

DO YOU KNOW THAT

- There is a difference between perception and observation.
- Observation needs training.
- Science involves experiments that can be repeated by others.

Introduction

The aim of the scientific investigation is to understand the nature of the universe. When a scientist observes nature, certain facts are clear to him; whereas certain facts are not. They explain these problems by discovering different laws and establishing theories. Laws in science are established by induction, which proceed from observed to unobserved, known to unknown, where the evidence is about some cases but the conclusion is about all cases, such **a leap from ‘some to all’ is called as an Inductive Leap** which makes the conclusion of an argument probable. Hence there is a need to justify Inductive Leap.

Inductive leap is justified on two grounds, namely, formal grounds of induction and material ground of induction

(a) Formal Grounds of induction

Principle of uniformity of nature and Principle of Causation are called ‘Formal grounds of Induction’.

(i) The principle of uniformity of nature :

It states that there is an order in nature. Whatever happens once will always happen again under similar circumstances. So on the basis of this principle; it is justified in arguing that what is true of some case of a kind is true of all the cases of that kind.

(ii) The principle of causation

It states that some events in nature are causally connected and causal relation is invariable i.e. the same cause always leads to the same effect.

Thus on the basis of these two principles, the Inductive Leap is justified.

(b) Material Grounds of induction :

The aim of induction in science is to arrive at laws or theories on the basis of particular facts. Science aims at establishing the material or empirical truth of laws. For this, formal ground is not enough. Material truth of empirical laws is established by the methods of observation and experiment. Therefore these methods are called material grounds of induction. They provide the initial data to scientist for enquiry.

6.1 Observation

The word observation is derived from two Greek words, ‘Ob’ means ‘before’ and ‘server’ means ‘To keep’. So observation literally means ‘keeping something before the mind’.

One gets knowledge of the world around us through the five sense organs. Whenever one looks around one notices many objects and their qualities. This is perception. **Perception is to become aware of objects and events that happen to come to our notice.** There is no definite purpose in perception and it is not deliberately chosen. So perception differs from observation due to these characteristics.

For example : when one passes by a corridor besides a chemistry laboratory, one becomes aware of some smells; one listens and hears sounds of various kinds. But this is not observation. It is mere perception.

Observation is defined as selective perception of facts with a certain purpose.

So every observations is perception but every perception is not observation unlike perception observation is purposive and selective.

6.2 Difference between observation and Perception :

Observation	Perception
(1) It has a definite purpose.	(1) It is without any definite purpose.
(2) It involves selection of facts.	(2) There is no selection of facts.
(3) Everything that is observed is Perceived.	(3) Everything that is perceived is not observed

6.3 Characteristics of observation :

Observation is done by common man as well as scientist but the scientific observation is systematic. It is the foundation of scientific investigation.

Following are the characteristics of observation.

(1) Observation is purposive :

When the scientist proceeds to observe nature he does so with a definite purpose. The main purpose is to collect data or facts, on the basis of which one can either prove or disprove a theory.

Thus it is purposive. e.g. Discovery of Neptune.

(2) Observation is selection of significant facts :

Observation is selective. Selection of facts is determined by the observer's purpose. From the countless facts in the world, scientists select to observe only those facts which are relevant to the problem under study. He observes only those significant facts that would help him to either establish or reject the suggested hypothesis.

(3) Observation is selection of a significant aspect of fact :

Facts are vast and complex. There are many aspects to facts. It is neither necessary nor

possible to observe all the aspects of facts. The observer therefore focuses attention only on the significant aspects of a fact, which are relevant to the hypothesis under consideration.

For example : When a doctor visits his patient he observes his blood pressure, temperature, heartbeats etc., as they are significant aspects for patient's health. Whereas a friend or a relative of the patient equally concerned about him may not observe these aspects. So though the fact (the patient) observed is the same, the aspect of facts considered significant can differ with each observer.

(4) The observer has to neglect the illusory aspects of a fact :

Our sense organs are means of observing facts. Sometimes our senses can deceive us and we may experience illusions.

For example : A stick looks bent when a part of it is immersed in water. This experience is an illusory aspect of fact and one should overlook it as a matter of optical illusion which is due to the refraction of sun rays. This needs to be neglected during observation.



(5) Use of instruments in observation :

Observation depends on one's sense organs. But the capacity of the sense organs is limited, so various instruments are used in science to extend the limits of sense organs.

For example : Telescope, Microscope, Sonography, X-ray etc.



6.4 Conditions of good observation :

Good observation is important in scientific investigation. Erroneous or bad observation can lead to wrong conclusion in science. It is therefore necessary to know the conditions of good observation which are as follows:

(1) Mental set and intellectual condition :

The observer should have inquisitiveness and craving for knowledge. Scientist should be mentally alert, attentive, active, free from prejudices, scientist must possess intellectual abilities to understand, explore and explain natural phenomena. To avoid bias and prejudices, the observer should observe all the facts and record them, whether they appear to be important or not. Test of 'public verifiability' and 'general consensibility' are another way of avoiding bias and partial observation. This means the observational record of one scientist is checked and verified by other scientists or one can make some more observations.

The scientist should also have openness and patience to wait for favourable conditions to occur under which observation is possible.

(2) Limitation of sense organs and instruments :

If the sense organs are defective, one cannot observe correctly. The conclusions derived on the basis of such observation will not be reliable. So the sense organs should be healthy.

Sense organs have limited range of perception. **For example :** One cannot perceive an object very clearly, if it is too far such as planets or too minute particle like bacteria in water. In such cases use of powerful scientific instruments becomes necessary and valuable.

Even the powerful instruments used in science have certain limitations. Therefore while doing observation scientist should consider the limitations of both sense organs as well as instruments.

(3) External conditions :

The scientist should take into account all possible external conditions under which observation is done. The external conditions or the environment can affect the observation of the fact.

For example : During winter season, due to excess fog, one may not be able to see the road



The observation is accurate, if the observer is aware of the external conditions and is able to assess their influence on the observation.

(4) Training in the techniques of observation :

Accurate or good observation is a necessary condition of scientific inquiry. For scientific observation, training in the techniques of observation is necessary.

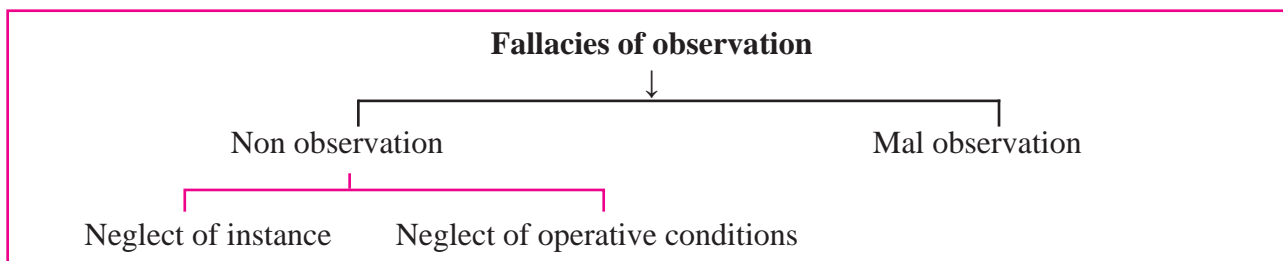
Training helps scientists in following ways :

- (a) It helps the observer to know what to observe, when to observe, where to observe and how to observe.

- (b) It also helps them in deciding, when, how and which scientific instruments are to be used.

6.5 Fallacies of observation :

Correct and precise observation is the key to success in scientific investigation. If conditions of good observation are not satisfied it can result in erroneous or fallacious observation.



There are two types of fallacies that occur in observation.

(A) Fallacies of Non- observation :

Fallacy of non-observation arises when an observer overlooks or ignores the relevant facts or circumstances, which should have been observed.

There are two ways in which this fallacy may occur.

(1) Fallacy of Non observation due to the neglect of instances :

Neglect of instances is a fallacy in which either knowingly or unknowingly the observer, overlooks the relevant instances for investigation. Neglect of instances can take place due to various reasons :

- (i) Due to unfavorable physical conditions.
For example : Non-observation of Sun during solar eclipse.



- (ii) Due to narrow range of experience.
For example : Human beings cannot hear sounds below the range of about 20 Hertz, which the bats can hear.
- (iii) Due to biased attitude.

For example : It is human tendency to consider and give importance to those facts which are in favour and ignore those which are unfavourable.

(2) Fallacy of Non observation due to neglect of operative Conditions :

This fallacy consists in neglecting essential and relevant circumstances and conditions responsible for the occurrence of a phenomenon. Instead of the real cause some other conditions are considered as the cause of a particular effect.

For example : Digby's sympathetic powder :-

In the 17th Century, Digby's sympathetic powder attracted great attention. When a person was wounded, the instructions were, 'to keep the wound clean and to rub the powder to a knife or a sword'. It was found that the wound was cured. This made people believe that, 'applying the powder to a knife or sword', was the cause

of curing the wounds. But the real cause was ‘keeping the wound clean’, which was neglected.

(B) Fallacy of Mal-Observation :

Fallacy of Mal-observation consists in interpreting sense impressions wrongly. In such cases of observation, an object is observed as something else. This is the fallacy of misinterpretation. In short **it is the fallacy of mistaking one thing for another thing.**

For example : Mistaking a rope as a snake.

Mal-observation arises due to following reasons:

(a) Unfavorable physical conditions :

For example :

- (1) Perception of a mirage in a desert, where one interprets sand as water.



(b) Observer's lack of experience :

If the observer is not experienced, he may wrongly interpret the sense impression.

For example :

- (1) A baby plays with one's own image in the mirror, thinking that there is another baby, and a baby cannot distinguish between person and the image due to lack of experience.



(c) The peculiar mental state of the observer:

A peculiar mental state of the observer may result in wrong interpretation of the sense impression.

For example : After watching a horror movie, the person waking up in the middle of the night may misinterpret white shirt hanging in the room as a ghost due to fear.

6.6 Experiment :

Experiment is also a material ground of Induction. **Experiment is defined as ‘observation under conditions controlled by the investigator’.**

In observation, the facts are observed under natural conditions. The facts can be observed just once because we have no control over natural conditions. Hence the investigator prefers to observe those facts, which are under his control.

Observation gives us information, but it may not be always adequate or sufficient to study the phenomenon thoroughly, so scientists perform experiments.

Experiment is keen, careful, systematic observation made under conditions artificially created and controlled by the investigator.

6.7 Nature of Experiment :

Experiment is conducted with a definite purpose. The purpose of any experiment is to find out the effect of one factor on another factor.

A variable is a factor that can change.

There are three kinds of variables :

- (i) Independent variable.
- (ii) Dependent variable.
- (iii) Relevant / Controlled variable.

(i) Independent variable :

Independent variable is that factor whose effect the experimenter wishes to study.

Hence by keeping the other conditions or factors constant, only independent variable is varied. (increased decreased or withdrawn) and then its effect is studied.

For example : If one is trying to determine which type of laundry soap removes the most dirt, one would test a variety of different kinds of soaps. The type of soap would be the Independent variable and one would change it each time when one conducts an experiment.

(ii) Dependent variable :

The effect of independent variable is called dependent variable. Thus it is a variable which gets affected by the independent variable.

For example : when one tests each type of laundry soap, one will measure, how much dirt is left. The amount of dirt remaining each time when one does the experiment, would be the dependent variables.

(iii) Relevant or Controlled variable :

The experimenter keeps the relevant or controlled variable constant. **Relevant or controlled variable is one which has a capacity to influence the dependent variable.** It can affect the outcome of the experiment.

For example : Apart from the type of soap, there are other relevant variables which can influence the removal of dirt from the clothes. Unless these variables are controlled, the result will not be accurate. Hence the experimenter has to keep all the relevant or controlled variables constant such as the amount of water, water temperature, the time spent in washing, the amount of soap, the amount of dirt on clothes etc., and see the effect of independent variable (Type of soap) on dependent variable. (Removing of maximum dirt from the clothes)

6.8 Characteristics of Experiment :

(1) Experiment is a deliberately undertaken :

Experiment is deliberately conducted either to collect data or to explore a relationship, or to test a hypothesis.

(2) Experiment involves setting up an artificial situation :

If the scientist wants to observe different aspects of the phenomenon carefully, he cannot do so in the natural setting because the phenomenon is surrounded by many circumstances which are complex and are accompanied by many conditions some of which are irrelevant and obstructing.

So the experimenter creates an artificial situation where he can find out the effect of one factor at a time by keeping other relevant factors constant.

For example : A coin is observed to fall faster than feather in air. But to prove that the weight of object has no relation with the acceleration with which the object falls to the ground, the scientist had to set up an artificial condition. i.e. he eliminated 'air' which is an irrelevant and obstructing condition and a vacuum was created, then the coin and feather was found to fall with equal acceleration in vacuum.

(3) Experiment involves systematic variation of conditions :

When scientists conduct an experiment they wish to find out the effect of one factor at a time. Hence there is a need to control all other relevant factors except the factor whose effect one wants to study. This factor is then increased or decreased to determine its exact influence.

(4) Experiment can be repeated :

The experimenter can repeat the experiment, because the experimenter has control over the conditions this is an important

characteristic of experiment. The experiment can be repeated by any one, any place & at any time to confirm the result of the experiment.

Distinction between Observation and Experiment

Observation		Experiment	
(1)	Observation is defined as selective perception of fact with a definite purpose.	(1)	Experiment is defined as observation under conditions controlled by the investigator.
(2)	Observation is natural as events are observed only in natural setting as they occur in nature.	(2)	Experiment is artificial as it is done in an artificial settings where the conditions are pre-determine, pre-arranged and controlled by the investigator.
(3)	In observation, the observer is the slave of nature because he can observe events only when they occur in nature.	(3)	In experiment, experimenter is the master of his experiment as he can bring changes according to his will and convenience.
(4)	In observation, the observer goes from both cause to effect and also from effect to cause.	(4)	In experiment the investigator goes only from cause to effect.
(5)	Scope of observation is wider than experiment because it can be done in all fields. Secondly observation is needed before conducting the experiment, during the experiment and also after the experiment to confirm the result of experiment.	(5)	Scope of experiment is narrower than observation because sometimes it is not possible to conduct experiment.
(6)	Observation cannot be repeated as the same phenomenon does not occur again in the nature.	(6)	Experiment can be repeated to confirm the results. It can be conducted any time, any place as per the convenience of the experimenter.
(7)	In observation scientist's personal bias, belief's etc., can affect the observation therefore observation is said to be subjective.	(7)	In experiment there is a little scope for experimenter's biasness, beliefs etc., it is said to be objective in nature.

Summary

Scientist uses inductive arguments to establish generalizations (laws) as well as theories. Inductive arguments involve inductive leap which is justified by the principle of uniformity of nature and the principle of causation which are called 'formal grounds of induction'.

Science aims at establishing the material truth of a generalization or law which is assured by material grounds. An observation and experiment are means of collecting facts in science, they are called 'material grounds of Induction'.

Observation is different from the perception of object. Perception means becoming aware of objects which happens to come to our notice. Perception is not selective and it is not grounded by any purpose. **Observation** on the other hand is, '**Selective perception of facts with a certain purpose**'.

Characteristics of observation :

- (1) Observation is purposive.
- (2) Observation is selection of significant facts.
- (3) Observation is selection of a significant aspects of fact.
- (4) Observation is to neglect the illusory aspects of a fact.
- (5) Use of instruments in observation.

Conditions of good observation :

- (1) Mental set and Intellectual condition.
- (2) Limitation of sense organs and instruments.
- (3) External conditions.
- (4) Training in the techniques of observation.

Fallacies of observation

They are of 2 types :

- (1) Fallacy of Non-observation –
 - (a) Neglect of instance
 - (b) Neglect of operative conditions
- (2) Fallacy of Mal -Observation

Experiment :

Experiment is keen, careful, systematic observation made under conditions artificially created and controlled by the investigator.

Characteristics of Experiment :

- (1) Experiment is deliberately undertaken.
- (2) Experiment involves setting up of an artificial situation.
- (3) Experiment involves systematic variation of conditions.

Exercises

Q. 1. Fill in the blanks with suitable words from those given in the brackets :

- (1) Observation and experiment are the grounds of induction.
(*Formal, Material*)
- (2) In, we perceive the things with a definite purpose.
(*Observation, perception*)
- (3) Observation is to facts.
(*Faithful, Unfaithful*)
- (4) The fallacy of consists of misinterpretation of facts.
(*Mal observation, Non- Observation*)
- (5) The method of is said to be used when facts are studied in natural conditions.
(*Observation, Experiment*)
- (6) means becoming aware of objects which happens to come our notice.
(*Observation, Perception*)
- (7) Observation should be
(*Bias, Impartial*)
- (8) Neglect of operative conditions gives rise to the fallacy of
(*Non-observation, Mal-observation*)
- (9) Illusions give rise to the fallacy of
(*Non-observation, Mal-Observation*)
- (10) Experiment involves setting up of condition.
(*Natural, artificial*)
- (11) In, phenomenon is deliberately produced.
(*Experiment, Observation*)
- (12) Observation is done under settings.
(*Natural, Artificial*)
- (13) In non-observation, the operative conditions are neglected due to
(*Fear, Bias*)
- (14) In, the object is present before the observer, yet he observes it wrongly.
(*Illusion, Neglect of relevant instances*)
- (15) means observation with alteration of conditions.
(*Perception, Experiment*)
- (16) can be repeated.
(*Observation, Experiment*)
- (17) In, the observer is the slave of nature.
(*Observation, Experiment*)
- (18) In, we go from both, ' Cause to effect ' and 'Effect to cause'.
(*Observation, Experiment*)
- (19) is a factor whose effect the experimenter wishes to determine.
(*Dependent variable, Independent variable*)

- (20) 'Mirage in a desert' is an example of
(*Mal-observation, Non-observation*)
- (21) gives more precise and accurate results.
(*Experiment, Observation*)
- (22) In experiment, the conditions are
(*Controlled, Invariable*)
- (23) is purposive.
(*Perception, Observation*)
- (24) involves selection of significant facts.
(*Perception, Observation*)
- (25) When we neglect relevant facts, we commit the fallacy of
(*Non-observation, Mal-Observation*)
- (26) is justified by formal and material grounds of Induction.
(*Deductive leap, Inductive leap*)
- (27) The principle of causation and the principle of uniformity of nature are grounds of induction.
(*Formal, Material*)

Q. 2. State whether the following statements are true or false.

- (1) Observation is not purposive.
- (2) Perception is purposive.
- (3) The fallacy of non-observation consists in neglecting or overlooking relevant facts.
- (4) The fallacy of non-observation of instances is committed when the relevant circumstances are neglected.
- (5) When we neglect the essential conditions responsible for particular phenomenon we commit the fallacy of non-observation of circumstances.
- (6) The fallacy of mal-observation consists in neglecting the relevant instances.

- (7) When the phenomenon is misinterpreted, it is called the fallacy of mal-observation.
- (8) There is no observation in experiment.
- (9) In observation, the investigator has control over the phenomenon.
- (10) In experiment, the experiments has control over the phenomenon.
- (11) In experiment, variation of factors is possible.
- (12) In observation, the investigator can isolate the factors.
- (13) There are certain areas in which the experiments are morally undesirable.
- (14) Observation is artificial while experiment is natural.
- (15) The good observer should be impartial and unbiased.
- (16) The use of scientific instruments improve the quality of observation.
- (17) Repetition is an advantage of experiment.
- (18) Observation always comes prior to experiment.
- (19) In experiment, we can proceed from effect to cause.
- (20) Causation is a formal ground of induction.
- (21) Experiment is a formal ground of induction.

Q. 3. Match the columns :

- | (A) | (B) |
|--------------------------------|-------------------------------------|
| (1) Mal-observation | (a) Misinterpretation of sense data |
| (2) Non observation | (b) Neglecting relevant facts |
| (3) Observation & Experiment | (c) Formal Grounds of induction |
| (4) The principle of causation | (d) Material Grounds of induction |

Q. 4. Give logical terms for the following.

- (1) Perception with a definite purpose.
- (2) The fallacy of observation in which one neglects or ignores relevant facts.
- (3) The fallacy of observation in which one misinterprets sense impressions.
- (4) Observation under conditions controlled by the investigator.

Q. 5. Answer in brief.

- (1) Differentiate between Observation and Perception.
- (2) What are the conditions of good observation?

- (3) Explain the fallacy of Non-observation.
- (4) Explain the fallacy of Mal-observation.
- (5) What are the characteristics of experiment?

Q. 6. Answer the following.

- (1) What is observation? Explain characteristics of observation.
- (2) What is experiment? Explain nature of experiment.
- (4) Explain the differences between observation and experiment.

