UNIT 1 INTRODUCTION TO CONTEMPORARY PHILOSOPHY OF SCIENCE

Contents

1.0 OBJECTIVES

This unit introduces you to the significance of philosophy of science and its relation to science. The manner in which science differs from philosophy of science is another issue with which you must become familiar. As science progresses philosophy of science also progresses. Therefore an understanding of contemporary philosophy of science helps you to assess and evaluate contemporary science. While doing so emphasis is laid on physics since physics and cosmology are interrelated.

When you are through this unit, you will be in a position to discover the hidden elements of science and critically evaluate various claims made by science

1.1 INTRODUCTION

It is difficult to locate exactly the origin of philosophy of science and to decide whether in antiquity or in modern era there was anything like philosophy of science either in the writings of philosophers or in the writings of scientists. This observation is essential because none of those philosophers who grappled with epistemological and metaphysical issues could afford to neglect the external world. Though some problems were common to philosophers and scientists, not all are philosophers of science. In the history of western philosophy Hume was the first philosopher to criticize certain aspects of science. He was critical of two aspects; one, the method purported to be the method of science and second, the nature of scientific law. Therefore in one sense of the term philosophy of science has its beginning in the philosophy of Hume and it began with attack on infallibility of scientific law and method purported to be the method of science. These criticisms, subsequently, exposed other aspects of science to closer investigation. The role of explanation is one such aspect. Therefore it is essential to begin our enquiry with what science is and what science is not. Before we do so we should get ourselves to the sense in which we use the term philosophy of science. Philosophy of science is the critique of science and whatever that is connected with science. Common sense suggests that science precedes philosophy of science not in temporal sense but in logical sense. Therefore philosophy of science comes after science. For this reason it is apt to call philosophy of science simply metascience. What does metascience reveal? Knowledge of any science helps us to acquire world-view. This is what metascience is all about. If metascience is the critique of science, what aspect of science is evaluated? This will concern us presently.

Metascience is essentially concerned with the attitude of the philosopher towards science. This attitude is reflected in the evaluation of various aspects which constitute science. A critical evaluation of the structure of scientific investigation, questions concerning the very possibility of scientific knowledge or impossibility and distinct method or methods of science which distinguish science from nonscience, etc. constitute the core of metascience. Therefore a brief survey of these prominent issues follows which provides a glimpse of the direction in which contemporary philosophy of science is proceeding.

1.2 SCIENCE AND EXPLANATION

At the outset, let us distinguish science from *Science.* The former is any specialized branch of knowledge. Hence it can be regarded as the species whereas *Science* is the class name. We are concerned with science in this sense. One of the ways of characterizing science is to regard it as an organized common sense. So we can go a step further and say that whatever contradicts commonsense also contradicts science. But such a characterization takes us nowhere. In the first place, science, on many occasions contradicts common sense, for example, modern physics. But on that account we do not sacrifice science to embrace common sense. Secondly, we are not sure at all as to what common sense is. We do not, certainly, mean that common sense is the opinion of a normal human being. If so, a collection and organization, if it is possible, of the opinions of average men should constitute science. But it is not so. So it is not a very good beginning unless we further qualify our stand. In the second place organization is possible in different ways. So it is equally essential that we specify the kind of organization we want. Mere sky watching does not make anyone an astronomer.

It is said that science has its origin in curiosity. Curiosity is not satisfied by organization of facts alone, whatever may be the type of organization. Science is distinguished from common sense by its 'explanatory power'. Curiosity arises when we are struck by something unexpected and unfamiliar. Science has its origin in problems. Explanation is the explanation of problem. Science is an organized common sense in the sense that such an organization must be capable of explaining and solving the problem.

1.3 EXPLANATION IN SCIENCE

An understanding of scientific enterprise requires that we should first know how science proceeds with its task. A good beginning is made when we begin with the nature of scientific explanation. Since explanation is qualified by the word scientific, we can infer that there is explanation which is not scientific. So there is need to distinguish scientific explanation from unscientific explanation. This is an important task set out by philosophy of science.

If the goal of science is to provide a satisfactory explanation, then an unsatisfactory explanation can be regarded as unscientific. A satisfactory explanation always answers *why,* i.e. reveals conditions under which an event occurs are stated. Though explanation is of various kinds, it has a common structure. The problem which is in need of an explication is called 'explicandum' and the statements which we offer by way of explication are called 'explicans' The minimum requirement is that there should be at least two explicans. One of them is a singular statement which applies to the event that has occurred and is called the "initial condition" and the other is a universal or conditional proposition and it is called a law. In a satisfactory explanation, the explicandum is implied by the initial condition or conditions and the law taken together. Consider an example.

L – Whenever pressure is reduced, volume of the given gas increases.

I - In this case pressure is reduced.

C In this case volume of the given gas has increased.

In this case L represents the law (which is Boyle's law), I represents the initial condition, and C represents the conclusion or explicandum.

It should be noted that though a law is always a universal proposition, not all universal propositions are laws. We shall consider two kinds of universal proposition; restricted or numerical universal and unrestricted or strict universal propositions. Only the later is considered a law. An example illustrates the difference between the two.

P_1: All objects "now" present in "this room" are good conductors of electricity.

P_2: All metals are good conductors of electricity.

P_1 is a restricted universal because by using the words "now" and "this room" we are imposing spatial and temporal restrictions. Tomorrow a bad conductor of electricity may enter this room, or to-day only outside this room a bad conductor of electricity may be present.P_1 is numerical because it is possible to count the number of objects in this room, since we take it for granted that this room has finite dimensions and the objects in this room have minimum dimensions. Another point to be noted is that either the law or the initial conditions taken singularly will not imply the conclusion. The absence of initial condition does not help because from a conditional proposition alone it is not possible to deduce singular (unconditional) proposition. The absence of law does not help us in establishing the relation between I and c.

A close look at the example given above indicates that the explanation assumes the deductive model, i.e., c_1 necessarily follows from L and I taken together. Here the 'explicandum…. is not a necessary truth, and….neither are the explanatory premises' (i.e. explicans)'. But what is important is that though the propositions here are a posteriori, the relation between them is logically necessary. In such a case scientific explanation is "structurally necessary", though in content or material it is contingent.

This is important because often a distinction is drawn between deductive explanation and other modes of explanation. It is enough for our purpose to consider one such model, viz., probabilistic explanation. The distinction between deductive and probabilistic explanations consists in the difference between the laws employed in these two kinds. In contrast to the conditional proposition or universal law, the probabilistic explanation includes what is known as statistical law. A statistical explanation is of the following form:

L_2: The probability of x occurring under condition y is n. (symbolically L_2 can be p (x, y) =n).

i_2 : z is y.

C_2 z is y.

Since the value of n ranges between 0 and 1 without touching either extreme, the conclusion also remains probable. Before proceeding further we can consider an example.

L_2: The probability of an undeveloped country (y) coming under military rule (x) is n (it is not necessary to specify the value of n).

i_2: Nicaragua (z) is an undeveloped country (y).

C_2 Nicaragua (z) will probably come under military (x).

It is believed that in a probabilistic explanation the conclusion does not necessarily follow from the premises. This mistaken view has its roots in the confusion between universal and statistical laws. The very fact that all laws are synthetic indicates that logical necessity is not involved in any law. Naturally, all laws are rendered improbable, i.e., falsifiable. So a statistical law also turns out to be improbable because that is also capable of being falsified.

Thus it can be seen that the difference between universal and statistical laws is only apparent. There is no real qualitative difference between the two. So structurally there does not seem to be any difference between the two, and consequently, in a satisfactory explanation. Whether deductive or probabilistic, the premises should necessitate the conclusion. Thus we are left with only one method of explanation, i.e., deductive explanation which Popper calls Axiomatized deductive system.

In a satisfactory explanation the premises should satisfy certain conditions. Apart from the condition that the premises should necessitate the conclusion, they should be true statements. It is not necessary that we "should know" the truth of the propositions. But as Popper says they should have testable consequence, and this is possible only when they are 'dense'. They are dense only when they are rich in content. Such a qualification eliminates speculative and theological explanations which, according to Reichenbach, are based upon similarity and hence pseudo-explanations.

1.4 LAWS AND THEORIES

Now it is obvious that the aim of science is to provide a satisfactory explanation and that in a satisfactory explanation the explicans must have the greatest explanatory power in virtue of their density of content. The discussion will be incomplete, if a reference is not made to another problem. One of the controversial issues in metascience is whether laws and theories are different or not. While Nagel holds that this distinction is fundamental, Feyerabend and Putnam consider the distinction only apparent. The logical extension of this argument is the attempts by philosophers like Bridgman, Russell, Eddington, etc. to reduce all theories to laws.

There are two kinds of laws; 'experimental laws and theoretical laws'. It is desirable to start with what is least controversial. An experimental law is expressed in a single statement while a theoretical law consists of a group and hence a system of statements. Consequently, the scope of the former is limited whereas the latter has wider application. Often, it is possible to deduce an experimental law from a theory. Finally, it is said that theories refer to abstract concepts and experimental laws refer to concrete entities.

The last one, when further pressed, points to an important difference. An experimental law consists of only those terms associated with certain observational traits whereas a theoretical law may or may not consist of such terms.

Stating the characteristic in this way is important because most of the terms employed in physics are not about what are directly observable. For example, pressure of a gas is not observable in the sense in which colour of that gas, if it has any, is observable; but pressure is observable in the sense that it can be measured. It is for this reason that measurement is considered an important characteristic of science. Physics, as a matter of fact, is full of such notorious terms. It is sufficient to name two experiments which illustrate this point; photoelectric effect discovered by Hertz and Max Planck's experiment on black body radiation. Photoelectric effect deals with the emission of electrons which are not observable. Planck's experiment was concerned with providing a physical picture of an ideal black body which is not observable because it is nonexistent. In the case of photoelectric effect the emission of electrons was studied by measuring such obvious entities like current (here called photoelectric current) and intensity of light. In the case of Planck's experiment black body radiation was studied by making use of measurable entities like the amount of heat, the visible spectrum etc.

These examples suggest that in an experimental law every term should refer to observable or measurable traits. So an experimental law is directly testable. But what is the status of a theory? To say that a theory is beyond test is, to say the least, highly unscientific. It is said that though a theory is not directly testable, it is possible to test a theory by testing the laws which are deduced from a theory. So the initial requirement of a good theory is that though, in itself, the theory is incapable of being tested, it should "generate" laws which are directly testable.

A reference to photoelectric effect and Planck's experiment on black body radiation has indicated the complexity of modern physics. The complexity is further aggravated, when we consider thermodynamics which studies the relation between heat and mechanical energy as in the case of driving car. In 1824 Carnot advanced the concept of an ideal heat engine. It is called an ideal heat engine because of the properties it is supposed to possess like perfectly non-conducting sides, perfectly frictionless, non-conducting and air tight piston and perfectly conducting base of the cylinder. The purpose of enumerating these qualities is to show that in the world of concrete objects no object possesses such properties. Hence it is an ideal heat engine. In other words, Carnot produced a concept to which no object in the world corresponds. Hence the observation, whether direct or indirect, of such an engine is not possible at all. How, then, can we study ideal heat engine? The second law of thermodynamics, which states that heat always flows from a body at higher temperature to a body at lower temperature, gave rise to another concept, i.e., "entropy." Clausius defined it as the ratio of heat received and the temperature at which it is received. If we represent the heat receive by q and the temperature by T, then entropy e is defined as

$$e = q/T$$

It should be noted that Clausius applied this concept to a system, i.e., an engine which does not interact with its surroundings. It is obvious that all engines interact with the surroundings, that they do not preserve heat constantly, but emit heat. Hence there is no engine to which the concept can be applied in reality.

These examples show that in science, in particular in physics, we study the concepts to which no real object corresponds. Then are they just fictitious? Certainly, they are not. These concepts are helpful because all objects or engines actually existing, and which are possible, roughly approximate to these concepts. In other words, with the help of the theories involving these concepts, it is possible to formulate the laws which explain all possible engines and thus we can generalize and say that all scientific discoveries have a conceptual basis.

Nagel holds another important distinction between an experimental law and a theoretical law. A descriptive term like current may occur in different situations, but will retain the same meaning, and in all cases the measurement yields the same result. But terms occurring in a theoretical law do not necessarily convey the same meaning always. The reason is that, according to Nagel, even when an experimental law undergoes modification, its truth-value remains constant. But when a theoretical law undergoes change, its truth-value is affected. For example, the law of gravitation is a theoretical law. Though the word gravitation appears both in Newtonian mechanics and the general theory of relativity, it does not convey the same meaning because the latter is the corrected version of the former. The same explanation holds good for other concepts, such as space, time etc. But in contrast to the theoretical terms, Nagel considers experimental law like Wien's displacement law which could explain only the shorter wavelength (to this we can add the experimental findings of Rayleigh and Jeans which explained only the longer wavelength, but not the shorter wavelength). Planck's hypothesis achieved the synthesis of these two laws without affecting their truth-value. The result is that both Wien's displacement law and Rayleigh - Jeans law are to be considered partially true and their inability to explain more is to be considered their limitation. But it is doubtful whether partial truth is not partially false. This issue cannot be settled unless it is possible to decide whether the degrees of truth can be allowed.

There is a striking similarity between Nagel and Popper. Both of them believe that a theory is not the result of an empirical generalization. Popper puts it slightly differently. Theories do not originate in observation, (however accurate they may be).Both of them believe that they are the “free creations” of mankind. Possibly, Popper had this aspect in his mind, when he said that science always tries to “explain the known by the unknown the observed (and observable) by the unobserved (and, perhaps, unobservable).

Here we find the point of departure. Nagel is not very emphatic regarding the relation between theory and observation. He goes to the extent of saying that observation may “suggest” a theory, though ‘the basic terms of a theory need not possess meanings which are fixed by definite experimental procedures’…. . Further, he says that ‘a law may survive the eventual demise of the theory. Here he comes very close to Popper’s account. Since Popper believes that the demarcation between science and nonscience is only through the criterion of falsifiability, a theory, according to him, stands in need of refutation or falsification. The function of observation is ultimately to refute the theory. If we can accept the identity between an experimental law which has observable traits and observation, then it is obvious that the experimental laws should rigorously test the theory. It is in this sense that scientific statements are objective or testable .When a theory is falsified, it gives place to a new theory which also undergoes similar treatement. Thus the so called scientific pursuit has no end. Such a characteristic reinforces Popper’s idea that science is not a system of absolute certainty, but a system of guesses or theories. Accordingly, he modifies the aim of science. To say that the aim of science is to provide a satisfactory explanation is tantamount to saying that its aim is not the search of irrefutable truth, but the ‘critical quest for truth, or it is not infallibility, but fallibility that is the aim.

Thus the theories are of varying degrees. Every theory is an approximation to another theory which is superior to it. Now we can finalize our findings with reference to the examples cited above, Wien’s displacement law and Rayleigh- Jeans law are closer approximations to Planck’s hypothesis. Similarly, all heat engines are approximations to Carnot’s ideal heat engine. All theories and laws, therefore, asymptotically approach the highest truth.

We can end up our discussion on laws and theories with a very brief reference to “reductionism” and its later formulation, viz., operationalism. Some scientists believed that it is possible to reduce or translate all theoretical terms to observational terms. Thereby, they meant that any theoretical term in science can be understood in terms of sense-data. Later, Bridgman gave a modified version by saying that all concepts in science are operationally understandable. For example, we can understand the concept of heat through sensation and can judge whether it is hotter or cooler. Not that Bridgman's attempt was free from defects. But the criticisms made against his theory, notably by L.J. Russell did not destroy operationalism, but only led to its reformulation by Bridgman. What is important is to note that equating operationalism with the involvement of sense organs, either directly or indirectly, meant that there were serious attempts to subject the physical world in all its finer details to experimental procedure.

Check Your Progress I

Note: a) Use the space provided for your answer

b) Check your answers with those provided at the end of the unit

1. What does metascience mean?

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1.5 METHODS

The word 'method' is derived from two Greek words,'meta' and 'odos'.'Meta'means following and 'odos' means way. So scientific method means following a way which science accepts. In our unreflective mood we may claim that the aim of science is the discovery of truth. But the nature of scientific enterprise, which we have considered, indicates that this aim is not unanimously endorsed. For example, the aim of science can be projected as the pursuit of truth knowing fully well that the truth is something that can never be discovered. So if we substitute the word discovery by 'pursuit', the aim also changes. But this change in the aim does not alter the method contrary to the expectation, but only results in the variation in the interpretation of scientific method. In other words, our analysis and critical examination of scientific method undergo considerable change. That is, the difference in our aim affects our understanding of scientific method.

All sciences (we shall ignore mathematics) are necessarily empirical. Thus the necessity of observation in scientific method is undeniable. Equally obvious is the fact that mere observation which helps us to collect data, however exhaustive it may be, does not constitute scientific method. Collection of facts or data should be purposeful. The purpose, obviously, is to explain the problem. So formation of hypothesis, its verification, etc. follow. Now we can tentatively formulate the steps involved in scientific method as follows:

1) observation, collection and classification of facts
2) formation of hypothesis
3) verification of hypothesis
4) proof of hypothesis and establishing the scientific law

At the outset, these steps constituting scientific method appear to be too simple. As it is, the formulation of these steps is defective and hence demands correction. However, a brief explanation of these steps may be of some help in our later venture.

Verification and proof:

These four steps indicate that scientific method begins with observation without which the material for investigation cannot be gathered. The second step indicates that a hypothesis has to be formulated to explain the problem. But a hypothesis is only a tentative explanation. In order to evaluate its value it is necessary that first it should be verified. Verification is possible by means of deducing the observable consequences from the hypothesis. If these consequences occur, then the hypothesis is verified; otherwise, it is not.

As far as proof is concerned, it has to be pointed out that the proof of hypothesis in its positive sense is not possible. However, proof in its negative sense is no less important. Popper's concept of falsifiability is very much close to the negative aspect of proof. If two or more than two hypotheses yield consequences which are observed, then all these hypotheses are verified. But we have to choose the best one among them. It is here that falsification plays its vital role. If an instance or experiment falsifies all but one rival hypothesis, then such an instance or experiment is said to be crucial. But a crucial experiment can only falsify hypotheses. That is all. Falsification of one hypothesis should not be taken to mean the final confirmation of the other hypothesis.

The method of falsification is as follows. Two hypotheses may explain several aspects. But one of them, say h1, may fail to explain some newly known aspect, while another hypothesis, say h2, may succeed in explaining that phenomenon. When it is possible to achieve this measure, the hypothesis becomes a universal law. The competition between corpuscular theory and wave theory of light is a very good example. While corpuscular theory could explain only rectilinear propagation, reflection and refraction of light, wave theory could explain, apart from these phenomena, other phenomena like interference, diffraction, etc. Hence wave theory gained preponderance over corpuscular theory for some time.

This is in a nut shell the explanation of the supposed steps which constitute scientific method. Several objections can be raised against such an explanation. If scientific method should start with the observation of facts, one can certainly ask the question, observation of which fact'? It is absurd to say observation of all facts. Obviously, a scientist does not and cannot observe all facts. He has to make a selection of facts, i.e., he has to distinguish between facts which are relevant and which are not. While making such a distinction the scientist is guided solely by their relation with the problem that has generated the inquiry. So apart from a collection of facts what is required is a certain kind of attitude towards these facts. What is this attitude? Popper calls this critical attitude. That observation is conditioned by the relevance of facts in the light of the problem points to two aspects. First, the origin of scientific investigation lies in the discovery of problem. It is not necessary to solve the problem, but even to discover a problem a lot of ingenuity is required. Second, to say that certain facts are related to the problem and others are not is tantamount to the assertion that a certain theoretical background is required to select facts. So observation not only tests the theory, but also its very basis is in the theory. It may appear that we are arguing in a circle. But it is not so. The theory which is tested by observation belongs to one level and the theory which makes observation possible belongs to another level

Now we have eliminated one defect in the scheme of scientific method mentioned above. However, the relation between the observation of facts and the formation of hypothesis is not yet explicit. The order in which they occur may suggest that the formation of hypothesis follows the observation of facts. But it is not so. It is only in a problem situation that a hypothesis arises. The scientist gathers facts with the help of observation only to test the hypothesis. Hence for a clearer understanding the order should be reversed.

Finally, the fourth stage asserts that the proof (in positive sense) of hypothesis is possible, and formation of a scientific law is supposed to be dependent upon the proof. This is an erroneous view. According to this view, once a law is established it becomes irrevocable. In other words, the highest truth is achieved. If so, no progress in science will be possible from this stage onwards. The last stage can be taken only as an ideal towards which science travels. Proof in its demonstrative sense, is not possible. On the same grounds, we have to reject the third step also. Accordingly, the verification of hypothesis as a permanent measure is not possible. So we shall substitute the word 'test' for verification.

To show that there is nothing like final confirmation or decisive proof we shall consider the dual nature of light. Earlier, it was pointed out that wave theory of light gained preponderance over corpuscular theory for sometime. Though several phenomena like interference, diffraction, etc., showed that light consists of waves, there were other phenomena like black body radiation, photoelectric effect etc., which wave theory could not explain. In these cases light (the word light is usually replaced by 'electromagnetic radiation') exhibited the properties of particles or corpuscules. To explain these new phenomena light was considered consisting of particles which were also packets of energy or photons. De Broglie made an attempt to synthesize these two theories and he came out with his famous concept of 'matter waves'. It should be remembered that he only attempted to synthesize, but did not deny the reality of particles in light waves or light waves or light waves in particles. Therefore the dual nature of light persists.

Now our scheme of scientific method requires to be remodeled. According to this revised pattern, scientific method can be split on the following lines.

1) The tradition or myth leading to inborn expectations
2) Formation of several hypotheses
3) Rigorous tests with the help of observation in the following way:

i) deducing the observable consequences from each hypothesis.

ii) comparing these consequences among themselves to ensure coherence.

iii) evaluation of hypothesis to decide whether it provides new information.

iv) detecting whether these consequences occur or not in the external world.

The revised pattern indicates two points. In the first place, the hypothesis, occupies the central position in scientific method. In the second place, and the most important, the method is deductive. Hence it is rightly pointed out that scientific method is characterized by hypothetico-deductive character.

1.6 NEWTON'S CONCEPT OF SCIENTIFIC METHOD

The role of hypothesis in scientific method has, very often, become a debatable issue. In some cases it is overestimated, when it is said that a hypothesis can be proved beyond doubt and hence becomes a law. In some cases it is underestimated. Mill is one philosopher who neglected the role of hypothesis. It is a point to be noted that if scientific method is identified with inductive generalization, then hypothesis will not have any place. Newton tried to strike a balance by combining inductive and deductive aspects. His method is generally known as the method of analysis and synthesis. Analysis consists in making experiments and observation and in drawing conclusions from them by induction….. and synthesis consists in '*assuming* the causes discovered' …. And with them explaining the phenomena and proving the explanations. It is obvious that analysis is inductive and synthesis is deductive according to Newton. The words in italics are very important. These words carry the same meaning which we attach to hypothesis today. But when Newton insisted that the hypotheses have no place in experimental sciences, by the word hypothesis he meant what we mean by a hypothesis that cannot be tested. His point is that observation should take precedence over hypothesis. That is what exactly we mean when we say that a hypothesis should be tested by observation. This point is made clear by the fourth rule which Newton discusses under 'Rules of reasoning in Philosophy.

Rule 4. In experimental philosophy (i.e. Physics) we are to look upon propositions collected by general induction from phenomena as accurately….true notwithstanding any contrary hypothesis that may be imagined…..

Thus what Newton sought was an explanatory hypothesis providing more and more information and, therefore, testable. If we assume that Newton used the word induction to mean observation or experience, but not the process of generalization, Popper's theory comes very close to Newtonian theory. In fact, Newtonian dynamics does not show any sign of generalization. On the contrary, dynamics exhibits the signs of abstraction from observation. Consider, for illustration, his first law of motion.

I law: Every object perseveres in its state of rest or of uniform motion in a right line unless impeded by an external force.

It is obvious that there is no object which is free from force. Yet the first law refers to such a free body. In the second place, uniform motion is not possible. So the first law is not the result of an inductive process or generalization.

Newton's emphasis on deductive approach to scientific method is illustrated by his emphasis on axiomatic method which is deductive. The axiomatic method consists in starting with a set of axioms and applying the method to the external world. The application of the axioms to the external world enables us to follow the procedure outlined earlier. Thus instead of using the word hypothesis Newton uses the word axioms, and the rest remains the same.

Check Your Progress II

Note: a) Use the space provided for your answer

b) Check your answers with those provided at the end of the unit

1. Define explicandum and explican.

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2. Explain falsification with examples.

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1.7 LET US SUM UP

Philosophy of science is of recent origin. Science precedes philosophy of science. Though science is temporally prior to philosophy of science, logically, philosophy of science is prior to science. Therefore philosophy of science is renamed as metascience. Metascience is an attitude towards science. It is a critique of science and whatever connected with science. Explanation is an important aspect of science. There are two kinds of laws; theoretical and experimental. Science is distinguished from nonscience in virtue of its method. The purpose of test is to falsify a theory.

1.8 KEY WORDS

Metascience: means critic of science. It includes a critical appraisal of the nature of laws of science, its methods and limits.

Falsifiability: There is a difference between falsification and falsifiability. The former means that a theory is, in reality, falsified. The later does *not* mean that a theory *should be* falsified. It only means that it must be possible for a scientist to falsify a theory under normal conditions. But he may not be in a position to falsify due to several limitations.

1.9 FURTHER READINGS AND REFERENCES

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1.10 ANSWERS TO CHECK YOUR PROGRESS

Check Your Progress I

1. Common sense suggests that science precedes philosophy of science not in temporal sense but in logical sense. Therefore philosophy of science comes after science. For this reason it is apt to call philosophy of science simply metascience.

Check Your Progress II

1. The problem which is in need of an explication is called ‘explicandum’ and the statements which we offer by way of explication are called ‘explicans’

2. The method of falsification is as follows. Two hypotheses may explain several aspects. But one of them, say h1, may fail to explain some newly known aspect, while another hypothesis, say h2, may succeed in explaining that phenomenon. When it is possible to achieve this measure, the hypothesis becomes a universal law. The competition between corpuscular theory and wave theory of light is a very good example. While corpuscular theory could explain only rectilinear propagation, reflection and refraction of light, wave theory could explain, apart from these phenomena, other phenomena like interference, diffraction, etc. Hence wave theory gained preponderance over corpuscular theory for some time.