Lecture 2
Views of Karl Popper

The positivistic construal of science was most systematically attacked by Karl Popper who provided an alternative image of science. His theory of scientific method has won a lot of admirers both in science and philosophy. Whereas positivists tried to work out a sophisticated version of the view called inductivism, Popper sought to resurrect its rival, namely, hypothesism. In what follows, we shall consider his views on the nature of sciences along with his attack on positivistic theory of science.

It might be pointed out that for Popper the value of the philosophical interest in scientific knowledge lies in its ability to shed light on the central question of philosophy, namely, the problem of cosmology: 'The problem of understanding the world including ourselves and our knowledge of the world as part of the world'[1]. In studying Popper's contribution to our understanding of science one must bear in mind his general philosophical concerns which alone set in motion, guide and lend deep significance to his painstaking work on the nature of science.

The philosophical inquiry into the nature of scientific method, according to Popper, must confine itself to the manner in which scientific theories are evaluated and accepted or rejected. Popper refuses to consider as legitimate the inquiry into the way in which these theories are arrived at. Therefore, according to Popper, philosophy of science must first confine itself to the context of justification and refuse to say that anything about the context of discovery. Popper considers the creative process in and through which scientific ideas are generated to be unamendable to any rational explanation. Secondly, an adequate philosophy of science, according to Popper, must provide a criterion of demarcation between science and non-science. Like positivists, Popper is convinced of the uniqueness and supremacy of science in the overall scheme of our activities aimed at knowledge acquisition. Hence, both positivists and Popper felt the need to demarcate science from the rest of knowledge-acquisition activities. That is why positivists who were inductivists maintained that the hallmark of scientific theories lies in their systematic verifiability. Popper replaces verifiability by falsifiability. According to Popper, the hallmark of scientific theories lies in their systematic falsifiability. Popper maintains that what distinguishes science from the rest of our knowledge is not that scientific statements are verifiable, but that they are falsifiable. The scientific theories are falsifiable, according to Popper, in the sense that they transparently state what circumstances lead to their rejection. Whenever scientific theories are advanced, it is also stated under what conditions they turn out to be false so that we try to obtain those conditions in order to falsify our claims. An ideal scientific statement is constituted in such a way that its terms instead of helping to survive enable it to readily accept the risk of being falsified. In other words, a model of scientific statement should readily yield test implications which we deduce in order to refute it. A statement however plausible and perfectly consistent with what we observe is not scientific unless we can easily deduce testable consequences from it. It is in this connection, Popper attacks Marxism as being pseudo-scientific[2]. When Marx propounded his theory of capitalist society, his theory was a falsifiable theory because it yielded test implications such as disappearances of middle class, revolution in advanced industrial societies, etc. However, these test implications were not borne out and hence the theory was falsified. But, the followers of Marx tried to explain the

fact that the Marxist predictions did not come about by taking recourse to *adhoc* explanations and thus insisted that there was nothing wrong with the theory. In the process, they went on building safety valves for the theory with the result that the theory becomes unfalsifiable. A religious theory about the world is, of course, also unfalsifiable. But, the propounders of religious theories about the world never claim scientificity for their views, whereas Marxists do so vehemently. Hence, Marxist theory is not merely unfalsifiable and therefore unscientific, but also pseudo-scientific. It is this pretension to be scientific while being unfalsifiable makes the theory pseudo-scientific.

In accordance with what Popper considers to be the hallmark of scientific theories, he puts forward an adequate model of scientific method. He characterizes his model of scientific method as hypothetico-deductive (H-D) model. According to him, the method of science is not the method of induction, but the method of hypothetico-deduction. What are the fundamental differences between these methodological models? First, the inductivist model maintains that our observations are theory-independent and therefore are indubitable. That is to say, since observations are theory-independent, they have probability value of 1. It also says that our theories are only winnowed from observations and therefore our scientific theories have the initial probability value 1 in principle. Of course, inductivists admitted that in actual practice, theories may contain something more than what observation statements indicate the result; our actual theories may not have been winnowed from observations. Hence, the need for verification arises. Popper rejects the inductivist view that our observations are theory-free and hence rejects the idea that our observation statements have probability equal to 1. More importantly, he maintains that theories are not winnowed from observations or facts, but are free creations of human mind. Our scientific ideas, in other words, are not extracted from our observations; they are "pure" inventions. Since our theories are our own constructions, not the functions of anything like pure observations, which according to Popper are anyway myths, the initial probability of our scientific theories is zero.

From this it follows that whereas according to inductivists, what scientific tests do is to merely find out whether our scientific theories are true. According to Popper, scientific tests cannot establish the truth of scientific theories, even when the tests give positive results. If a test gives a positive result, inductivists claim that the scientific theory is established as true, whereas according to Popper, all that we claim is that our theory has not yet been falsified. Popper suspects even that "The sun always rises in the east". In Popper's scheme, no amount of positive result of scientific testing can prove our theories. Whereas inductivists speak of confirmation of our theories in the face of positive results of the test, Popper only speaks of corroboration. In other words, in the inductivist scheme we can speak of scientific theories as established truths, whereas in the Popperian scheme a scientific theory however well supported by evidence remains permanently tentative. We can bring out the fundamental difference between verificationism (inductivism) and falsificationism (hypothetico-deductivism) by drawing on the analogy between two systems of criminal law. According to one system, the judge has to start with the assumption that the accused is innocent and consequently, unless one finds evidence against her/him, s/he should be declared innocent. According to the other, the judge has to start with the assumption that the accused is a culprit and consequently, unless evidence goes in her/his favour, s/he should be declared to be a culprit. Obviously, that latter system of

criminal law is harsher than the former. The inductivist scheme is analogous to the former kind of criminal law, whereas the hypothetico-deductive scheme is akin to the latter one.

In the inductivist scheme of observation, tentative generalization, verification and confirmation constitute the steps of scientific procedure. In the Popperian scheme, we begin with a problem, suggest a hypothesis as a tentative solution, try to falsify our solution by deducing the test implications of our solution, try to show that the implications are not borne out and consider our solution to be corroborated if repeated attempts to falsify it fails. Thus, problem, tentative solution, falsification and corroboration constitute the steps of scientific procedure. Popper's theory of scientific method is called hypothetico-deductivism because, according to him, the essence of scientific practice consists in deducing the test implications of our hypotheses and attempt to falsify the latter by showing that the former do not obtain, whereas according to inductivism, the essence of scientific practice consists in searching for instances supporting the generalization arrived at on the basis of some observations and with the principle of induction.

Popper claims that the hypothetico-deductive model of scientific method is superior to inductivist model for the following reasons. First, it does justice to the critical spirit of science by maintaining that the aim of scientific testing is to falsify our theories and by maintaining that our scientific theories however corroborated permanently remain tentative. In other words, the hypothetico-deductivist view presents scientific theories as permanently vulnerable with the sword of possible falsification always hanging on their head. The inductivist view of scientific method makes science a safe and defensive activity by portraying scientific testing as a search for confirming instances and by characterizing scientific theories as established truths. According to Popper, the special status accorded to science is due to the fact that science embodies an attitude which is essentially open-minded and anti-dogmatic. Hypothetico-deductivism is an adequate model of scientific practice because it gives central place to such an attitude. Secondly, Popper thinks that if science had followed an inductivist path, it would not have made the progress it has. Suppose a scientist has arrived at a generalization. If s/he follows the inductivist message, s/he will go in search of instances which establish it as truth. If s/he finds an instance which conflicts with her/his generalization, what s/he does is to qualify the generalization mentioning that the generalization is true except in the cases where it has been held to be unsupported. Such qualifications impose heavy restrictions on the scope of the generalization. This results in scientific theories becoming extremely narrow in their range of applicability. But, if a scientist follows the hypothetico-deductive view, s/he will throw away her/his theory once s/he comes across a negative instance instead of pruning it and fitting it with the known positive facts. Instead of being satisfied with the theory tailored to suit the supporting observations, s/he will look for an alternative which will encompass not only the observations which supported the old theory, but also the observations which went against the old theory, and more importantly, which will yield fresh test implications. The theoretical progress science has made can be explained only by the fact that science seeks to come out with bolder and bolder explanations rather than taking recourse to the defensive method of reducing the scope of the theories to make them consistent with facts. Hence, Popper claims that the hypothetico-deductive model gives an adequate account of scientific progress. According to him, if one accepts the inductivist account of science, one fails to give

any explanation of scientific progress. Thirdly, the hypothetico-deductive view, according to Popper, avoids the predicament encountered by inductivist theory in the face of Hume's challenge. As we have seen, Hume conclusively showed that the principle of induction cannot be justified on logical grounds. If Hume is right, then science is based upon an irrational faith. According to the hypothetico-deductive view, science does not use the principle of induction at all. Hence, even though Hume is right, it does not matter to science if science follows the hypothetico-deductivist lines of procedure. Also, Popper seeks to establish that inductivism and hypothetico-deductivism are so radically different that the latter in no way faces any threat akin to the one faced by the former. In this connection, he draws our attention to the logical asymmetry between verification, the central component of the inductivist scheme, and falsification, the central component of the hypothetico-deductivist scheme. They are logically asymmetrical in the sense that one negative instance is sufficient for conclusively falsifying a theory, whereas no amount of positive instances are sufficient to conclusively verify a theory. It may be recalled that Hume was able to come out with the problem of induction precisely because a generalization (all theories according to inductivism are generalizations) cannot be conclusively verified.

How does Popper characterize scientific progress? According to him, one finds in the history of science invariable transitions from theories to better theories. What does the word, "better" stand for? It may be recalled that, according to Popper, no scientific theory however corroborated can be said to be "true". Hence, Popper drops the very concept of "Truth" and replaces it by the concept of "Verisimilitude" (truth-likeness or truth-nearness) in his characterization of the goal of science. In other words, though science cannot attain truth, that is, though our theories can never be said to be true, science can set for itself the goal of achieving higher and higher degrees of Verisimilitude, that is, they can progressively approximate to Truth. So, in science, we go from theory to better theory and the criterion of betterness is Verisimilitude. But, what is the criterion of Verisimilitude? The totality of the best implications of hypothesis constitutes, what Popper calls, the empirical content of the hypotheses. The totality of the test implications, which is borne out, constitutes the truth content of the hypothesis, and the totality of the test implications, which is not borne out, is called the false content of the hypothesis. The criterion of the Verisimilitude of a theory is nothing but truth content minus the falsity content of a theory. In the actual history of science, we always find the theories being replaced by better theories, that is, theories with higher Verisimilitude. In other words, of the two successive theories, at any time in the history of science, we find the successor theory possesses greater Verisimilitude and is therefore better than its predecessor. Indeed, according to Popper, theory is rejected as false only if we have an alternative which is better than the one at hand in the sense that it has more test implications and a creator number of its test implications are already borne out. The growth of science is convergent in the sense that the successful part of the old theory is retained in the successor theory, with the result the old theory becomes a limiting case of the new one. The growth of science thus shows a continuity. In other words, it is the convergence of the old theory into the new one that provides continuity in the growth of science. It must also be mentioned in this connection that unlike inductivists or positivists, Popper is a realist in the sense, according to him, scientific theories are about an unobservable world. This implies that the real world of unobservables though can never be captured by our theories entirely is becoming more and more available to us. Popper contends that the greater and greater Verisimilitude attained by our theories evidence that the gap

between the Truth and our theories can never be completely filled, it can be progressively reduced, with the result the real world of unobservables will be more and more like what our theories say though not completely so.

How does Popper establish the objectivity of scientific knowledge? Inductivists sought to establish the objectivity of science by showing that scientific theories are based upon pure observations. The so-called pure observations were supposed to be absolutely theory-free. They are only "given" and hence free from the subjective inferences. Popper, as we have seen, rightly rejects the idea of pure observations. Consequently, he cannot accept the inductivist account of the objectivity of science. First, what engenders scientific objectivity according to Popper is not the possibility of pure observation, but the possibility of inter-subjective testing. In short, science is objective because it is public, and it is public because its claims are inter-subjectively testable. Secondly, Popper makes room for relative autonomy of facts or observations. That is to say, whereas inductivists considered observations to be "absolutely" theory-free, Popper construes them to be "relatively" theory-free. He maintains that though an observation must depend upon some theory, it can be independent of the theory which is tested in terms of it. Hence, a theory depends upon (rejected or tentatively accepted) a prior observation, which in turn, needs ratification in terms of a theory prior to it. To the question, "which comes first, observation or theory?", the inductivist answers "observation". Popper answers earlier observation or earlier theory. To Popper, the question is as illegitimate as the question "which comes first, egg or hen" that can be only answered by saying "earlier egg or earlier hen".

Comment on Popperian Methodology

In what follows, we shall make a few critical comments on Popperian methodology which has as many detractors as admirers.

Popper draws an invidious distinction between the context of discovery and the context of justification, and maintains that philosophy of science as methodology of science must confine itself to the latter, since according to him, discovery process involves a-rational factors which defy rational explanation. His rejection of the possibility of a rational account of discovery has been called into question. He seems to confine his attention to the examples like Kekule's discovery of Benzene structure wherein the central idea occurred to Kekule in a dream. But not all such cases are standard. Typical discoveries are provided by an elaborate reasoning process. Even in the case of Kekule, one must explain why only that dream was taken as providing clue to the Benzene structure. It appears more plausible to say that Kekule had undertaken enough reasoning to get the hint from that dream. That is to say, though clicks, hunches, intuition and other imponderables do play a role in the formation of hypothesis, they are preceded and succeeded by a long and guided chain of reasoning. Perhaps, the main reason for Popper's rejection of the possibility of a rational account of discovery is his identification of the possibility of a rational account of discovery with the possibility of an inductivist account of discovery. The inductivist account of discovery maintains the use of the principle of induction coupled with repeated observations leading to discovery. Later, inductivists like Mill even tried to work out thumb rules of discovery. Popper is right in showing that inductivists came nowhere near providing an account of discovery. No amount of observations can suggest us a theoretical idea. But, Popper is wrong in thinking that from this it follows that a

rational account of discovery is an impossibility. Hanson, in his *Patterns of Discovery*, comes heavily on Popper and advances a theory concerning discovery on the basis of the work by Charles Pierce. If according to Popper, the essence of science consists in the way in which theories are tested, according to Hanson, real science is over with the conception of the hypothesis. To quote Hanson, 'There is something wrong with the H-D account… If it were construed as an account of physical practice, it would be misleading. Physicists do not start from hypotheses; they start from data (though not in the inductivist fashion). By the time a law has been fixed into an H-D system, really original and physical thinking is over. The pedestrian process of deducing observation statements from hypothesis comes only after the physicist sees that the hypothesis will at least explain the initial data requiring explanation'[3]. Reacting to Popper's contention that the context of discovery is irrelevant from the methodological point of view, Hanson says, 'Galileo struggled for 34 years before he was able to advance his constant acceleration hypothesis with confidence. Is this conceptually irrelevant? Was it only the predictions from his hypothesis which commend it to Galileo? The philosopher of science must answer "NO"'[4]. Discussing in detail the process by which Kepler arrived at his final position, Hanson concludes, 'Kepler never modified a projected explanation capriciously: he always has a sound reason for every modification he made. When exactly satisfied the observations it stood upon a totally different logical footing from what it would if it has been struck out at random… and has been found to satisfy observations. Kepler shows his keen logical sense in detailing the whole process by which he finally arrived at the true orbit. This is the greatest piece of retroductive reasoning ever performed'[5].

The type of reasoning which has gone into Kepler's thinking, Hanson characterizes as retroductive. The form of the inference is – (1) Some surprising phenomenon P is observed: (2) P would be explicable as a matter of course if a hypothesis H is true: and (3) And hence, there is a reason to think that H is true. H does not emanate from some unaccountable creation as hypothetico-deductivists think nor from simple repetitions of observations as inductivists think. It emanates from a mode of thinking which seeks to find out a plausible pattern into which what are observed are fitted. A hypothesis provides such as a plausible pattern. Before we test a hypothesis, it must at least be plausible and not just a conjecture. Of course, apart from its plausibility, the hypothesis must satisfy further conditions such as if a hypothesis H is meant to explain a phenomenon P, then H cannot itself rest upon the features in P which required explanation. 'That is why the peculiar colour and odour of Chlorine (P) are not explained by reference to atoms in a volume of Chlorine, each one having the colour and odour in question (H). Grasping this point is essential for any understanding of the fundamental concepts of modern particle physics'[6].

Of course, the current work on discovery has gone much ahead of Hanson in terms of sharpness of articulation and rigour of analysis. But, the credit of putting on defensive the Popperian position on discovery goes to Hanson's path-breaking work.

Another serious lacuna in Popper's position concerns his idea of scientific progress. The progress of science is continuous in the sense that in two successive theories the latter contains the former or the best part of it. The continuity of scientific progress is exemplified by the fact that between two successive theories, the former is always the limiting case of the latter. In this connection, Popper cites the example of Newtonian theory and Einsteinean theory. But, Popper first overlooks the fact that in the actual

history of science, such comparables are rare. For example, it is assured to say that Phlogiston Chemistry is the limiting case of Oxygen theory or Polemic theory is the limiting case of Copernican theory. Secondly, Popper's idea that our successive theories exhibit increasing degree of Verisimilitude is more like what our present theory says than what our earlier theory indicated. It implies, following Popper we must say, that the ultimate constituents of matter are more like fields (as contemporary physical theory indicates) than particular (as classical physics indicated). But, this is slightly unintelligible. In short, we are led into unintelligibility, if we literally apply Popper's characterization of two successive theories to the very cases he takes to be paradigmatic. Finally, in characterizing the old theory as an approximation to the new one, Popper assumes that the general locations of the new theory imply the same things as in the old one. That is to say, Popper assumes that when a fundamental shift in theory takes place, the meaning of the terms remain invariant. This assumption has been called into question by some philosophers of science who show that the terms like "mass", "force", etc. have one meaning in Newtonian framework and another in the post-Newtonian framework. Thomas S. Kuhn and Paul Feyerabend, whose views we explicate below, have convincingly argued that a shift from one theory to another is accompanied by a shift in the meaning of the works that are common to both the theories. If so, Popper's characterization of growth of science, as continuous, collapses.

Notes and References

[1] Karl Popper, *The Logic of Scientific Discovery*, Hutchinson and Company, 1975 (first edition: 1959), p. 15
[2] Karl Popper, *The Open Society and its Enemies*, Volume II, Routledge and Kegan Paul, London, 1945
[3] N.R. Hanson, *Patterns of Discovery*, Cambridge University Press
[4] *Ibid.*, p. 172
[5] *Ibid.*, p. 84
[6] *Ibid.*, p. 87

Questions

1. What is the central question of philosophy, according to Popper?
2. What is the problem of cosmology?
3. What is context of discovery?
4. What is context of justification?