That is, it must account for all the facts. This, obviously, is what a relevant hypothesis does.

2. Self-consistency : A hypothesis must not be inconsistent. There must be no contradiction among its different elements. Let us take an example. For example, the hypothesis of "living ghost", or that of "weightless matter' is inconsistent.

3. A hypothesis must be capable of deductive development[4]: It must be formulated in such a way that consequences can be deduced from it. Galileo proposed the hypothesis that change in the velocity (speed) of a freely falling body is proportional to the time it has been falling. From this he deduced the consequence that the weight of the body would make no difference to the rate of fall. It is said that he conducted an experiment by throwing two cannon balls, of different weights, from the Leaning Tower of Pisa. This experiment convinced him that the hypothesis is worth considering seriously.

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[3] *Principles of Science*, p. 510.

[4] This requirement cannot be insisted upon if the hypothesis is capable of direct verification. However, very few hypotheses in science are verified directly.

4. Testability : A hypothesis is put forward for explaining the observed facts. So, before a scientist can consider it seriously, he must find out whether the hypothesis is testable. A hypothesis is said to be testable (verifiable) if it is capable of being shown to be either true or false.

Science is not interested in untestable hypotheses. An untestable hypothesis never makes predictions about unobserved events. No doubt, such a hypothesis can never be proved false. But it can never be confirmed too. A good example of an untestable hypothesis is provided by the "devil" theory of disease. At one time, disease was explained by the presence of devils in the body. The treatment was that the patient be bled, so that the devils would rush out with the blood, and he would be cured. When some people were bled and still did not recover, it was explained that some devils did not want to come out. Nothing can possibly falsify such a hypothesis.

Science regards the condition of testability as the most important requirement of a good hypothesis. This can be illustrated by the attitude of scientists to their hypotheses. Newton wanted to confirm the hypothesis of gravitation by observing the monthly revolutions of the moon. But he found that the movements of the moon did not take place according to his prediction. He set aside his hypothesis for twenty years. After that period, a French expedition showed that the earlier calculation about the circumference of the Earth was wrong. The corrected information enabled Newton to make revised calculations. He found that the movements of the moon occurred as predicted, and then he proposed his hypothesis.

5. A hypothesis should be compatible with previously established laws : The goal of science is to establish a deductive system. One of the conditions of a system is consistency. That is, all the laws included in a system must be compatible with one another. Every new hypothesis has to find a place in the system of laws already established by a science. So, it should be compatible with the existing knowledge. Torricelli proposed the hypothesis that water can be pumped to the height of 34 feet (at sea level), because the pressure of air is equal to the weight of a column of water which is 34 feet high. This hypothesis (of "sea of air") was compatible. It was already known that air has weight. So, Torricelli's hypothesis fitted in with the general body of scientific knowledge.

This demand is reasonable. After all, existing knowledge in a science consists of laws for which there is a large amount of evidence. If a new hypothesis conflicts with any of the established laws, its chances of being true are poor.

However, the requirement of compatibility cannot be insisted upon. The history of science provides many examples where new hypotheses were inconsistent with the established theories; and yet they were established. For example, the Copernican system overthrew the Ptolemaic system even though the Ptolemaic system was well-established. Hence, there is nothing to prevent a scientist from formulating hypotheses which are opposed to established theories. But a scientist who challenges an established hypothesis must take certain precautions. He must show how the established hypothesis is not able to explain facts. This is the usual procedure in science. Lavoisier's hypothesis opposed the phlogiston theory. But there were facts (e.g. calx is heavier than the metal from which it is formed) which could not be accounted on the phlogiston theory.

Thus, we see that scientists put forward a new hypothesis only when they are dissatisfied with the explanation provided by the established one. However, in good many cases, well-confirmed hypotheses are merely modified. Newton's law of gravitation had a great amount of evidence in its support. So, when Einstein's theory was established, the main change in science consisted in incorporating Newton's law of gravitation in a wider system. Of course, Einstein's theory gives more accurate predictions. But the change is so little that, for most purposes, we still use Newton's law.

6. Simplicity : Scientists prefer the simpler of the rival hypo-theses. But they are not clear about what simplicity of a hypothesis means.

According to one view, a simpler hypothesis is one which makes the minimum number of independent assumptions. The Copernican theory was preferred to the Ptolemaic theory on this basis. Ptolemy had to assume that every heavenly body has its own peculiar epicycle. So, on this hypothesis, for every new body that is discovered, a new epicycle had to be proposed. On the other hand, on the Copernican hypothesis, motions of all heavenly bodies follow from the theory itself.

Another view of simplicity is dynamic simplicity. *Dynamic simplicity* is the capacity of a theory to explain completely new facts. Newton's law of gravitation had this characteristic. On its basis, it was possible to predict the existence of comets which revolve in hyperbolic orbits, though such comets were unknown at that time.

Scientists do not agree upon any particular criterion of simplicity. But, in actual practice, they have no difficulty in deciding which of the rival hypotheses is simpler.

7. A sound hypothesis must provide at least as satisfactory a solution as the other alternative hypothesis : The need for this requirement arises, because a hypothesis is proposed against the background of an alternative hypothesis. A scientist cannot give weight to his hypothesis if it is less satisfactory than its rival. The Copernican hypothesis was not only simpler than the Ptolemaic one, but also it gave a more satisfactory explanation of the retrograde movement of Mars. Ptolemy had observed that, though Mars advances from west to east, occasionally it pauses, moves back for a while, again pauses, and then resumes its ordinary onward progress. Ptolemy accounted for this by attributing two motions to Mars – general forward motion and retrograde motion. Though Mars moves round the earth in a circle (earth on this theory is stationary), this circular motion is made up of cycles. See the diagram (Fig. 20.1) below :

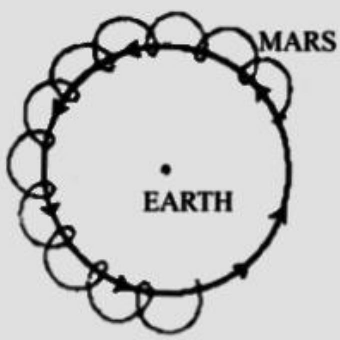

Fig. 20.1 : Ptolemy's Theory of Epicycles

Copernicus gave a more satisfactory explanation of the apparent retrograde movement of Mars. On his theory, the earth is in motion. Since the earth moves faster than Mars, to the observer on earth, it appears that Mars is moving backwards. That is why the retrograde motion seems to be the greatest when the earth is directly between Mars and Sun.

The purpose of the above condition is to ensure that a scientist does not advance wild guesses as hypotheses. But there are no restrictions on how many hypotheses he considers.

5. VERIFICATION (OR TESTING) OF HYPOTHESIS

One of the conditions of a good hypothesis is that it be testable (or verifiable). Let us now see how a hypothesis is verified.

Verification of a hypothesis consists in finding out whether it is in agreement with facts. If it agrees with facts, it is said to be confirmed. But if it does not agree with facts, it is said to be disconfirmed. When a hypothesis is disconfirmed, it is either refuted or modified.

No hypothesis can be exhaustively confirmed. This is because the collection of observations in science is never complete. There is no guarantee that all yet-to-be observed facts will support the hypothesis. However, there can be more, or less, confirmation of a hypothesis. The degree of confirmation would depend upon the extent of evidence for it. We shall discuss this in the next section.

Direct verification : Hypotheses are verified either directly or indirectly. *Direct verification consists in observing the things which the terms in the hypothesis refer to.* Here the appeal to facts is direct, and not through the deduced consequences. Very few hypotheses in science can be verified directly.

Some scientific hypotheses are capable of direct confirmation. Harvey's hypothesis, that the blood in the human body circulates, could have been verified directly. But Harvey did not have the equipment for directly verifying his hypothesis. Similarly, Rayleigh's hypothesis was verified directly. It was observed that nitrogen obtained from air is heavier than nitrogen obtained from other sources. To explain this, Rayleigh put forward the hypothesis that nitrogen in the air is mixed up with some unknown gas. Rayleigh and others conducted experiments, and succeeded in isolating a gas. This gas, which was about 1% of the weight of nitrogen, was called argon.

Indirect verification : *This consists in deducing the consequences from a hypothesis, and testing those consequences by appeal to facts.* This means, there are two steps involved in indirect verification. The first step is that of deductive development of the hypothesis. By deductive development, certain consequences are predicted. The second step is that of finding out whether the anticipated (or predicted) conse-quences take place. If the predictions come true, the hypothesis is said to be indirectly verified.

The consequences are tested either by observation or by experi-ment. On Galileo's hypothesis, the weight of a body is irrelevant to the acceleration with which it falls. From this, it follows that a heavier and a lighter body should reach the ground at the same time. Galileo conducted an experiment to test this consequence. He threw two cannon balls, one of them weighing 1 lb., and the other 100 lbs., from the Leaning Tower of Pisa. The anticipated consequence occurred. In this way Galileo's hypothesis was confirmed. Torricelli's "sea of air" hypothesis too was confirmed by experiment. On the other hand, Einstein's hypothesis was confirmed by observation. Einstein predicted that the deflection of a ray of light, by the sun, would be twice as great as that on Newton's law. This was observed during the total eclipse of the sun in March 1919.

There is a logical difference between direct and indirect verification. When a hypothesis has been confirmed directly, there is hardly any doubt about its truth. In indirect verification, a scientist deduces some of the consequences, and finds out whether they take place. Since the scope of a hypothesis is wider than the consequences that have been deduced from it, indirect verification cannot show that the hypothesis is true.

Since direct verification is a more satisfactory means of establishing a hypothesis, scientists prefer it to indirect verification. However, as we have shown above, very few hypotheses in science can be verified directly.

6. PROOF OF HYPOTHESIS

The term 'proof' stands for certainty. So to prove a hypothesis means to show that there is no possibility of its refutation. This implies that there is no alternative hypothesis which could possibly account for the relevant facts. *Thus, proof of a hypothesis consists in showing that it is the only possible hypothesis to explain the relevant facts.* It should be obvious that no investigator can prove his hypothesis. Even if he is very thorough in eliminating the alternative hypothesis, he has no way of finding out that he has exhausted all possible hypotheses.

Though a hypothesis cannot be proved, it can be established. A hypothesis is said to be **well-established** or, to use Popper's term, "corroborated"; when

i) it is confirmed under many different circumstances;

ii) it is compatible with existing knowledge; and

iii) it provides a better explanation than other available hypotheses.[5]

Proving (Establishing) Hypothesis

1. *Verification* - shows extent of direct evidence.
2. *Consilience of inductions* - provides indirect evidence.
3. *Explanatory power* - differs in degrees.
4. *Predictive power* - predicting new facts (has psychological value).
5. *Crucial experiment* - results oppose one of the rival hypotheses.
6. *Simplicity* - when other means not available, this test used.

Let us now see how scientists proceed to establish hypotheses.

1. Verification : Verification is the means by which science determines the extent of evidence for a hypothesis. One hypothesis is preferred to another when the evidence for it includes, not only the evidence for its rival, but some further evidence.

If the verification of a hypothesis is identified with its proof, the fallacy of Affirming the Consequent will be committed. For, in that case, we shall say that the deduced consequences have occurred; and so the hypothesis is true.

If H, and then C_1, C_2, C_3

C_1, C_2, C_3

$\therefore$ H

(Here 'H' stands for hypothesis; C_1, C_2 and C_3 are its deduced consequences.)

The only way we can infer the truth of a hypothesis from the deduced consequences is by assuming that no other hypothesis is possible. In that case, the form of the argument would be :

If and only if H, then C_1, C_2, C_3

C_1, C_2, C_3

$\therefore$ H

Now the evidence succeeds in proving the hypothesis. However, as we have already pointed out, no scientist can assert that the given hypothesis is the only one from which the deduced consequences follow.

[5] Carney and Scheer, *Fundamentals of Logic*, p. 349.

2. Conscience of inductions : The evidence that comes from the confirmation of a hypothesis is direct evidence. More important than this is the indirect evidence. A hypothesis becomes strengthened if it is shown that it is of a similar pattern as the other hypotheses that have been established independently. The yellow fever hypothesis, that yellow fever is transmitted through a mosquito bite, became more acceptable after it had been established that malaria is transmitted in a similar way. The indirect support that a hypothesis gets from the evidence of other hypotheses is called by Whewell "consilience of inductions".

Scientists today attach great importance to indirect support. That is why they lay down that a hypothesis be compatible with existing knowledge.

3. Explanatory power : A hypothesis is formulated for explaining facts. But the explanation provided by one hypothesis may be more satisfactory than the explanation offered by the other. One of the means of establishing a hypothesis is to show that it explains the facts in a better way than its rivals. Lavoisier's hypothesis accounted for the phenomenon of burning in a better way than the phlogiston theory. That is why it was preferred to the phlogiston theory.

4. Predictive power : A hypothesis is advanced to explain certain observed facts. But from some hypotheses new phenomena can be accurately predicted (and thus explained). When this happens, the hypothesis in question is said to be firmly established. Newton's hypothesis, as well as Einstein's, satisfied this test. In Newton's time only comets which move in elliptical orbits were known. But the theory of gravitation predicted the existence of comets which move in hyperbolic orbits. Six such comets were later observed between 1729 and 1843. The confirmation that came from the observation of these comets was said to have added to the reliability of Newton's hypothesis. Einstein's hypothesis too had this predictive ability to a remarkable extent. On Einstein's theory, it was predicted that there would be a slight bending of the rays of light travelling from a distant star. This prediction came out true during the total eclipse of the sun on 29th March, 1919.

The test of predictive power can be applied for determining whether a hypothesis really explains facts, or whether it is merely an *ad hoc* one. As we have seen, an *ad hoc* hypothesis cannot be used to account for new facts.

5. Crucial experiment (or experimentum crusis) : Sometimes two hypotheses are able to explain the same facts; and both are compatible with the already established laws. In that case, scientists have to find some consequence which follows from one hypothesis, but is incompatible with the other. They conduct an experiment, and find out whether this consequence occurs. Such an experiment is called crucial experiment. *Thus, a crucial experiment (or experimentum crusis) is that experiment which helps to decide between two rival hypotheses.* In this respect, a crucial experiment is like a guide post. It indicates the hypothesis which is the right explanation of facts.

History of science provides plenty of examples of crucial experiments. At one stage, there were two theories about the nature of light – Newton's corpuscular (particle) theory, and Huygens' wave theory. There was complete opposition between these theories in one respect. On the corpuscular theory, light travels faster in water than in air. But, on the wave theory, light travels more quickly in air than in water. Foucault performed an experiment to find out which theory was correct. He found that light travels less rapidly in water than in air. Foucault's experiment was a crucial one. The position involved in a crucial experiment is represented in the diagram (Fig. 20.2) below :

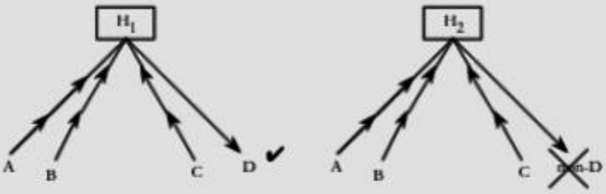

Fig. 20.2

Both the hypotheses (H_1 and H_2) are able to explain the same facts (A, B and C.) But one of the consequences of H_1, namely D, contradicts the consequences of H_2, namely non-D. An experiment shows that 'D' occurs. So the hypothesis H_2 is rejected.

Usually, what is crucial in deciding between hypotheses is an experiment. But, occasionally, a carefully made observation may serve the same purpose. For instance, Einstein's theory of relativity was established by an observation. From Einstein's theory, it was calculated that the deflection of a ray of light, by the sun, would be twice as great as that anticipated by Newton's law. In 1919, the image of a star was photographed in Brazil and in the Gulf of Guinea. These observations established Einstein's theory. However, only when experiments cannot be set up, scientists depend upon observation.

Crucial experiments do not affect all hypotheses, with which their results are incompatible, in the same way. If a hypothesis is capable of direct verification, a crucial experiment falsifies it. But a hypothesis which can be verified indirectly is not falsified by a crucial experiment. Rayleigh's experiment isolated argon from air. This experiment established Rayleigh's hypothesis, that nitrogen prepared from air is mixed up with some unknown gas. Also, it led to the refutation of the older hypothesis, that air consists of only nitrogen and oxygen. Here, both the hypotheses were capable of direct verification. So, the experiment succeeded in falsifying one of them. On the other hand, a hypothesis that can only be verified indirectly is not falsified by a crucial experiment. Such a hypothesis involves a number of assumptions. So, a crucial experiment merely shows that either the theory or one of its assumptions is false. In fact, this is what happened in the case of the controversy between the wave and the corpuscular theory. Science today accepts the quantum theory. This theory incorporates certain aspects of both the above theories. According to the quantum theory, light travels in photons. (A photon is a wave packet; it is a wave, made up of corpuscles (particles).)

Though a hypothesis which can be verified indirectly is not falsified, it would never again be maintained in the same form. It has been dealt, what Carney and Scheer call, a "death blow".[6]

6. Simplicity : There are instances in science where the decision between the alternative hypotheses cannot be made on the basis of the above considerations. Both the hypotheses may have the same evidence and explanatory power. Also, crucial experiments may not be possible. In such cases, scientists use the criterion of simplicity. Other things being equal, the simpler hypothesis is preferred. We have seen earlier what simplicity of a hypothesis means. We may recall that the choice between the Ptolemaic system and the Copernican system was partly determined by the consideration of simplicity.

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[6] *Fundamentals of Logic*, pp. 367-68.

7. KINDS OF HYPOTHESIS

The objective of science is to explain; and so one may say that a scientist always puts forward explanatory hypotheses. This, however, is not the case. Sometimes scientists have to be satisfied with the other kinds of hypotheses. Moreover, all scientists do not hold the view that science aims at explanation. Some would say that accurate description is the goal of science. In any case, hypotheses in science serve several purposes; and our classification must take into account the different purposes. On the basis of their purpose, Stebbing classifies hypotheses into explanatory, descriptive and analogical.[7] Two other kinds of hypotheses may also be mentioned. These are *ad hoc* hypothesis and working hypothesis.

1. Explanatory hypothesis : *An explanatory hypothesis is advanced to explain the data of observation.* In this kind of hypothesis the facts are deducible from the hypothesis. Explanation is required when the observed facts have become a problem. What becomes a problem may be merely an individual fact, or it may be a class of facts. The nature of explanation in the two cases would differ.

i) A large number of hypotheses in everyday life have to do with the explanation of individual facts. Scientists too, occasionally, advance such hypotheses. The hypothesis accounting for the wayward behaviour of Uranus, as well as the hypothesis in the Kon-Tiki expedition, was concerned with a particular phenomenon.

The hypothesis which explains an individual fact, or event, is sometimes called **hypothesis concerning agent.**

ii) Scientists are more interested in finding explanations for classes of facts, rather than for individual happenings. Usually, a scientist establishes a hypothesis that would explain, not only the particular occurrence which drew his attention, but every such occurrence. Kepler had before him a series of observations of Mars made by Tycho Brache. No doubt, his hypothesis of elliptical orbit accounted for these observations. But it also applied to the orbits of all the other planets. Lavoisier's and Galileo's hypotheses are also of this type.

A hypothesis which explains a class of facts is sometimes called **hypothesis concerning law.**

2. Descriptive hypothesis : Sometimes scientists aim at finding a suitable description for a phenomenon. This happens when the phenomenon is of great complexity, and accurate description would be a help towards finding explanation for it. In such cases, scientists advance descriptive hypotheses. A *descriptive hypothesis symbolizes the connection between the different elements of a phenomenon.* The Ptolemaic system is a descriptive hypothesis. This system did not explain why a planet, say Mars, revolves round the earth in a certain epicycle. The epicycle theory merely symbolized the relationship between the earth and the heavenly bodies.

3. Analogical hypothesis : An analogical hypothesis too explains; but its explanation is not of the deductive type. *It explains a phenomenon (or a set of phenomena) by showing its similarity to some other phenomenon (or set of phenomena).* Ether hypothesis is an apt example of analogical hypothesis. Huygen's wave theory of light was established; but the question was: "In what medium do the light waves travel?" Sound waves require air as the medium; sea waves require water as the medium. So it was argued, by analogy, that light waves too require a medium. This was called ether.

By itself, an analogical hypothesis is of little value. But the history of science shows that analogical hypotheses have sometimes led to great advances. For instance, Maxwell's electromagnetic theory was based upon an analogical hypothesis.

[7] *Modern Introduction to Logic*, pp. 307-310.

4. Ad hoc hypothesis : Sometimes a theory is well-establislled. But a particular fact, or a set of facts, cannot be accounted for on its basis. In such cases, scientists may save the theory by putting forward a special hypothesis, which will explain the exception to the theory. Such a hypothesis is called *ad hoc* hypothesis. **Thus, an ad hoc hypothesis is one which accounts for only that set of facts, for the explanation of which it has been advanced.** It has no further explanatory power.

The hypothesis which explained deviation in the orbit of Uranus was *ad hoc*. Bouvard observed that there was deviation in the calculated orbit of Uranus. This observation went against the law of gravitation. The law of gravitation was able to explain a wide range of phenomena. So scientists were not prepared to discard it. They proposed the hypothesis that some planet, beyond Uranus, was disturbing the gravitational force of Uranus. This was an *ad hoc* hypothesis.

Scientists are never satisfied with *ad hoc* hypotheses. An *ad hoc* hypothesis has no independent evidence in its support. Moreover, it cannot be tested by deducing consequences from it. However, a hypothesis which is *ad hoc,* when proposed, may be established later. When this happens, it ceases to be an *ad hoc* hypothesis. It becomes a part of a general theory. The above *ad hoc* hypothesis was later established. It was incorporated in the law of gravitation. When Neptune was discovered, there was no more any deviation in the orbit of Uranus.

The above account of ad hoc hypothesis does not mean that every ad hoc hypothesis is established later on. A hypothesis may remain purely ad hoc. It may even be refuted. In the middle of the 19th century, astronomers observed disturbances in the orbit of Mercury. This too was explained by an *ad. hoc* hypothesis. It was proposed that an unknown planet was exciting disturbances in the gravitational force of Mercury. But this hypothesis remained purely *ad hoc*. No such planet was discovered. In fact, Einstein's theory of relativity accounted for the disturbance in Mercury's orbit. Thus, this *ad hoc hypothesis* was refuted.

5. Working hypothesis : Hypotheses are required both for collecting relevant facts and for explaining them. If scientists do not know much about a phenomenon, they need some hypothesis so that they may collect relevant data. If a hypothesis is proposed merely for guiding investigation, it is called working hypothesis.

A **working hypothesis is a supposition which is advanced solely for the purpose of conducting investigation.** The hypothesis "Electricity is a fluid" was a working hypothesis. Scientists were not able to understand the nature of electricity. Yet they found that they could carry on investigation by comparing electricity to a fluid. The main characteristics of a fluid are the facility and rapidity of movement. Electricity resembles fluids in these respects. However, scientists were aware of the differences of electricity from fluids. A fluid adds to the weight of the body through which it flows, but electric current does not. Therefore, the hypothesis was not proposed as an explanation of the flow of electric current through its conductor.

We may mention here that a working hypothesis is discarded when the nature of the phenomenon is understood better. To take an example, Rutherford wanted to understand certain phenomena concerning radioactivity. To do so, he put forth the working hypothesis of disintegrating atom. This hypothesis was discarded later on.

SUMMARY

Hypothetico-deductive method : Most scientists and philosophers assert that science uses the hypothetico-deductive method. The four stages of this method are : (i) formulating a hypothesis as a tentative solution, (ii) collection of additional facts, and modification of hypothesis if necessary, (iii) deductive development of the hypothesis and (iv) testing of the hypothesis.

Nature of hypothesis : A hypothesis is a tentative supposition, which is put forward for explaining the facts, that cannot be understood without it. A hypothesis has four main characteristics. Every hypothesis is an attempt at explaining facts. So, it has always a kind of provisional character. Since a hypothesis claims to be an explanation of facts, it is an organizing principle. Since the same facts can be organized in different ways, this involves thinking. So a hypothesis is said to be a result of rational activity.

Conditions of sound hypothesis : A sound hypothesis must be relevant. It must be consistent too. Further, it must be capable of deductive development. To find out whether a hypothesis really accounts for the facts, the condition of testability is of help. Testability, in fact, is the most important condition.

Science is interested in a system. So the other requirement of hypothesis is that it should be compatible with previously established laws. Further, a hypothesis should be simple and must provide at least as satisfactory explanation as the other alternative hypotheses.

Verification : Testability of a hypothesis is determined by verification. Verification consists in finding out whether a hypothesis is in agreement with facts. In direct verification, the things referred to by the terms in the hypothesis are themselves observed. Indirect verification consists in deducing consequences from a hypothesis and testing them by appeal to facts.

Proof of hypothesis : In its strict sense, it is not possible to prove a hypothesis. So, scientists merely aim at establishing their hypotheses.

To establish a hypothesis, scientists find out, by verification, the extent of direct evidence. But more important than this is the support from, what Whewell called, **consilience of inductions**. The third consideration is the explanatory power. When a hypothesis is able to predict new phenomena, it gets further support. When two hypo-theses have equal support from facts, a crucial experiment becomes the means for deciding between them. When all the other means fail, scientists choose between hypotheses by applying the test of relative simplicity.

Kinds of hypothesis : Stebbing classifies hypotheses into explanatory, deductive and anologous. In addition, ad hoc hypotheses and working hypotheses are also used in science.

TEST QUESTIONS

1. Explain and illustrate the stages in the hypothetico-deductive method.
2. What is hypothesis? Explain, with illustrations, any three conditions of a good hypothesis.
3. Can a good hypothesis violate the condition that it should be compatible with the laws which have already been established? Discuss.
4. What is meant by verification of a hypothesis? Distinguish between direct and indirect verification.
5. Distinguish between verifying a hypothesis and establishing (proving) it.
6. Explain that the verification of a hypothesis is not the same as its proof.
7. When is a hypothesis said to be established (proved)?
8. Explain, with illustrations, the nature and function of crucial experiment.
9. Define the following terms :
   1. Hypothesis
   2. ad hoc hypothesis
   3. Testable hypothesis
   4. Working hypothesis

5. Relevant hypothesis
6. Descriptive hypothesis
7. Verification of hypothesis
8. Crucial experiment
9. Direct verification
10. Indirect verification

10. Give reasons for the following :
    1. Why is an *ad hoc* hypothesis not a satisfactory solution to a problem?
    2. Why is compatibility with established laws not a necessary condition of a good hypothesis?
    3. Why is it said that crucial experiments do not always falsify the hypothesis with which their results disagree?
11. State whether the following statements are true or false :
    1. Every hypothesis is a tentative supposition.
    2. A hypothesis enables us to arrange facts into a meaningful pattern.
    3. A scientific hypothesis must be a true proposition.
    4. A common man cannot construct sound hypotheses.
    5. The same facts can be explained by alternative hypotheses.
    6. An ad hoc hypothesis has unlimited explanatory power.
    7. An ad hoc hypothesis is a satisfactory solution to a problem.
    8. Direct verification is a means of finding out whether a hypothesis has support from established laws.
    9. If a hypothesis has been confirmed by direct evidence, scientists would regard it as having been established.
12. Fill in the blanks with appropriate word/words in the following :
    1. _____ is a tentative supposition which is put forward for explaining facts.
    2. _____ consists in finding out whether a hypothesis agrees with facts.
    3. _____ verification involves the work of deduction.
    4. When there are two rival hypotheses, an experiment which helps to decide between them is called _____.
    5. _____ hypothesis explains only those facts for whose explanation it has been formulated.
13. Give technical terms used in logic for following :
    1. A hypothesis which is capable of being shown to be either true or false.
    2. The kind of verification which consists is observing the things to which the terms in a hypothesis refer.
    3. An experiment which helps us to decide between rival hypotheses.
    4. A hypothesis whose explanatory power is limited to some particular fact.

CHAPTER – 21

MILL'S – EXPERIMENTAL MEHTODS

DO YOU KNOW THAT.....

- *Mill's experimental methods do not always get results through experiments?*
- *The method of agreement may offer us amusing results?*
- *The method of concomitant variations is nothing more than increase or decrease in the quantity of two phenomena?*
- *You and I often use the method of residues?*
- *Mill's experimental methods are, realy, weapons of elimination?*

1. MILL'S METHODS – BACKGROUND AND OBJECTIVES

When established, hypotheses become laws. For testing hypotheses and, occasionally, for discovering suitable ones, science uses certain inductive procedures. *The most commonly used techniques are, what go by the name of, Mill's experimental methods.* However, while using these procedures, scientists do not feel committed to accepting Mill's objectives. Let us now proceed to the background against which Mill proposed his methods, and find out his objectives in doing so.

According to Bacon, we can establish laws of nature indirectly. Every phenomenon has a limited number of causes. By excluding those factors which cannot be the cause, a scientist can find out what the cause of a phenomenon is.

Mill is a follower of Bacon in his conception of scientific method. He too believes that science is a search for causes.[1] He presents five methods. These methods, called Mill's experimental methods, are claimed to be the means of discovering and proving causal connections.

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[1] Mill's conception of cause differs from Bacon's. It is influenced by Hume's views.

Mill's methods are based upon certain assumptions about the causal relation. According to him, every event has a cause; and the same cause is followed by the same effect. On this basis, he states two basic principles. These are :

i) A circumstance in the absence of which the phenomenon under investigation occurs cannot be its cause.

ii) A circumstance in the presence of which the phenomenon under investigation does not occur cannot be its cause.

These principles would not suffice. Two more principles are needed. These are :

iii) The cause and the effect vary together, and the variations are proportional.

iv) Whatever is known to be the cause of some other phenomenon (effect) cannot be the cause.

By using these principles, a scientist can eliminate those factors in the antecedent which are not the cause of the phenomenon under investigation. But the principles will not enable the investigator to find out the cause. Since Mill's five methods are dependent upon these principles, *the methods are called the weapons (or principles) of elimination*. They cannot discover, or prove, causal connections.

2. THE METHOD OF AGREEMENT

The method of agreement deals with investigations in which several instances of a phenomenon can be examined. Mill states the method thus :

> *If two or more instances of the phenomenon under investigation have only one circumstance in common, the circumstance in which alone all the instances agree, is the cause (or effect) of the given phenomenon.*

The method of agreement requires that we examine two or more instances in which a certain effect occurs. We analyze the antecedent factors in the different cases. And if we find that one factor is present in all the instances, that common factor is to be regarded as the cause.

Symbolic expression : Mill used corresponding capital and small letters for the antecedents and consequents. But we shall not follow that practice, because it tends to give the impression that cause and effect are already known. This was not the intention of Mill. We shall use capital letters as symbols.

ABC is followed by XYZ.

ADE is followed by XPQ.

∴ A is the cause of X.

This method depends upon the principle that an absent circumstance cannot be the cause.

The method of agreement is easy to apply. It does not demand that the conditions under which the phenomenon occurs be controlled. To use this method, we merely need to notice the presence of a common antecedent. That is why this method is essentially one of observation. Of course, there is nothing to prevent us from using it when experiments can be conducted.

Illustrations : (I) Mill takes the example of investigation into the effect of the contact of an alkaline substance and an oil. A number of instances of the combination of an alkaline substance and oil are investigated. It is found that the effect in all the investigated instances has a single common circumstance; in all cases soap is formed. Therefore, combination of an alkaline substance and oil is the cause of soap formation.

Critical estimate : The method suffers from several defects. The following are the main ones :

1. *Mill does not rely much upon the method of agreement.* If there is plurality of causes, the method will point to an irrelevant circumstance as the cause. The example of a scientific drinker is often used to illustrate this defect. A person used to take liquor every night. As a result, he had gone down in health. His friends urged him to give up drinking. The drunkard had a scientific mind. He decided to investigate whether drinking was the cause of his poor health. On succeeding nights, he took whisky and soda, brandy and soda, rum and soda, and so forth. By applying the method of agreement, he found that the only circumstance common to all the nights was soda. Therefore, he determined to give up soda. This illustration merely brings out that *the method is not applicable unless the relevant conditions are analyzed.* In this case, the relevant factor is the alcoholic content of the different types of liquor, and not soda. However, this defect is not peculiar to the method of agreement. Every method presupposes that the investigator has determined what factors are relevant.

2. *The so-called cause may include certain factors that are not necessary to the effect.* In the days of sailing ships and long voyages, it was known that fresh vegetables prevented scurvy. The sailing masters did not understand the precise cause. Now it is known that the cause is not vegetables, it is vitamin 'C'. Since a common antecedent is regarded as the cause, the investigation which uses this method is *liable to commit the fallacy of post hoc ergo propter hoc.* The scientific drunkard committed this fallacy. Moreover, the method uses the technique of observation. Since, in observation, the conditions are not under the control of the investigator, some relevant factor may be ignored; and that may be the cause.

3. *The method fails to distinguish between the cause and a co-effect.* People of an island to the north of England observed that whenever boats came to the island, they suffered from cough and cold. So they believed that the coming of boats was the cause of cough and cold. Really, boats could come to the island only when north-west wind blew. Since north-west wind blows from the arctic region, cold arctic wind was the real cause. Here coming of the boats is a co-effect.

4. *The method cannot be applied when the cause is complex.* Let us suppose, a group of students goes to a hill station. On their return, it is observed that they have improved in health. By applying this method, it would be said that going to the hill station is the cause of better health. The real cause may be complex. Better health may be the joint effect of better climate, rest and recreation, cheerful company, etc.

Apart from the above defects, it is difficult to meet the requirements laid down by Mill. *How are we to know that the observed instances agree in one circumstance alone?* If the method necessarily required the investigator to conduct experiments, there would be a fair chance that the instances do agree in only one relevant factor. But the investigator has to rely upon this method precisely when he cannot conduct experiments. That is why this method is in greater use in the social sciences.

The defects of the method should not lead us to ignore its positive features. The *method of agreement is the first attempt to analyze the factors in a phenomenon.* Its approach is very much similar to that of induction per simple enumeration. Here too we go by the evidence of positive instances. But we try to find out exactly what is common to the positive instances. In this way, we eliminate those factors which vary.

3. THE METHOD OF DIFFERENCE

Mill attached special importance to this method. According to him, the method of agreement is useless whenever there is plurality of causes. So its conclusions are, at best, probable. But the method of difference will yield certainty. He states the method thus :

> *If an instance in which the phenomenon under investigation occurs, and an instance in which it does not occur, have every circumstance in common save*

one, that one occurring only in the former; the circumstance in which alone the two instances differ is the effect, or the cause, or an indispensable part of the cause, of the phenomenon.

In the method of difference only two instances are examined. In one of these the phenomenon occurs, and in the other it does not occur. The positive and the negative instance differ in only one circumstance. This circumstance is regarded as the cause. The method is symbolized thus :

ABC is followed by XYZ.

BC is followed by YZ.

∴ A is the cause of X.

This method is based upon the second principle of elimination. A circumstance in whose presence the phenomenon (effect) does not occur cannot be the cause. The phenomenon "X" does not occur in the presence of B and C (in the negative instance). Therefore, neither B nor C is the cause. By elimination, it is inferred that "A" is the cause of "X".

Illustration

1. Mill takes the example of a person who is shot through the heart. Immediately before the gunshot he was alive. Since all circumstances, except the wound, are the same, we conclude that it was the gunshot that killed him.

2. Let us take an example from everyday life. When a weight is placed on a weighing machine, the needle goes up; and when the weight is removed, it (needle) comes back to its original position. Therefore, placing the weight is the cause of the change in the position of the needle.

Critical estimate : The requirements of this method are extremely difficult to satisfy. To find instances which differ in one circumstance is not easy. By observation it cannot be determined in how many circumstances the positive and the negative instance differ. *So the method can really be used only when the investigator can set up an experiment.* But when he conducts an experiment, he cannot be sure that the difference is in one circumstance alone.

When this method is used for investigations in the social sciences, the difficulties are still greater. Suppose we pick up two groups of students, as similar in intelligence and hard work as possible. One of the groups is taught with the help of television, and the other group by the old method of class teaching. The results indicate that the former method is decidedly better. Now the students who participated in the new method know that they are being experimented upon. If they have heard that the new method is better, they may, unknowingly, put great efforts. So the better results may not be due to the superiority of the new method. In social sciences, it is difficult to control the attitude of the subject (i.e. the person undergoing an experiment).

Apart from the above difficulties, *the cause may not be sufficiently analyzed.* In that case, an irrelevant factor may be regarded as the cause. To take an example, people used to think that darkness frightened children. When a child is in the dark, he is afraid; and when he is out of it, he is no more afraid. But later it was discovered that darkness was not the cause of fear. It was always something that happened in darkness, usually a loud noise, that was the cause.

The method also fails to distinguish between the cause and a condition. We strike a match against the side of a match-box, and the match burns. So striking a match against the match-box is regarded as the cause of burning. It is obvious that this is only a condition, and not the cause. Mill had realized this. That is why his statement of the method states that we may get either the cause or an indispensable part of the cause. But Mill himself places great reliance on this method. He believes that by this method the cause of a phenomenon can be determined.

Mill claims that the method of difference is not affected by plurality of causes. This claim is not admissible. We have no guarantee that 'A' is the only cause of 'X'. To take an example, a doctor is able to cure malaria by quinine. But he will not assert that quinine is the only cure for malaria. However, plurality of causes is a result of improper analysis. Therefore, this defect need not be emphasized. Moreover, none of the methods will be useful in the case of plurality of causes.

The above criticisms should not make us under-estimate the value of the method. Though there is a danger that an irrelevant factor may be considered as the cause, scientists place great reliance on this method. Experiments are conducted on the assumption that this method is reliable. However, a scientist would not assert that the circumstance in which the positive and the negative instance differ is the cause. He would merely say that the circumstances found in the negative instance are not necessary to the occurrence of the phenomenon. He would then infer that the difference is *probably* the cause. And to confirm this, he would conduct many experiments, so that he may systematically vary the factors.

4. THE JOINT METHOD OF AGREEMENT AND DIFFERENCE

Mill had great confidence in the conclusions obtained by the method of difference. But it is not always possible to obtain instances which meet the strict requirements of the method of difference. Sometimes we cannot find a positive and a negative instance which differ in one circumstance alone. In such cases, we have to use the joint method of agreement and difference. This method, according to Mill, does not express any new principle. It is merely a combination of the earlier two methods. However, it is superior to the method of agreement. In agreement, we have to rely upon positive instances alone. Here we take both positive and negative instances. The set of positive instances agrees in one circumstance; and the set of negative instances differs from the positive set in that one circumstance. Now though this method uses agreement as well as difference, in Mill's view, it is inferior to the method of difference. Mill's statement of the method is as follows :

> *If two or more instances in which the phenomenon occurs have only one circumstance in common, while two or more instances in which it does not occur have nothing in common save the absence of that circumstance, the circumstance in which alone the two sets of instances differ is the effect, or the cause, or an indispensable part of the cause, of the phenomenon.*

The method is symbolized thus :

$$\left.\begin{array}{l}\text{ABC is followed by XYZ.}\\ \text{ADE is followed by XPQ.}\end{array}\right\}\ \text{set of positive instances}$$

$$\left.\begin{array}{l}\text{BDF is followed by YPR.}\\ \text{CEG is followed by ZQS.}\end{array}\right\}\ \text{set of negative instances}$$

$\therefore$ A is the cause of X.

Illustration : A good illustration of this method is provided by Pasteur's demonstration of the effectiveness of anthrax vaccine.

At a farm near Melun, Pasteur selected two groups of animals. Each group consisted of twentyfour sheep, six cows and a goat. Pasteur used his vaccine on one group (called experimental group); the other group (called control group) had no benefit of the vaccine. After some days, both the groups were innoculated with powerful microbes of anthrax. All the animals in the experimental group (i.e. the group which was vaccinated) survived, while all the animals in the control group (i.e. the group which was not vaccinated) died. Here the set of positive instances consists of 31 animals in the experimental group. These instances have one common characteristic, namely, being vaccinated with anthrax vaccine. The set of negative instances consists of 31 animals in the control group. The positive and the negative set (i.e. the experimental and the control group) differed in one characteristic, namely, being vaccinated. So, it was inferred, by the joint method of agreement and difference, that vaccine is the cause of preventing anthrax.

Critical estimate : Mill's statement of the method shows that the instances in the two sets should differ as much as possible. But if Mill is strictly followed, the method would be practically useless. For, then, the instances in the negative set would be totally irrelevant. They would have no connection with those in the positive set. Therefore, to preserve the utility of the method, *the instances in the negative set should be as similar to those in the positive set as possible*. This is what Pasteur did, in the above investigation. Further, the value of the method would be still greater if the instances within the set vary widely.

If the instances in the positive set are similar to those in the negative set, the method will be a modification of that of difference. On the other hand, if the instances in the two sets have nothing in common, the joint method will be a modification of the method of agreement. Not only that, in the latter case, its results would be no better than those of agreement.

We may mention here that *Mill is wrong in holding that the joint method is inferior to the method of difference*. On the contrary, it is vastly superior.

Howsoever carefully a scientist may choose instances, and howsoever much a scientist varies the conditions, he cannot be certain that the conclusion is established. This method too is affected by the difficulties arising from insufficient analysis and plurality of causes. An irrelevant factor may be regarded as the cause, while a relevant factor may be ignored. Moreover, the difference between the two sets may be a necessary condition, and not the cause.

5. THE METHOD OF CONCOMITANT VARIATIONS

We come across phenomena which vary together; and when we observe their co-variations we believe that they are connected. This connection is suggested by the method of concomitant variations. However, Mill does not conceive of this method so widely. He restricts its use to only those cases in which the relevant factors cannot be eliminated. Let us illustrate certain phenomena, e.g. the moon and the tides, and the pressure of atmosphere, are ever present. So the method of difference cannot be used. In such cases only, Mill recommends the use of this method. Mill's statement of the method is as follows :

> *Whatever phenomenon varies in any manner whenever another phenomenon varies in some particular manner is either a cause or an effect of that phenomenon, or is connected with it through some fact of causation.*

This method can be applied both when the phenomena vary directly and when they vary inversely. By direct variation, we mean that the increase in one phenomenon is accompanied by the increase in the other, and vice versa. The inverse variation means that the increase in one phenomenon is accompanied by the decrease in the other; and vice versa. Galileo's law of freely falling bodies is a case of direct variation, while Boyle's law expresses inverse variation. The method is symbolized thus :

A_1 BC is accompanied by X_1 YZ.

A_2 BC is accompanied by X_2 YZ.

A_3 BC is accompanied by X_3YZ.

∴ A is the cause of X.

This method depends upon the third principle of elimination (stated in Section 1). The factors that do not co-vary are not causally connected.

Illustrations : (I) Mill takes the example of the phenomenon of tides to illustrate the employment of this method. He says, we find that all the variations in the position of the moon are followed by corresponding variations in the time and place of high water. From this evidence, we conclude that moon is, wholly or partially, the cause of the tides.

Critical estimate : Mill's strong preference for the method of difference does not allow him to realize sufficiently the merits of this method. He loses sight of the fact that, while all the other methods are qualitative, the method of concomitant variations is quantitative. Now science is not interested in establishing merely qualitative relations. A scientist expresses his laws, if possible, in quantitative terms. And to do so, he must find out how quantitative variations in certain factors affect the other factors. Moreover, this method is not restricted to discovering and establishing causal connections. *Its application extends to laws of functional dependence.* When quantitative correlations are deduced as consequences from a hypothesis, this method is used to test the hypothesis. We all know that the longer the time an object has been falling, the faster it falls. Galileo's law expresses the relation between the time and the distance of fall precisely. So Galileo's hypothesis was tested by this method.

From the above discussion, we see that the *method of concomitant variations can be used both independently and in conjunction with the other methods.* When a factor cannot be eliminated, this is the only method for suggesting, as well as establishing, a hypothesis. When qualitative connections have been discovered by the other methods, this method is helpful in making the connections quantitative. However, as in the case of the other methods, this method too eliminates certain factors as being irrelevant to the phenomenon under investigation.

This method may be regarded as a modification of either the method of agreement or that of difference. If the non-varying factors remain constant, it is a modification of the method of difference. But if they change, it is a modification of agreement. In the former case, its value is greater. But still we cannot assert that the method will yield reliable results.

A number of problems arise in connection with this method too. Firstly, in many cases, there are *limits to the co-variations.* By the method of concomitant variations it may be established that fertilizer improves the crop yield. But too much of fertilizer may harm the soil; and so, beyond a certain limit, the quantitative relationship between the use of fertilizers and crop yield may not hold. *Secondly, the factor we regard as the cause may be merely one of the conditions.* For example, we observe correlation between share values and the deficit budgets of the Government of India. The higher the deficit, the lower become the values. But if one sells shares when the Finance Minister proposes a heavy deficit in the budget, one may be shocked to find that the prices have risen. For, the other factors, which we have not taken into account, may offset the effect of the deficit budget. That is why, on the ground of mere co-variation, a connection cannot be established. It is difficult to ensure that there are no other relevant factors. Not only this, irrelevant factors may vary together; and we may be misled into thinking that one of them influences the other. *Lastly, the supposed cause and effect may really be co-effects of the same cause.*

6. METHOD OF RESIDUES

The method of residues is applicable when the work of determining causal connections has been partially done. It is used when, in a complex situation, the causes of some of the elements are known. Mill states the method thus :

Subduct from any phenomenon such part of it as is known by previous inductions to be the effect of certain antecedents, and the residue of the phenomenon is the result of the remaining antecedents.

The method is symbolized as follows :

ABC is followed by XYZ.

$\left.\begin{array}{l}\text{B is known to be the cause of Y.}\\ \text{C is known to be the cause of Z.}\end{array}\right\}$ By previous inductions

∴ A is the cause of X.

This method is based upon the last principle of elimination.

Illustrations

1. The use of this method in everyday life is shown by cases such as determining the weight of the load in a truck. A loaded truck is weighed. From this the weight of the empty truck, which is already known, is subtracted. What remains is the weight of the load.

2. A well known example of scientific discovery by the use of this method is that of Neptune. Bouvard observed a deviation in the orbit of Uranus. This could not be accounted for by the attractions of the known planets. By subtracting the effect of gravitational pull of the known planets, from the gravitational force as shown by the orbit of Uranus, Leverrier calculated the size and position of the unknown planet. This planet was named Neptune.

Critical estimate : This method suggests causal connection between a part of the antecedent factors and a part of the consequents. It does this when some of the antecedents and some of the consequents are already known to be causally connected. In actual scientific practice, a scientist does not assume that the remainder of the antecedent and the remainder of the consequent are necessarily causally connected. For it is possible that each antecedent, by itself, may produce a certain result. But a number of antecedents, jointly, may produce an altogether different effect. In such cases (i.e. in heteropathic intermixture of effects), this method will be of no use. Thus, we see that *this method assumes that each factor in the antecedents is causally related to a definite factor in the consequents.* This assumption is not justified. That is why scientists treat the results obtained by the method of residues merely as a hypothesis, which is to be established by further observation.

For Mill, the method of residues is a variation of the method of difference. When a phenomenon is complex and we cannot get a suitable negative instance, the method of difference cannot be applied. In such cases, if we know the cause of some elements in the phenomenon, by the method of residues, we can determine the cause of the remainder of the phenomenon. Mill regards residues more as a method of using mathematical calculations and deduction than as a strict experimental method.

This has led to the charge that *the method of residues is deductive in character.* That is why some books omit this method from their account of Mill's experimental methods. It is, of course, true that deduction is involved in the method of residues. But it would be wrong to say that the method is deductive in its results. Deduction involves certainty, while a scientist would regard the conclusion, arrived at by residues, only as a hypothesis. In fact, Mill is wrong in supposing that the causal connection between the remaining part of the antecedents and the remaining part of the consequents is determined by mere subtraction. However, the method is applicable only in later stages of science. It can be employed when scientists already know the effect of certain causal factors.

Apart from this, we must not be under the impression that this method is free from the defects common to the other methods. *Here also, we may get an irrelevant* *factor as the cause, or we may ignore some relevant factors.* The latter defect is clearly shown by experiments in psychology. Let us suppose a psychologist wants to find out the effect of tobacco on work. He may take two groups which, by other tests, are found to be equally efficient. Members of the experimental group are allowed to smoke, while those of the control group are not. He finds that the output of the experimental group is greater than that of the control group. By the method of residues, he will conclude that the difference in the output was caused by smoking. This conclusion cannot be regarded as established. The members of the experimental group may know that they were being experimented upon; and this factor may affect the result. So the difference—either the whole of it or a part of it—may not be due to smoking. If smoking does not contribute to the difference in the output, it would be an irrelevant factor. But if it is responsible for only a part of the difference, it would mean that some relevant factor has been ignored.

7. EVALUATION OF MILL'S METHODS

Mill thought that the primary goal of inductive inquiry is the discovery and proof of universal causal laws. His experimental methods are the means of realizing this goal. By their use, the causal connections can be discovered and proved. Let us examine this claim.

Mill's programme is over-ambitious. Science does not aim at proof. Its conclusions are probable. The primary theoretical aim of science is explanation. And explanation takes the form of hypothesis. In suitable cases, this hypothesis may be established, but it can never be proved. Proof of a hypothesis, as we have seen in the last chapter, consists in showing that the given hypothesis is the only hypothesis which can explain the facts. Such a position, as we know, is never taken by a scientist. Therefore, Mill's claim, that the methods are the means of proof, may be rejected without any hesitation.

While Mill's programme is over-ambitious in one respect, it falls far short of the goal of science in another respect. Discovery of causes is only a part of the scientist's activity. Scientists also establish non-causal laws, e.g. classificatory laws, developmental laws, and statistical laws. However, this is no serious limitation. The goal of much of the activity in the less advanced sciences is to find out causes. And, more important still, the methods can be used for confirming non-causal hypotheses too. Let us now examine the methods with reference to the less ambitious goal of establishing hypothesis.

Mill's methods are not satisfactory even for establishing hypotheses. There are three reasons for holding this view. Firstly, establishing a hypothesis requires systematic elimination of the alternatives to it. And if we are to go by Mill's instructions, we cannot eliminate the other likely hypotheses. He wants us to use each method separately; and systematic elimination is not possible if we depend upon any one method. However, this is not a serious drawback. A scientist is free to use as many methods in an investigation as he needs. Secondly, the methods, by themselves, would not be sufficient for establishing a hypothesis. A hypothesis is not established merely on the basis of direct evidence. Indirect evidence has also to be considered. Not only this, a hypothesis is established if its explanatory power is superior to its rivals, as well as it is simpler than its rivals. Since Mill's methods have to do with direct evidence, it follows that they are merely *one* of the means of establishing hypothesis. Thirdly, the methods have so many defects that they can be of only limited help in finding direct evidence. While dealing with the different methods we have seen what defects each of them has. Let us now examine briefly the defects common to the various methods.

The value of the conclusions obtained by the use of any method depends upon *the analysis of the factors* into relevant and irrelevant. But analysis is no easy matter. Satisfactory analysis depends upon expert knowledge, training and insight of the investigator. In fact, scientists are well aware that their analysis may not be correct. A factor that is regarded as irrelevant may turn out to be relevant; and vice versa. That is why scientists keep varying the conditions, until they are satisfied that they have not ignored any relevant factor. Even then the possibility of confusing irrelevant factors with relevant ones cannot be eliminated. Now if we look at the methods, we see that they attach hardly any importance to the work of analysis. They seem to take for granted that, in nature, antecedents and consequents are clearly determined. This is too unreal a view of nature. Conditions in nature are very complex; and it is left to the scientist to analyze them correctly. If the analysis is defective, none of the methods will yield reliable results.

Because a scientist realizes the difficulties involved in analysis, he pays attention to the supposedly irrelevant factors. He varies them systematically, so that he may find out whether they are really irrelevant. On the other hand, *Mill's methods give more attention to cause and effect than to the "irrelevant factors"*. That is why their results are so unreliable.

Mill admitted the possibility of plurality of causes. He believed that there may be many causes of the same phenomenon. This has serious consequences. If there is plurality of causes, no inference to the unknown cases will be possible. Mill thought that plurality of causes affects the method of agreement only. But, as we have seen, even the method of difference, which is the most dependable method according to him, is helpless if there is plurality of causes. However, the problems created by the plurality of causes need not trouble us. Science assumes that there is no plurality of causes. And, as a matter of fact, this is the minimum a scientist must assume, in order to carry on an investigation.

Mill has paid no attention to the choice of the right instances. Unless the examined instances are a fair sample of the cases within the scope of the generalization, the methods will prove useless. The very next instance may disprove the generalization.

In view of the above defects, the results obtained by Mill's methods have to be treated merely as probable. Of course, the results obtained in one investigation may be more reliable than those obtained in another. This is because the reliability of the results depends upon how an investigation is conducted. If it has been conducted systematically, the results may be quite reliable.

Let us now evaluate *the second claim*, namely, that the methods are the means of *discovering causal connections*. As we have pointed out above, science is not necessarily interested in causal connections. So we shall take this claim to mean that the methods help the investigator to discover hypotheses. This claim too cannot be admitted. Formulation of a hypothesis is a result of flight of imagination and relevant knowledge. Mill's methods do not possess any special quality which will enable a scientist to "think up" suitable hypotheses. As sources of hypotheses, they are as useful as simple enumeration. We know that, occasionally, generalizations by simple enumeration may suggest hypotheses. In a similar way, Mill's methods may also do so. Mill's methods are really used after a hypothesis has been formulated. They help scientists to test hypotheses. When a problem arises, the scientist thinks up various possible initial hypotheses. Then he may employ Mill's methods to eliminate the unfruitful ones.

We shall now indicate *the place of Mill's methods in science*. By eliminating the alternatives to a hypothesis, they help in increasing its probability. However, Mill's methods are not applicable in the same manner to all investigations. *They can be best used for dealing with social sciences.* In these sciences we rely mainly on direct evidence; and the methods are the means of collecting direct evidence. Moreover, the conclusions of the social sciences are not as exact as those in the advanced sciences, e.g. in physics and chemistry. Now it is difficult to attain exactitude with Mill's methods. Therefore, these methods are more relevant for conducting investigations in the social sciences than those in the advanced sciences.

In conclusion, we may say a word in Mill's defence. Mill proposed the methods at a time when there were no clearly formulated procedures of scientific inquiry. Therefore, he thought that he had presented to science the "sure success" means of discovery and proof. Progress in science has shown that even the most firmly established theories may prove false. Moreover, today science is at a much more advanced level. And so scientists are better able to judge the validity and value of any inductive procedure.

SUMMARY

The theoretical aim of science is to explain. Explanations are proposed as hypotheses. To establish hypotheses, scientists use certain inductive procedures. These procedures are called Mill's experimental methods.

Bacon was the first one to use inductive techniques. Mill elaborated Bacon's principles into five separate methods. These methods, according to him, are the ways of discovering and proving causal connections.

The method of agreement : Here a number of positive instances are examined. If these instances have a single factor in common, that is to be considered the cause. Agreement is primarily a method of observation. When the conditions are not within the control of the investigator, he relies upon this method. Though the method of agreement is particularly liable to commit the fallacy of *post hoc ergo propter hoc* and is useless in the case of plurality of causes, it is an improvement over simple enumeration.

The method of difference : Mill regards this method as the most reliable one. Here two instances are chosen. In one of them the phenomenon occurs, while in the other it fails to occur. The single factor in which these factors differ is regarded as the cause.

The requirements of the method of difference are difficult to fulfil. Even in an experiment, the investigator cannot be sure that the difference is in only one circumstance. Moreover, the noticed difference may be in an irrelevant factor. So Mill's confidence in this method does not seem to be justified.

Joint method of agreement and difference : In this method a set of positive and a set of negative instances is taken. The two sets differ in one circumstance, and that circumstance is regarded as the cause. Though Mill did not attach much importance to this method, really, the scientists rely upon this method the most.

The method of concomitant variations : When we observe co-variation between certain phenomena, we believe that it is an indication of connection. By this method, we establish such connections. For Mill, the method of concomitant variations is to be used when the other methods are inapplicable. But scientists do not place such restrictions on this method. However, it too has certain defects.

The method of residues : This method is used to determine causes when the intermixture of effects prevails. By subtracting the causes of certain parts of the phenomenon, the residue of the phenomenon is considered to be due to the remaining antecedent. The description of the method seems to suggest that the method can be applied mechanically. But the application is never mechanical.

Evaluating Mill's methods : Mill claimed that his methods are the means of discovering and proving causal connections. This claim has to be rejected. Science is interested in establishing hypotheses; and Mill's methods are one of the means used for this purpose. However, even for this limited purpose, the methods do not seem to be satisfactory. Firstly, establishing a hypothesis requires systematic elimination of the alternatives to it. This does not seem possible if we are to accept Mill's views. Secondly, methods, by themselves, would not be sufficient to establish a hypothesis. A hypothesis is established only when it is able to account for the phenomenon under investigation more satisfactorily than its rivals, as well as when it is simpler than them. Thirdly, the methods have too many defects; and so their help in finding direct evidence is also rather limited.

TEST QUESTIONS

1. State and explain the following method and indicate its applications :
   1. The Method of Agreement.
   2. The Method of Difference.
   3. The Joint method of Agreement and Difference.
   4. The method of Concomitant Variations.
   5. The method of Residues.
2. What are the main defects of the method of Agreement?
3. Explain the method of Difference and examine its value.
4. What are the main features of the Joint Method of Agreement and Difference? Is the method inferior to the method of Difference?
5. State the method of Residues? Is this method a deductive one?
6. Examine Mill's claim that the experimental methods are the means of discovering and proving causal connections?
7. Show how Mill's methods are essentially eliminative.
8. State whether the following statements are true or false :
   1. In the method of Agreement we have only positive instances.
   2. The method of Difference is mainly a method of observation.
   3. In the Joint Method of agreement and difference, we observe one positive instance and one negative instance.
   4. The method of Difference is based on the principle that an absent circumstance cannot be the cause.
   5. The method of Agreement is based on the principle that the circumstance in whose presence the effect does not occur cannot be the cause.
9. Fill in the blanks in the following with appropriate word/words :
   1. In _____ (method) we observe one positive and one negative instance.
   2. In _____ (method) there is a set of positive instances and a set of negative instances.
   3. When two phenomena vary together, we use the method of _____.
   4. In _____ (method), the cause of a part of the effect is already known.
   5. _____ (method) gives quantitative results.

6. In _____ (method), the first stage is determining the effect of each of the separate causes of a complex phenomenon.

10. Give technical terms used in logic for the following groups of words :

    1. The method in which we establish a causal relation between two factors after eliminating the factors that are known to be causally related.
    2. The method in which a causal relation is established between two factors after observing the quantitative variation in them.
    3. The method in which we observe two or more positive instances and consider the common feature as the cause.

12. Indicate the method used in the following and examine it :

    1. Metchnikoff took two apes and innoculated them with the virus of syphilis. After one hour, he rubbed the ointment into the spot on one of the apes. The ape which was given treatment with the ointment did not get syphilis, but the other one did. So, the ointment is a cure for syphilis.
    2. Five hundred litres of wine, half of it heated and half unheated, were put aboard a ship at Brest, and taken on ten months' cruise. Pasteur also kept casks of heated and unheated wines in his own cellar for many years. In all these cases, the heated wine remained healthy, but the unheated wine had bad flavour.
    3. The higher the Torricelli tube was taken, the lower the level of mercury in the tube. During the experiment, an observer at the bottom of the mountain watched a Torricelli tube, and found that the level remained unchanged. So the pressure of atmosphere was the cause of the change in the level of mercury.
    4. Davy found that when water was decomposed into oxygen and hydrogen, an acid and an alkali developed at the opposite poles.
    5. Von Guericke used his air-pump to exhaust a metal sphere. He weighed the sphere before the air was removed. The sphere was heavier before the air was removed. From this he inferred that air has weight.
    6. After one stroke of the pump, the mercury in a Torricelli tube fell from 30 to 9 or 10 inches. After another stroke, it fell nearly to the level of mercury in the trough. So the column of mercury in the tube is supported by pressure of air on the open mercury surface in the trough.
    7. Jenner innoculated a small boy in the arm with pus from a milkmaid infected with cowpox. The boy contracted cowpox. Then he was innoculated with pus from a person who was suffering from severe smallpox. The boy did not catch smallpox. From this, Jenner inferred that a person who catches cowpox does not catch smallpox.
    8. Eijkman took two lots of hens. To one of these lots he gave husked rice, to the other unhusked rice. The hens which were fed on husked rice contracted beri-beri; the others remained healthy. So husk of the rice contains some element, the lack of which causes beri-beri.
    9. The pituitary gland of dwarfs shows a small development, and that of a normal adult weighs about half a gram. This shows that there is connection between the functioning of the pituitary gland and the body growth.
    10. Twice Mr. W had a dream about falling through space. Each time it was the night before an examination. Both times he failed. So he believes that dreams foretell the future.

11. Rats A and B are of the same age and from the same litter. They took 30 trials to learn a maze. The rat A was given a small amount of vitamin B_1. Now the rat A took 5 trials less to learn the maze. This proves that vitamin B_1 increases the intelligence of rats.
12. A coin and a feather are dropped at the same instant in the receiver of an air-pump. When there is air in the pump, the feather falls to the bottom after the coin. When the air is pumped out, both reach the bottom of the receiver together. Thus, resistance of the air is the cause of this difference.
13. Psychologists have tested thousands of people working in business organizations. They find that the vocabulary of top executives is generally much larger than that of lower-level employees. Therefore, large vocabulary is responsible for appointment as a top executive.
14. Mr. C wanted to find out the weight of his cat. He got hold of the cat, and stepped on the scale. In this way, he determined the weight of the cat.
15. Sacks found that when light is excluded from a plant, other conditions remaining the same, no starch was formed. But when the plant was exposed to light again, starch was formed. So light is the cause of starch formation.
16. A person wished to test the durability and protective value of two brands of paint. He painted the door on one side of his house with green paint of the brand 'N', and the door on the other side with green paint of the brand 'R'. After a year, he found that the door painted with brand 'R' was in a better condition. From this he concluded that brand 'R' protects wood better than brand 'N' does.
17. A survey of college students in an American University showed that those who do not smoke are more intelligent than those who smoke. Also, they do better at examinations. This proves that smoking reduces mental ability of students.
18. Cholera was prevalent in London in 1854, and Broad Street was within the affected area. Mrs. E lived in the West End of London (which was free from cholera); but she preferred to drink water from the pump in Broad Street. On Thursday and Friday she drank water from this pump. She was seized with cholera on the evening of Friday. Her niece, who was on a visit to her, also drank of the same water. She too was attacked with cholera. Therefore, the death occurred due to the cholera germs in the water from Broad Street pump.
19. Darwin's experiment :

Instance 1 : twenty heads of Dutch clover exposed to bees – result, 2290 seeds.

Instance 2 : twenty heads of dutch clover protected from bees – result, no seeds at all.

Therefore, bees influence the fertilization of clover.

20. No dew is deposited on a peace of metal which has been polished. But on the same metal, if unpolished, quite much dew is deposited. Therefore, the deposit of the dew is affected by the kind of surface which is exposed.
21. A bell is struck in a vacuum, and no sound is heard. Air is allowed to enter, and the bell is clearly audible. Therefore, sound is communicated through air.
22. Finlay observed that the yellow fever zones correspond to the distribution of a certain mosquito. In every epidemic area, this mosquito is found. Therefore, the disease is caused by it.

CHAPTER – 22

SCIENTIFIC EXPLANATION

DO YOU KNOW THAT ......
* *The laws of a science do explain facts, but facts are the final court of appeal for a law howsoever mighty it be ?*
* *To explain is to make something plain, but what is plain to a scientist may confound the common man ?*
* *Not only facts are explained by laws, even laws are explained by laws ?*
* *A scientist differs from you and me in seeking explanation for familiar facts too ?*
* *A scientist's explanation never appeals to God or fate ?*
* *Axioms need no explanation?*

1. WHAT IS EXPLANATION ?

The aim of knowledge, whether is everyday life or in science, is to understand the nature of events. To understand anything is to have an explanation for it.

Explanation is an answer to the "Why" question. When we ask, "Why is the milk man late today?" or "Why do we perspire?", we are king for explanation. If the milkman tells us that his train was late, the happening becomes clear to us. In a similar way, the phenomenon of perspiration is clarified when we understand that the sweat glands are the air-conditioners of the body. Their function is to keep the body temperature constant. Obviously, explanations will not be demanded if the facts are clear. It is only when a situation puzzles us that we ask for explanation. A puzzling situation, or problem, arises if some fact clashes with our system of knowledge.

A scientist's system of knowledge differs from that of a common man. So the problems in the two cases would not be of the same type. Similarly, the types of explanation also would not be the same. But, in both cases, an explanation would be regarded as satisfactory only if the puzzling facts are corrected to the system of knowledge. In the milkman's case, we are satisfied; because we know that the late arrival of trains would make the passengers late. But suppose we were told that the political situation in Pakistan had made the milkman late, the explanation would not satisfy us. A scientist too is satisfied when the explanation agrees with the system of knowledge prevalent in a science. That is why an explanation which is found satisfying at one time may fail to satisfy at some other time. At one time the Ptolemaic system was a satisfactory explanation; but later on it has the Copernican system.

The fact (or law) which is to be explained is called explicandum, the reasons offered as explanation are call explicans.

2. SCIENTIFIC EXPLANATION

All explanations are advanced to solve a problem. But a scientific explanation performs a more important function. It gives insight into the nature of phenomena. It does this by means of laws and theories. It is said that Newton's attention was drawn by the fall of an apple; but his explanation (the law of gravitation) improved our understanding of a large body of facts. Such unconnected facts as the fall of bodies in the neighbourhood of the earth; the movements of the moon, the planets and the sun; and the ebb and flow of tides were now seen to be due to the gravitational pull.

Though a theory may explain a large body of facts, science is not satisfied with isolated theories. Its ultimate goal is universal explanation. Science aims to explain all facts by establishing an interrelated system of laws. In this system, all the laws would be deducible from a few most general laws.

In the next Section we shall see how science explains the individual facts (or events) and laws. For the present, we may merely mention that explanations in science are given by means of laws. For explaining a fact, a law (or laws) is required; and for explaining a law, at least one more general law is needed. So, we may say that explanation consists in deducing the explicandum from the explicans, such that the explicans, such that the explicans contains at least one more general proposition than the explicandum, and is true. Let us now analyze the requirements of scientific explanation.

1. Logical consequence : In a satisfactory explanation, the explicandum must be a logical consequence of the explicans. That is, from the explanation which is given, it should be possible to deduce the fact or law which is to be explained. Galileo's law of freely falling bodies is explained by deducing it from Newton's laws of motion and his law of gravitation.

2. More general statement : In the scientific explanation of law, the explicans must contain at least one more general law than the explicandum. We find this feature in the explanation of Galileo's and Kepler's law. The scope of Newton's law is wider than the scope of these laws. Similarly, Einstein's theory is able to explain Newton's law of gravitation, because it covers laws relating to electrical and mechanical energy. This requirement is a drawn, because science aims at systematization. That aim cannot be realized ullless less general laws are deduced from more general laws. Moreover, if the explicans is not more general than the explicandum, it is possible that the explanation be circular. That is, the explicandum and the explicans may state the same thing in different words. For example, it is no explanation of the sleep-producing qualities of opium to say that it is soporific. For soporific means "sleep producing."

3. Verifiable : In a scientific explanation, the explicans must be verifiable. A]aw is advanced to explain facts. But how is one to know that it does explain these facts. Obviously, by finding out whether it agrees will facts. That is why science demands that laws be verifiable. In fact, a law is regarded as the explanation of facts, only so long as it does not conflict with them. If scientists come across facts that do not support a law, the law ceases to explain. It is rejected, and a new law takes its place. The condition of verifiability is the basic requirement of science. Even a hypothesis is not considered seriously if it fails to satisfy this requirement.

4. True : Lastly, a scientific explanation must be true. In view of the fact that every law is subject to rejection, this requirement cannot be interpreted strictly. The requirement merely means that, at the time a law is advanced as explanation, there must be independent evidence in its support. That is, the evidence for it should not be restricted to the facts, or laws, which it is supposed to explain. Newton's law could explain the already established laws of freely falling bodies, tides and planetary motions; because it had some additional evidence, such as the movements of comets. This characteristic enables scientists to rule out an *ad hoc* hypothesis as explanation.

The problem now arises : How is one to know whether the above conditions are satisfied? Scientists use the test of predictive power for this. A law is not accepted as explanation unless some unobserved phenomena can be restricted from it. The predictive power would show that the law is supported by facts and that it is not restricted to the facts, or laws, which is has been advanced to explain. It would further show that the law has independent evidence, and so is not an *ad hoc,* hypothesis. Both Newton's law and Eistenin's law had great predictive power.

3. SCIENTIFIC EXPLANATION OF FACT AND LAW

The pattern of scientific explanation for facts as well as laws in the same. In both cases, the explicandum is deducible from the explicans. However, there are certain differences in the propositions that form the explicans.

Explanation of fact (or event) : ,An individual fact (or event) cannot be deduced from a law, by itself. Every event occurs under certain specific space and time conditions; and these can not be explained by a law: Therefore, in the explanation of a fact, the explicans includes not only a law (or laws), but also certain initial conditions. These initial conditions are the peculiarities of the fact, or event, to be explained. It is those circumstances or properties which are possessed by that fact alone. Thus, we may say that explanation of a fact (or event) consists in the statement of additional data and a law (or laws), from which the fact to be explained could be deduced. Let us take an example. Totricelli conducted an experiment in which mercury in the tube rose to about 30 inches height. Now to explain this individual event, it would be necessary to state the law regarding the pressure of air as well as the peculiar conditions under which the experiment was performed. However, the scientist is not interested in explaining individual events as such. His explanation is intended for any event of a certain kind.

Explanation of law : This consists in the statement of at least one more general law from which the law to be explained could be deduced. Thus, Galileo's law was explained by deducing it from Newton's three laws of motion and be law of gravitation. In its turn, Newton's law of gravitation was explained by Einstein's theory of relativity.

By deducing less general laws from more general laws, and those from still more general laws, science introduces greater and greater degree of systematization. A more general law (or theory) has a wider range of application. It explains all the phenomena explained by the less general laws, as well as some other phenomena. These other phenomena may not have been understood without its help. This is illustrated by the explanation provided by the law of gravitation, and the theory of relativity.

4. SCIENTIFIC AND COMMON SENSE EXPLANATIONS

We have discussed the requirements of scientific explanation. Now whatever explanation fails to satisfy those requirements is unscientific. If a scientists explanation violates any of the essential conditions, his explanation would be pre-scientific or common sense explanation.

Explanations in science and those in everyday life duffer (i) in the types of problems that give rise to them and (ii) in the nature of reasons that are found satisfying. Let us see how scientific and common sense explanations differ.

1. Familiarity : For a plain man, the need for explanation is felt when a difficulty arises. The familiar events are clear to him. So he does not require explanations for them. He is puzzled by anything unfamiliar; and he explains unfamiliar events by showing their connection with something familiar.

The notion of familiarity is connected with our experienced and expectations. anything unexpected is unfamiliar. Let us suppose that, one fine evening, we have gone for a walk to the Nariman Point in Bombay. We see a row of bullock carts, full of market produce, and a large gathering of villagers wearing gaily coloured clothes, talking excitedly. We would certainly want to find out the "why" of it. Let us further suppose, we are told that the Government has organized 'Meet the people of India Exhibition' for educating the city dwellers about the village life. The situation will no more be a puzzle. We know that exhibitions improve understanding. So we are able to correlate the unfamiliar situation with our experiences.

Explanating in science have nothing to do with familiarity. The scientist seeks explanations for all phenomena, the familiar as well as the unfamiliar. There are several reasons for this. Firstly, what is familiar is not fixed. It is relative to the individual who needs explanation. A scientist cannot rely upon his personal feeling of familiarity. His attitude is objective. He aims to discover the laws of nature. Secondly, the function of explanation in science is both positive and negative. The negative function is to solve the problem; and the positive one is to improve understanding. The latter is the more important function. Scientists attempt to realize this goal by finding relations among facts and laws. That is why scientists seek explanations for all phenomena. The phenomena such as tides, lightning, thunder, and rain are familiar. Yet scientists want to find explanations for them. Further, if we examine explanations in the advanced sciences, we shall find that, in many cases, the explicans is more unfamiliar than the explicandum. The theory of relativity ($E = mc^2$) is certainly more unfamiliar than the phenomena it explains.

2. The type of explicandum : The plain man's explanations are determined by his practical interests. These purposes are not served by seeking explanations for events in general, or for laws : That is why he demands explanations only for some particular occurrence which puzzles him. As we have emphasises above, science aims at universal explanation. So a scientist's explanations are not restricted to events He explains laws too In fact, he rarely explains a particular event. He is interested in an event, only because it is an instance of a class. This distinction is of great importance. For it shows that science aims at systematization.

3. Evidence : The common man's explanations may not be supported by evidence. He is not critical about his explanations. He does not attempt to find out whether the explicans has evidence in its support. That is why sometimes the action of a supernatural agency is advanced as the explanation for the puzzling situation. Let us illustrate this. The cult of "Thugi" was prevalent in India till the end of the last century. Whenever the "thugs" failed in their enterprises, they attributed the failure to the anger of Goddess Kali.

Science demands that its explanations be verifiable. A law is advanced as the explanation, only if it is supported by independent evidence. Now, if a scientist's explanation is unstable, it ceases to be scientific. It is in no way superior to a layman's explanation. An interesting example of unsupported explanation is the one advanced by a follower of Galen, to account for the human thigh bones being straight. (This is recounted in chapter 20.)

4. Attitude : It follows from the above that the common man's attitude is dogmatic. He is not prepared to find out whether his explanations are supported by facts. To take an example Galileo offered his telescope to one of the schoolmen to look at the newly discovered moons of Jupiter. He (the schoolman) declined to look, as he was already convinced that Jupiter could not have moons. As against this the scientist's attitude is open minded. He maintains an explanation so long as, it is supported by facts. When it fails to account for them, it is discarded.

5. Based on similarity : Lastly, the plain man's explanations are often based on similarity in irrelevant characteristics. But for a scientist, the explanatory value of a similarity consists in the law of which it (the observed similarity) is consequence. A scientist does not regard analogy as the explanation for a phenomenon. For the scientist, analogy only suggests an explanation. As we have seen, analogy itself is a source of hypothesis. On the other hand, for the common man, analogy itself is an explanation. The unfamiliar resembles the familiar; and so he can understand the unfamiliar by comparing it to the familiar. Not only this, quite often similarities in unessential characteristics appeal to him,, and he feels that he has found the explanation for the puzzling situation. For example, foxglove-tea was regarded as a remedy for heart attacks; because the shape of the foxglove flower is similar to that of the heart. Obviously, similarity in this feature is irrelevant.

5. TYPES OF EXPLANATION

Our account of scientific explanation may have given rise to the impression that, in all sciences, explanation consists in deducing the explicandum from the explicans. But this is not so. We have merely presented the ideal pattern of explanation. At present, this pattern is found only in the advanced sciences. In the less advanced sciences the data has not been so systematized that is why the deductive type of explanations cannot be advanced. Scientific explanations follow a number of different patterns. This is because there are a number of ways its which the explicans can be related to the explicandum. On this basis, Negel classifies scientific explanations into four types.

1. The deductive model explanation : We have already discussed this type of explanation. It consists in deducting the explicandum from the explicans. An individual fact (or event) explained by stating the additional data and a law (or laws) from which it could be deduced. A law is explained by deducing it from at least one more general law.

Mill conceived of scientific explanation on the lines to the deductive model. He states three modes (or kinds) of explanation. These sub-kinds of deductive model explanation are :

i) **Analysis :** In this form of explanation a joint effect is analyzed into the effects of the separate causes and their conjunction. Thus, it is shown that a joint effect occurs, because several causes act together. For example, the path of a projectile is explained by determining its separate causes. These are (a) the law of falling bodies (i.e the law about the gravitational pull of the earth), (b) the law of the jnitial force with which the projectile is thrown, and (c) the law of the resistance of air. We have also to state how these separate causes act together to produce the joint effect. Galileo showed that the path of a projectile is a parabola, because of these three causes. So his explanation took the form of analysis.

ii) Concatenation : When we want to find out the cause of a remote effect, we have to find out the links in the causal chain. In such cases, explanation takes the form of concatenation. *Thus concatenation consists in discovering the steps of causation between a cause and its remote effect.* To illustrate, lightening is accompanied by thunder. We can explain this by showing how thunder is a remote effect of lightening thus : Lightening is a form of electricity. Electricity produces heat. Heat produces expansion; of air. Sudden expansion of air produces a loud sound; and this loud sound is thunder. Thus, we see that heat is an intermediate link between electricity and thunder.

iii) Subsumption : This consists in explaining a less general law by deducing it from a more general law (or laws). Thus Galileo's law is explained by subsuming it under Newton's law of gravitation. In turn, Newton's law is explained by subsuming it under Einstein's theory of relativity.

Subsumption leads to the systematization of a science. In fact, without subsumption, science will consist of isolated laws.

2. Probabilistic explanation : Scientists advance statistical laws too. The explanations based on such laws are called probabilistic. *In a probabilistic explanation, the explicans consists of one (or more) statistical generatizatians singular statements stating the initial the initial conditions.* The explicandum is a singular statement regarding an individual member of the class covered by the generalization. The probabilistic explanations have the following form :

$$\left.\begin{array}{c}\text{Statistical generalization (s)}\\ \text{Initial conditions}\end{array}\right\}\ \text{Explicans}$$
$$\overline{\text{Singular statement}}\quad \text{Explicandum}$$

Many explanations in the social sciences, as well as in biology, are of this kind. Suppose we wish to explain why child is blue eyed. We may state that both the parents are blue-eyed; and in most cases where both the parents are blue-eyed, the children are blue-eyed. Similarly, we may wish to explain why, by cross-breeding a tall pea plant with a dwarf one, we got a tall offspring. Here Mendel's law, that dominant characteristics are inherited by about 75 per cent of the offspring, and that tallness is a dominant characteristic, may be put forward as the explanation.

In a probabilistic explanation, the explicandum is not a logical consequence of the explicans. In the above example, though in about three-fourths of the cases we get tall plants, in one-fourth we do not. So the tallness of the offspring cannot be said to follow from the explicans.

3. Functional or teleological explanation : In this type of explanation, the explicans states the function that the explicandum serves. We come across functional explanations mainly in biology and in the social sciences. When we ask: "Why does the heart beat?", or "Why do people breathe ?", we are demanding functional explanation. In the one case we are asking for the function of the heart in maintaining the organism, while in the other we want to know the function of the process called 'breathing'. The former is explained by stating that the heart beats, so that the blood may circulate. The latter is explained by pointing to the body's need for oxygen.

When a functional explanation refers to some future goal, the explanation is said to be actions are often **teleological**. The question, "Why do students work bard during the examination days?" may be answered by pointing out the goal of doing well in the examination.

4. Genetic explanation : *This type of explanation accounts for events or conditions, by referring to the circumstances out of which these events developed.* The explanation shows that the phenomenon to be explained is the final stage in the development. Developmental laws offer such explanations. The explanation of the traits of a child would be genetic. A child's traits would be shown as the final stage in the process of development, which started with what he inherited from his parents. Similarly, the explanation of a chemical process is of this type. It will consist in stating how the process started, and what were the stages in it till its completion, Explanations in history are mainly of this type.

6. LIMITS OF EXPLANATION

To explain a fact is to show that it is an instance of a law. To explain a law is to show that its operation is due to a more general law. But to do so, the similarities of the explicandum to the other facts, or laws, included in the explicans have to be discovered. From this it follows that a fact which has no similarities with other facts cannot be explained. In the case of laws too, we find a similar position. Thus, the limits to our capacity for finding out similarities become the limits of explanation. Of course, what is regarded as a limit today may not be so considered in the future.

1. Axioms : The axioms of a science fall outside the scope of explanation. The reason for this is that axioms are the assumptions of a system. All the laws in the system are formulated subject to these axioms. Therefore, axioms will remain outside the scope of explanation for ever.

2. Fundamental law : The fundamental (or primary law of a science also cannot explained. However, this limit is purely temporary. With the advance in a science, the fundamental law of a narrower system is explained by deducing it from a law (or laws) of a wider system. The law of gravitation is the fundamental law of Newtonian mechanics. But when Einstein established his theory of relativity, this law was deduced from it, and thereby it was explained.

3. Individual characteristics of a fact : We have seen that the scientific explanation of an individual fact (or event) consists in stating the initial conditions and the laws from which the fact could be deduced. Now it is not possible to find out all the circumstances and properties of an individual fact. Therefore, its complete explanation will never be possible. Moreover, what is really explained is the common features of a fact, and not ice peculiarities. The individual charactetistics of a fact, say the colour of this particular stone, cannot be explained.

4. Basic qualities of experience and matter : If we look to our mental life, we shall find that basic qualities of our experience, eg. our sensations and feelings, cannot be explained. And if we turn our attention to the material bodies, we cannot discover any explanation for such properties as shape and extension. These features of objects and our experiences are 'something given'. We proceed from these; we cannot account for them. However, no explanation is required in their cases.

SUMMARY

The need for explanation, whether in everyday life or in science, is felt when a puzzling situation arises. The fact to be explained (called explicandum) is inferred from the reasons offered its explanation (called explicans).

Scientific explanation does not merely account it for the problematic facts. It also gives insight into the nature of phenomena. It does this by introducing connections between them by means of laws. Scientific explanation of an individual fact or event) consists in the statement of additional data and a law (or laws) from which the fact to be explained could be deduced. In the explanation of a law, the explicans contains at least one more general law than the explicandum. Science demands that the explicans be verifiable and that it have independence evidence in its support.

There are significant differences between scientific and common sense explanations The plain man demands explanations only for individual occurrences, and that too when they are unfamiliar. Science aims at universal explanation. Scientific explanation have the support of evidence; and the scientist's attitude is open-minded. The plain man's explanations may refer to supernatural agencies; and he is dogmatic. Lastly, any similarity is a basis for the common man's explanations.

Types of explanation : The explicandum of a deductive model explanation is a logical consequence of the explicans. In a probabilistic explanation it is not so. Here the explicans consists of a statistical law. In a functional explanation, the function of the explicandum is indicated, while in a genetic one its origin is traced

Mill conceived of scientific explanation on the deductive model. He stated three modes of explanation. These sub-kinds of deductive model explanation are analysis, concatenation, and subsumption.

Limits : Those features of our experience which have no similarities with other features, and facts and laws for which similarities cannot be traced, fall outside the scope of explanation.

TEST QUESTIONS

1. What is scientific explanation ? Explain its characteristics.
2. How does science explain individual events and laws ?
3. Distinguish between scientific and popular (common sense) explanation.
4. Explain the different types of explanation.
5. Bring out the limits of explanation.
6. Distinguish between deductive model explanations and probabilistic explanations.
7. Give technical terms used in Logic for the following groups of words :
    1. The fact or law which is to be explained.
    2. The reasons offered as explanation.
    3. The kind of explanation in which the explicandum is deduced from the explicans.
    4. The explanation in which the explicans contains at least one statistical law.
    5. The explanation in which the explicans states the purpose that the explicadum serves.
    6. Tho explanation in which a phenomenon is explained by finding out its origin.
    7. Discovering the steps of causation between a cause and its remote effect.
8. State whether tho following statements are true or false :
    1. The reasons advanced as explanation are called explicandum.
    2. A hypothesis provides explanation for the facts within its scope.
    3. Scientific explanation has nothing to do with familiarity.
    4. A scientific explanation must be verifiable.
    5. In a deductive model explanation the explicans consists of at least one statistical generalization.
    6. In a functional explanation the explicandum is a logical consequence of the explicans.
    7. Concatenation is a form of explanation.
    8. In subsumption, we trace steps of causation between a cause and its remote effect.
    9. The axioms of a science cannot be explained.

CHAPTER – 23

JUSTIFICATION OF INDUCTION

DO YOU KNOW THAT.....

* *If nature were not orderly, miracles would be possible?*
* *Induction cannot be justified?*
* *We need not believe that the nature is uniform?*
* *Science must assume that the system of nature is relatively simple?*

1. PROBLEM OF JUSTIFICATION

In everyday life, as well as in science, we take for granted that the past is a reliable guide to the future, the observed to the unobserved, Every one of our actions is an expression of this belief. If we take a glass of water, we know that it will quench our thirst; because it did so in the past. When we get into a train, we know that it can be made to stop. The laws of mechanics are our guarantee. But the scientific laws themselves are an expression of the belief that what is true of the known cases will be true of the unknown ones.

Let us examine the situation in science. On the basis of the observational data, scientists establish laws. But observations can never be complete. Yet scientists have confidence in laws. The question is: Why do scientists have such trust in the laws? The only answer can be that they trust the reasoning involved in establishing them. Since laws are established by induction, this means that the scientist regards inductive inferences as reliable.

Philosophers have done a great deal of thinking to find out whether the scientists' confidence in induction is justified. A number of solutions have been proposed. One group of solutions justifies induction by making assertions about the constitution of the universe. The character of the universe, these thinkers hold, is such that laws can he discovered. The solutions of Mill and J.M.Keynes belong to this category. Mill advanced the principle of Uniformity of Nature and the law of Universal Causation in justification. J.M.Keynes proposed the principles of atomic uniformity and independent variety. The other group of solutions relies upon the theory of probability. Still another group talks of "inductive policies" adopted by scientists. The scope of our discussion is limited to Mill's solution. We shall see what Mill has to say, and then examine whether he succeeds in his attempt to justify induction.

2. MILL'S CLAIM

Mill wanted to base induction on a principle which will guarantee the truth of its conclusions. He had realized that the only possible way this could be done was by assimilating induction to deduction. Can induction be supplied with a principle which may form the ultimate premise of every inductive argument, and thus guarantee its truth? Mill thought that it could be done. Mill holds that uniformity of nature is such a principle.

According to Mill, induction involves an assumption regarding the course of nature. This assumption is expressed by saying that nature is uniform, that it is governed by laws. Without belief in the principle of uniformity of nature, the scientist will have no guarantee that, what is true in the observed cases, will turn out to be so in the unobserved ones.

3. THE PRINCIPLE OF UNIFORMITY OF NATURE

Not only Mill, but other philosophers too, had propounded the principle of uniformity of nature.

According to Mill, uniformity of nature is the principle that there are parallel cases in nature. That is to say, what happens once will, under a sufficient degree of similarity of circumstances, happen again. And not only again, it will recur as long as the circumstances repeat themselves. The universe is so constituted that, what is true in any one case, is true in cases of a certain description. Thus, we see that *the principle of uniformity of nature says that regularities found in any region will hold good in all regions and at all times.*

The principle of uniformity of nature should not be taken to mean denial of changes in the course of nature. We observe variety and change in nature. The succession of rain and fine weather is not the same every year. Nor are our dreams the same every night. In fact, there is evidence of disorder and chance. If there were no variety in nature, that would be impossible. Mill had realized this. He says, *"The course of nature, in truth, is not only uniform, it is also infinitely various."*

4. KINDS OF UNIFORMITIES

The uniformity of the course of nature, Mill points out, is a complex fact. Nature is not merely uniform; it consists of all the separate uniformities which exist in respect of the different phenomena. These uniformities, he says, can be classified into two types; namely, (i) uniformities of co-existence and (ii) uniformities of succession.

A uniformity of co-existence is a regularity that certain phenomena are constantly conjoined. It refers to the familiar experience that certain properties co-exist. Snow is white, fire burns, water is fluid, are such uniformities.

Not only phenomena co-exist, they also stand in the relation of succession to one another. Every phenomenon is related, in uniform manner, to some phenomena that preceded it and to some that will follow it. These regularities he calls the uniformities of succession. *Thus, a uniformity of succession expresses the fact that one event always follows another event.* Uniformities such as moisture rusts iron, rubber melts when heated, and water quenches thirst, belong to this class.

To Mill, uniformities of succession are of special importance. For he says, knowledge of these uniformities is necessary for inferences to the future events. The most universal of these uniformities is the causal law. The causal law, he asserts, expresses the nature of all uniformities of succession.

5. LAW OF UNIVERSAL CAUSATION

Mill is faced with a difficulty. He realizes that the principle of uniformity of nature is not a sufficient justification of induction. As we stated above, the principle merely asserts that, whatever is true in one case, is true in all cases of *a certain description*. But, as Mill himself says, the difficulty is how to find out what description is relevant. By considering the nature of the difficulty, Mill comes to the conclusion that induction must be the search for causes. But the search for causes can be conducted only if there are causal connections in nature. This leads Mill to the principle of universal causation. He says that the law of causation is "the main pillar of inductive sciences".

The law of universal causation is the truth that every fact which has beginning has a cause. Mill holds that all instances of succession are examples of the law of causation. The universality of the law of causation consists in that every succession is connected in this manner with some particular antecedent, or set of antecedents. That means, everything in the universe has some definite set of conditions; and it would not accur in the absence of these conditions.

Mill arranges laws of nature in a hierarchy. He says that they form a deductive chain. At the top of the chain is the "Law of Causality", and beyond this, the principle of uniformity of nature. So, for him, the law of causation is next in its scope to the law of uniformity of nature.

Mill required the principle of universal causation to justify the work of the scientist. But today science does not establish merely causal laws. Since the scientist's activity is not restricted to a search for causes, the need for the law of universal causation does not arise. Therefore, we may reject the law of causation as a principle required for justifying induction.

6. GROUNDS FOR BELIEF IN UNIFORMITY OF NATURE

There are two possible ways of arriving at the principle of uniformity of nature. One of these is experience; the other is reason. Mill takes the first position.

Mill's theory : Mill asserts that the principle of uniformity of nature is the fundamental principle of induction. Yet it itself is arrived at by inference from experience. It is an induction from particular uniformities observed in experience. He holds that it is not the first induction; in fact, it is one among the last. The more obvious laws of nature were understood as general truths before this principle was ever heard of. He says that it would be impossible to affirm that the nature, as a whole, is uniform if particular uniformities had been observed.

According to Mill, science requires to believe that the course of nature is uniform. But scientific inquiry arose after the common man had already observed many uniformities in his experience. He puts it thus : "No science was needed to teach that food nourishes, that water drowns, or quenches thirst, that sun gives light and heat, that bodies fall to be ground. The first scientific inquirers assumed these and the like as known truths, and set out from them to discover others which were unknown." From this, Mill comes to the conclusion that the principle of uniformity is a result of generalization from the experience of particular uniformities.

Mill's proof of the principle of uniformity of nature is said to involve a paradox. The paradox is that uniformity of nature, which is the ground of induction, is itself a result of induction. This clearly shows that the argument is circular. It commits the fallacy of *petitio principii*. He holds that the inductive inferences are trustworthy, because the nature is uniform. Yet he says that uniformity of nature itself is arrived at by an inductive inference. Now no principle can be advanced as a proof for itself.

But this is what Mill does. Therefore, we may conclude that Mill fails to prove the principle of uniformity.

Not only this, the induction involved in the proof of uniformity is *induction per simple enumeration*. As Mill himself admits, its conclusions are unreliable. Yet he proposes this method in proof of his most universal principle. In fact, he says that no other method is available.

Mill is fully aware of both these features of his proof. He knows that the reasoning by which he proves the principle of uniformity is circular, and that the method of proof is induction per simple enumeration. But he pleads that the only way to arrive at this principle is through simple enumeration. Since science presupposes that the nature is uniform, scientific induction cannot be used to prove this principle. So he has to depend upon the method of simple enumeration. But he goes to great lengths to argue that simple enumeration is capable of proving this principle.

Mill maintains that induction per simple enumeration is not always untrustworthy. So far as the particular generalizations are concerned, it cannot be relied upon. But its reliability increases in direct proportion to the generality of the subject matter. Since the principle of uniformity of nature is the most general truth, simple enumeration can be used to prove it. His argument is that the principle of uniformity of nature is independent of the limitations of time and place. So every experience of mankind would either confirm or refute it. Since the past experience of mankind shows no exceptions to uniformity of nature, he concludes that the nature must be uniform.

Mill's argument is rather curious. It is strange that a particular generalization cannot be established by simple enumeration; and yet the most general principle can. The reverse should have been the case.

To sum up, the principle of uniformity of nature cannot be proved inductively. It cannot even be brought in by the back door by saying that it is a postulate of induction. (A postulate is a principle which cannot be proved, but which is required in order to justify other knowledge.) As Braithwaite points out, it would be wrong to call an empirical principle a postulate.[1]

7. DOES SCIENCE NEED UNIFORMITY?

Mill attempted to prove too much. Science does not require belief in the uniformity of nature, as Mill had conceived it. If scientists were to believe that the nature is uniform, and that the laws of nature can be established with certainty, there would be no need for further scientific investigation. Moreover, the changes in scientific laws present to us the possibility that the nature may not be uniform. Of course, science uses laws for predicting the unknown events and this would not be possible without making some assumptions about nature. But the assumption need not be that the nature is uniform. Kemeny proposes an alternative. He says that a scientist can carry on his work if he assumes that the changes we observe in our small piece of nature are representative of the whole.[2] If the changes in scientific laws correspond to the changes in the course of nature, the work of science can still be carried on. On this assumption also, the laws can be used for predicting the unobserved.

It is now clear that whether a scientist believes that the nature is uniform or not, he must make some assumptions about nature. Two such assumptions may be pointed out. Firstly, the scientist must assume that nature is a system. Secondly, the system of nature is relatively simple. So by knowing a part of it, reasonable predictions about

[1] *Scientific Explanation*, p. 259.

[2] *A Philosopher Looks at Science*, pp. 59-64.

the whole of the system would be possible. The second assumption is an expression of the limitations of human understanding. If the nature were complex, human beings would be unable to establish laws.

Scientists have no means of knowing whether these assumptions are correct or not. They have to take nature on faith. That is why these assumptions are described as *scientist's articles of faith.*

8. CAN INDUCTION BE JUSTIFIED?

Logicians and scientists of today find fault with Mill for having attempted to turn induction into deduction. But every attempt at justifying induction suffers from the same fault. Logicians are now aware that science believes in probability. Still they justify induction by using deduction as a model. Therefore, Mill is in good company when he tries to assimilate induction to deduction. If we examine Keynes' principles of atomic uniformity and limited variety, we shall find similar faults. The theories of probability are no better. They too judge induction by the standards of deduction. Even the so-called "inductive policies" fail to justify induction. This leads us to the conclusion that induction cannot be justified.

We may, like Strawson, go even further and say that the very demand for the justification of induction is unreasonable.[3] Strawson points out that the problem of justification arises, because deduction is considered to be the model for all reasoning. Once it is realized that the standards of deduction cannot be applied to induction, no attempt will be made to seek its justification. Inductive argument has its own standards of correctness. So, it does not need any further justification.

SUMMARY

Scientific laws are established by induction. In induction we infer the unknown from the known. This gives rise to the problem whether there are any grounds for trusting inductive reasoning.

Many attempts have been made to justify induction. We are merely concerned with Mill's attempt. Mill wanted to assimilate induction to deduction. He wanted to justify induction, by proposing a principle which may form the ultimate basis for all inductive arguments. This principle is the law of uniformity of nature.

The law of uniformity of nature is the principle that there are parallel cases in nature. Whatever is true in any case is true in all cases of a certain description. Mill makes it clear that the belief in uniformity of nature does not involve the denial of changes in the course of nature.

There are two kinds of uniformities. These are uniformities of co-existence and those of succession.

Mill finds that induction cannot be justified merely on the basis of the belief that nature is uniform. For that, the **law of universal causation** is also required. This principle means that every event has a cause. However, we cannot agree with Mill that science needs the law of causation. We know that scientific laws are of many different types.

Mill's theory appeals to experience in proof of the principle of uniformity of nature. He says that uniformity of nature is an induction from the observation of particular uniformities. This argument is a failure. There is circularity in Mill's reasoning.

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[3] *Introduction to Logical Theory*, pp. 248-263.

Mill attempted to prove too much. Science need not believe in uniformity. What science needs to assume is that nature is a system, and that this system is simple. In fact, no theory has so far been successful in justifying induction. Really, the demand for justification is unreasonable.

TEST QUESTIONS

1. Explain the principle of uniformity of nature. Does it mean the denial of variety?
2. Discuss the view that uniformity of nature is a generalization from experience.
3. Can uniformity of nature be proved?
4. Point out the importance of the law of uniformity of nature for induction.
5. Explain the law of universal causation. How is it related to the principle of uniformity of nature?