Virendra Shekhawat

SOME EPISTEMOLOGICAL TRENDS IN PHILOSOPHY OF SCIENCE*

Some of the relatively significant contributions to epistemology, in recent times, have been made by Karl Popper,[1] Thomas Kuhn,[2] Paul Feyerabend,[3] and Hans Reichenbach.[4] All these authors seem to make some radical departures from the inherited theories of knowledge. A common characteristic of their epistemologies is that they try to tackle the problem of growth of knowledge; that is to say, what is meant by saying that theories of science, as they get more and more refined, increasingly approach the truth and what

* This research was supported by the Special Assistance Programme (UGC), and the author is grateful to Professor Daya Krishna, Director of the SAP, for necessary suggestion and encouragements.

1 Karl Popper, *Logic of Scientific Discovery*, London, Hutchinson, 1980.
2 Thomas Kuhn, *Structure of Scientific Revolutions*, Chicago, University of Chicago Press, 1962.
3 P. Feyrabend, *Against Method*, London: Verso, 1978.
4 H. Reichenbach, *Experience and Prediction*, Chicago, University of Chicago Press, 1938.

https://doi.org/10.1177/039219218403212805 Published online by Cambridge University Press

the nature of relationship is between the earlier theory and the more refined, later, and present theory. Philosophy in the past hardly grappled with these issues, and therefore it would be of interest to critically examine these new dimensions in Epistemology, which is the concern of this paper.

THE NEW EPISTEMOLOGIES

1. We will try very briefly to present the epistemological import[5] of the views of Popper, Kuhn, Feyerabend and Reichenbach.

According to Popper, scientific knowledge is expressed in the form of a theory or description of the world, of its order, regularities and laws. Theoretical knowledge is "genuine conjecture" or "highly informative guess" about the world which seriously seeks to discover the truth. But theoretical knowledge can never be verified or established as true although it can be submitted to severe critical tests. It is nevertheless our own imaginative description of something real for whenever any theory is falsified it is a proof that reality has been touched. The logic of scientific discovery is such that it is always guided by theories, rather than theories being discoveries due to observation. This is so because no distinction between theoretical terms and observational terms can be made, all terms being theoretical to a certain degree. However, a neutral observation language does exist although the terms occurring in it are theoretical. The basic observation statements of which the observation language is made refer to publicly observable material objects and can therefore be affirmed or denied as true or false. It is a characteristic feature of the logic of scientific discovery that a number of competing theories can simultaneously be held which is further facilitated by the availability of a neutral observation language. Further, the greater the empirical content of a theory, the more sensitive would it be to falsifiability. This makes possible the comparison of many theoretical knowledges and their falsifiability by *crucial experiments.* Since theories can only be falsified and not verified, a proliferation of theories becomes possi-

[5] A comprehensive and satisfactory presentation of some of the views can be found in F. Suppe, *The Structure of Scientific Theories*, Urbana, University of Illinois Press, 1979.

ble which exactly is responsible for the growth of scientific knowledge, according to Popper.

For Popper, therefore, knowledge does not have any infallible base in either senses or reason. Senses, stimulated and controlled in the practice of experimentation, play a *critical* role for the knowledge created imaginatively, this latter process not being strictly rational or logical. The test statements which occur in the theoretical knowledge may be *motivated* by experience but these cannot be *deduced* from it. Moreover, the selection of any hypothesis as a provisional candidate for theoretical knowledge is also not based on strict reason but is a decision made on the basis of hope or belief. Theoretical knowledge, therefore, is always provisional, protected by unfalsifiability so long as it lasts and growing by the possibility of competing theories being critically exposed over and over again to crucial tests.

2. Kuhn views the process of scientific knowledge as working within a general outlook, a world-view, a perspective which *directs* how reality will be viewed, what the criteria of acceptability or rejection of theories wil be or when theories will be considered as falsified. This outlook of the scientific community is shaped by *examplers* and *disciplinary matrixes.* The former are concrete solutions of problems which are considered paradigmatic by the community. The latter constitute the "shared elements" of the community and are responsible for intercommunication and unanimity in professional judgements; its chief components are the examplers themselves as also the shared commitments, beliefs and values which make the community a cohesive body of seekers. The process of scientific change, according to Kuhn, is fundamentally revolutionary and discontinuous with far-reaching epistemological consequences. Scientific knowledge, being dynamic, repeatedly passes through *normal* and *revolutionary* phases making it possible to characterise revolutionary scientific knowledge as radically different from normal scientific knowledge. It is characteristic of normal science that it is carried out by communities which share a common disciplinary matrix and a common stock of examplers. Under the activity of normal science every puzzling experience is sought to be understood within the framework and the perspective of the disciplinary matrix which thus further articulates the matrix

and extends its scope. Normal science is, then, the attempt to subsume an increasingly larger class of phenomena under the world-view provided by the evolving disciplinary matrix. Thus, it is a *cumulative* enterprise whose aim is not to produce novelties of theory or experience but rather to show that nothing is novel. In this process, however, normal science invariably confronts anomalous phenomena which defy it and are not according to its expectations. Anomalies appear only against the epistemic background provided by the disciplinary matrix and the more precise and well-articulated this matrix the more sensitive an indicator it would be to anomalies and hence would provide occasion for its own change. When anomalies accumulate and the repeated efforts to reconcile them with the given world-view fail, attempts are made to alter the disciplinary matrix itself. However, these alterations become increasingly *ad hoc* resulting in less unanimity among the scientific community so that a *scientific crisis situation* results which then sets the stage for a scientific revolution. The crisis situation is characterised by a proliferation of alternative theories so that there is a breakdown of the scientific community with the loss of a common disciplinary matrix. Such a crisis, says Kuhn, is a necessary condition for scientific revolution and for emergence of novel theories in an established area, but it is not itself a sufficient condition. Before a disciplinary matrix is rejected, its replacement must emerge and scientific revolution consists in the switch of allegiance from the old to the new disciplinary matrix. This replacement will be the product of *extraordinary science.*

As opposed to normal science, extraordinary science is individual not communal, different scientists looking at the problems in different ways. It is a random research not being constrained by a common disciplinary matrix, and is marked by a willingness to try anything and recourse to philosophy and debate over fundamentals.

Since a theory is an interpreted symbolic generalisation, the new theory provides newly interpreted symbolic generalisations. Since it permits predictions that are not permitted by the old theory it must be logically incompatible with the latter. To accept the new theory is to accept new symbolic generalisations and their applications as new archetypal examplers. Since the examplers implicitly interpret the symbolic generalisations and determine the meanings of theore-

https://doi.org/10.1177/039219218403212805 Published online by Cambridge University Press

tical terms, accepting the new theory implies accepting an altered vocabulary for viewing the world and for engaging in theoretical science, which amounts to acquiring a new disciplinary matrix, a new world-view, a new way of doing science.

Now, the success of the new candidate for disciplinary matrix can only be measured relative to some standards of what kind of problems science ought to tackle, what sorts of solutions are appropriate and what sorts of methodology and experimental techniques are to be employed. But these are determined by the examplers embraced. Since the competing disciplinary matrixes share different examplers they do not share common standards and values. As the two camps do not share common standards or values, no logical argument can prove the superiority of one theory over the other. The argument ultimately must be one of persuasion. One reason why the arguments are at cross purposes is that the same terminology is being used with different empirical meanings by the two camps. This is not limited just to theoretical terms, but also to data terms. There is not even a neutral observation language since the examplers, *inter alia*, involve interpreting and classifying the phenomena (to which the symbolic generalisations are applied) differently. Hence when revolutions occur, the scientific advance that results is not cumulative; rather, it is a *fundamental reorientation* of the scientific process even though some of the old generalisations are retained under the new interpretation. The conceptual changes which come from accepting a new disciplinary matrix are like a *gestalt switch*: two observers looking at the same thing from within different disciplinary matrixes see different things. "Though the world does not change with a change of disciplinary matrix, the scientist afterwards works in a different world."[6] What is happening here is not that one sees the world and then interprets it from within one's disciplinary matrix; rather one sees the world *through* one's disciplinary matrix, and although change in disciplinary matrix does not change the world, what is seen of it and how it is seen does change.

3. Feyerabend seems to agree largely with Popper except that he sees an "empirical core" in Popper's philosophy of science which

[6] Kuhn, *op. cit.*, p. 120.

implies the necessity of a neutral observation language. However, such a neutral observation language does not exist, and need not be a precondition to the testability of theories, according to Feyerabend. Any theory of scientific knowledge that imposes *consistency condition* and *meaning invariance condition* on its theories is unrealistic for it forbids the simultaneous employment of mutually inconsistent theories. But *theoretical pluralism*, or proliferation of incompatible theories, is a practice characterising historically the spirit of scientific seeking. Development of science is not possible by reduction of new theories into a single set of mutually consistent theories because the descriptions of facts are theory-dependent and a neutral observation language is useless in testing scientific theories.

The doctrine of *radical empiricism*, according to Feyerabend, insists that only two kinds of theory are admissible for a given domain of scientific research: those which *contain* theories already employed in that domain and those which are *consistent* with them inside the domain. In order that this *consistency condition* be met, terms in theories will have to be used with the *same meanings* when they occur in any of the admissible theories of the domain. This *meaning invariance condition* has the effect that whenever these terms are employed in future theories of the domain they will have to be used with the same meanings. But in actual practice the major advancements of science do not typically satisfy these conditions; instead, it is the *theoretical pluralism* that obtains in the history of science rather than the reductionism of radical empiricists. This is further strengthened by Feyerabend's contention that meanings of terms are dependent on theoretical contexts in which they occur and that no autonomous facts are available independent of theoretical context, the interpretation or description of every single fact being dependent on some theory. Not only that, "there also exist facts that cannot be unearthed except with the help of alternatives to the theory to be tested and that become unavailable as soon as such alternatives are excluded".[7] Thus theoretical pluralism is indispensable if a given theory is to be exposed fully to every relevant fact so that it can be given a thorough test. Moreover, all descriptions of observable facts, too, are dependent upon some

[7] Feyerabend, *op. cit.*, p. 175.

theory so that a neutral observation language usable for testing theories is impossible. No theory even agrees with all the facts in its domain and such a clash between theory and facts may be proof of progress. How, then, are the theories to be tested? They can be tested on the basis of observation without assuming a neutral observation language. Observation sentences are to be distinguished from other sentences, not by the neutrality of their meanings, but by the *circumstances of their production*, says Feyerabend. Sensations or perceptions are indicators of situations and are, therefore, on a par with the indicators of meters and dials. To function in a test, they need to be interpreted. An observation sentence, then, is a causal or behavioural response to a sensation which *interprets* the situation of which the sensation is an indicator. But the interpretation has to depend on the theory in whose context it is advanced. Thus, observation statements *extrapolate* beyond the received sensation, the extrapolation interpreting the situation as an objective state of affairs behaving with characteristic regularities. Since observation reports as well as other factual descriptions are theory dependent, how one views the world will depend upon the theories one holds in a given context. "We may even say that what is regarded as 'nature' at a particular time is *our own product* in the sense that all the features ascribed to it have been invented by us and then used for bringing order into our surroundings".[8] While the low-level empirical generalisations may be tested against the background of a general theory within whose perspective the test statements are interpreted, the same cannot be done for general theory itself. To test a general theory, then, it must be pitted against an alternative theory. If they overlap, then both can face a crucial experiment, but if they are *incommensurable*, in the sense that the meanings of their main descriptive terms depend upon mutually inconsistent principles, then either they have to be compared by internal examination vis-à-vis their connection to observation (more direct, clearer interpretations) or by comparing their observation sentences, the more acceptable being those which most successfully mimic our own behaviour. Thus, criticism of general and fundamental theories is possible only in the face of alterna-

[8] P. Feyerabend, *Minnesota Studies in Philosophy of Science*, Ed. H. Feigl and G. Maxwell, Vol. 3, p. 29.

tives, necessitating a proliferation of as many theories as possible. Further, these theories are the more lively, the more diverse, creative, and novel the methods they try in their defence and establishment and in unearthing the facts so that an *anarchistic* approach rather than a *law and order* approach to knowledge is indispensable if science is not to stagnate.

4. Reichenbach holds that the concept of *weight* of propositions as a predictable value lies at the foundation of all knowledge and *truth is nothing but high weight*. The weight is a predicate of propositions and is identical with probability. Now, if probability is interpreted as *frequency of events*, a probability statement would concern events; if, on the contrary, probability is taken to be a *generalisation of truth*, it has to be concerning propositions, for only propositions, not things, can be called true. Reichenbach, however, interprets the two concepts by the notion of *frequency*; in one case, probability being frequency of events, and in the other, of propositions about events. There are no single unrepeatable events but *ordinary language suppresses reference to a class* and speaks incorrectly of a single event where a class of events should be considered. Such a class *must* always be constructed if the probability statement is to have meaning. But there can be only as much meaning in proposition as is utilizable for actions so that even if the meaning of probability statements is bound to a class of events, the statement is applicable for actions concerned with only a single event. An individual statement, then, is neither uttered as true, nor false, or probable but is uttered as a *posit*. We posit the event with highest probability as that event which will happen. We do not thereby say that the proposition about the happening of the event is true but we only *decide to deal with it* as a true proposition. The reason why we decide to take the proposition as true is that this decision leads, in repeated applications, to the greatest ratio of successes. Reichenbach says, "Whenever a prediction is demanded, we face the future like a gambler. We cannot say anything about the truth or falsehood of the event in question. But a posit concerning it has a determinate weight for us which may be expressed in a number".[9] This shows, then, that the concept of probability is

[9] Reichenbach, *op. cit.*, p. 315.

indispensable for knowledge, that probability logic determines the methods of scientific investigation. This logic, however, does not add anything to the results of experience because it is empty (being nothing but a system of syntactical rules of language); what we know about nature is all taken from experience only.

The importance of probability statements derives from the fact that they sustain predictions. That is, from a given frequency statement we can *infer* another frequency concerning the future; we can proceed from a known frequency to an unknown frequency. This inference is also inductive but it does not claim to obtain a *true* statement, what is obtained is only a wager but it is the *best* wager because it corresponds to a procedure which seeks to find a converging limit to the frequency of occurrence of events. If such a procedure were not available, predictions would not be possible. "To fulfill the conditions sufficient for the attainment of true predictions does not lie in our power; let us be glad that we are able to fulfill the conditions necessary for the realisation of this intrinsic aim of science".[10] And we *should* at least actualise the necessary conditions of success by adopting this procedure, even though the actualisation of sufficient conditions is not within our reach. And precisely this is done in scientific discovery.

Further, there must exist a relation between a theory and the facts of which it is a theory, otherwise there would be nothing to discover. It is the *inductive expansion* of the known facts that leads to the new theory. It is not that a theory is constructed by a "mystic presentiment" and later it is proved to be true after confirmation of the predictions contained in the new theory. Actually, we never have a definitive proof of the theory; demonstration of some facts confers only a higher probability upon the theory. It is the postulate of best predictive character of theories which is the regulative principle for the construction of scientific theories and for choice between them. This conferring of at least some probability upon the theory distinguishes it from others as our best posit, according to inductive methods. A good theorist sees these inductive relations, which, if they were non-existent, would make the theory a mere guess and its success due to chance only. Thus knowledge in general and scientific knowledge in particular is not a system of

[10] *op. cit.*, p. 357.

https://doi.org/10.1177/039219218403212805 Published online by Cambridge University Press

two-valued propositions. Knowledge is to be interpreted as a system of posits or wagers and logical analysis shows, holds Reichenbach, that scientific knowledge is our best wager because its inductive procedures lead to most favourable posits.

EXAMINATION OF THE VIEWS

5. These epistemologies are the result of serious attempts of philosophers to understand the nature of modern science which seems to be a remarkable cognitive enterprise. Is it primarily a hit-and-miss method or is there any order, repeatability and regularity in the method? As a *technique of theorisation* of knowledge,[11] is it a *technique* which only highly gifted creative and special individuals can undertake or is it quite general? What are the features that can more or less completely satisfactorily characterise the technique? What are the necessary and sufficient conditions which any technique of theorisation must fulfill so as to yield knowledge in which *error*, resulting from subjective and objective factors, can be overcome or minimized? Does modern science, as one such technique, satisfy these conditions? Different approaches have been tried for seeking answers to these questions but most of them suffer from their characteristic defects. For one thing, Popper and Feyerabend commence with an implicit rational, liberal commitment and seek to fit scientific enterprise into that mould. For another, Kuhn studies only the *history* of practice of science succeeding only in giving his own interpretation of how it has been in the past and failing to answer whether the enterprise succeeds at all in overcoming error to a certain degree. In spite of their shortcomings, however, each succeeds in unearthing very important features of knowledge in general and of scientific knowledge in particular.

Consider Popper first. The core of his argument is that:

1) Although scientific knowledge seeks to express, in the form of a theory, something real, it always remains a tentative proposal and can never be proved to be true. The construction of conjectures is an imaginative, creative act and though

[11] See V. Shekhawat, "Scientific vs Darsanik Knowledge: Two Techniques of Theorisation," *Diogenes*, 116, 1982.

it may be governed by psychological laws, the methodology of science is not concerned with these. Similarly the selection from these conjectures of the provisional candidate for holding on to in future is also a random process not governed by any definite criteria.

2) These conjectures are not and cannot be derived from experience of the senses which only plays a critical role in falsifying them. The experience of the real or the observation of facts cannot guide the scientific process because of this non-derivability. Therefore, the theory, not observation, guides the discovery.

3) Falsification becomes possible due to the availability of an observation language of which the theoretical terms have neutral meaning. Because of this availability of a neutral observation language and consequent ability of falsification by crucial experiments, a number of competing theories can proliferate, making possible the continuing progress of scientific enterprise.

If we accept this as Popper's characterisation of science as a technique of theorisation of knowledge, we can formulate the necessary conditions which, according to him, this technique must satisfy in order that it may yield knowledge which is true, although partially so. Popper's conditions are that:

A technique T yields adequate theoretical knowledge if, and only if:

i) conjectures are proposed,
ii) every conjecture selected for acceptance as a theory is falsifiable and its falsification is sought,
iii) a neutral observation language is available for critical examination of theories,
iv) there is more than one competing theory in the field .. (1)

The necessary conditions of adequacy of theoretical knowledge, according to Popper are:

A piece of theoretical knowledge K is adequate if, and only if:

i) it is deductively linked to earlier knowledge,
ii) its sensitivity to falsification is proved,
iii) it remains unfalsified for the moment ....(1')

https://doi.org/10.1177/039219218403212805 Published online by Cambridge University Press

Close to Popper's view is the view of Feyerabend of which the central thesis is as follows:

1) If radical empiricist understanding of the scientific enterprise is true, then the natural growth of science should be stunted by the consistency condition and the meaning invariance condition which it expects the theories to satisfy. But historical evidence indicates that scientific practice does not care for these.
2) Since (i) meanings of terms are theory-dependent and (ii) facts can be interpreted only in the context of a theory, certain facts cannot be unearthed except by the help of a theory; therefore, theoretical pluralism obtains and it must obtain if fullest confrontation of a theory to facts is sought, which must be sought.
3) A clash between theory and facts is a proof of scientific progress so that no theory is without discrepant facts.
4) A theory cannot be tested by neutral observation language because, (i) there is no neutral observation language, and because, (ii) observation statements are interpretations in the context of the theory.
5) Empirical generalisations can be tested in the background of higher generalisations; and general theories can be tested by pitting one against another alternative theory if the two overlap so that they can both face an *experimentum crucis*; or a general theory can be tested, if it is incommensurable with other theories, only by internal examination of its connection with observation sentences themselves, the more satisfactory being those which mimic our behaviour more successfully.
6) If the progress of science is not to stagnate, then as diverse and novel methods must be adopted as is possible, and there must be an emphasis on creativity, novelty and subversion rather than on law and order.

From these we can extract the following conditions which any technique of theorisation must necessarily satisfy if it is to yield adequate theoretical knowledge:

A technique T yields adequate theoretical knowledge if, and only if:

i) mutually inconsistent theories are constructed in the same domain, the theories providing their observation sentences;
ii) there is a continuous clash between theories and facts, theories seeking fullest confrontation with facts;
iii) it allows a free search of techniques and facts with commitment to creativity and novelty rather than to prevailing norms .... (2)

According to Feyerabend:

A piece of theoretical knowledge K is adequate if, and only if:
i) its superiority is shown by its passing the *experimentum crucis* in competition with other such *overlapping* knowledge;
ii) it has a more direct connection with its observation sentences as compared to other such *incommensurable* knowledge;
iii) or, its observation sentences mimic our behaviour more successfully as compared to the observation sentences of other such incommensurable knowledge;
iv) it helps in unearthing novel facts which its predecessors could not ....(2')

These adequacy conditions for technique of theorisation as well as for theoretical knowledge are not quite adequate. In the case of 1-i, for example, it is not necessary that for any theory to stay in the domain it be falsifiable but not yet falsified for indeed there normally exist minor anomalies side by side and yet the theory need not be rejected at once although its adequacy will be suspect. If this condition were to be taken seriously, then indeed no technique can ever be said to yield adequate knowledge. Moreover this leads to the paradoxical situation that the better theory will be eliminated quicker since the more sensitive to falsification the theory, the less likely it is to stay in the field. Similarly, in the case of 1-iv, it is not necessary that a competing theory come into existence more or less simultaneously with the accepted theory so that the adequacy of this theory is seen in comparison with that. In fact too quick a proliferation of competing theories is more likely to create instability and thus harm progress rather than promote it. Further, the condition 1-i is ambiguous for it leaves unanswered the question: under what conditions shall the conjectures be proposed?[12] In fact this is one of the most serious defects of Popper's thesis. It fails to see the significance of the context of discovery of hypotheses. Indeed it is one of the most important requirements of any technique of theorisation to spell out the conditions under which the theoretical knowledge will be generated by the knowing subject. Just as science leaves the knowing subject out of account, so, too, does Popper in his theory of science. But a theory of science need not and must not do so if science is to be seen both as a body of knowledge as well as an activity involving a complex of decisions and judgements by the knowing subject as a part of a larger process.

A significant aspect of this process is the assimilation of past experience. Conjectures are never made and can never be made *ad hoc*. They come from an imagination which *understands* certain theories, has been *enriched* by certain experience, and has acquired a *skill* in certain practice. A conjecture may not certainly be *derivable* from experience but it is concocted from ingredients of which experience is surely one. A novel observation may not guide discovery, may not derivatively generate a conjecture, but it will indeed illuminate the imagination, it will puzzle it and force it to see things from a different angle, make it think in different ways, make it leave the track and try a different path. Further, a theory may not derive its strength directly from experience. When it is said that a theory is true unless falsified by subsequent experience, it is not being asked: on what strength does this truth stand? The possibility of this truth can be provided by nothing except the *connection* with a theory which, though presently falsified by *some* experience, had stood the test of *past experience* in its heyday. The connection with that past experience must indeed give an *indirect* support to the new theory.

A similar ambiguity as pointed out above lurks in the condition 2-i for it is not clear what the conditions are that will make the construction of mutually inconsistent theories possible. Mutually

[12] Popper rather shifts the attention to the fact that the proposing of conjectures and their selection as suitable candidates for theory are not strictly logical processes. But imaginative creation of hypotheses can have a logic of randomness and selection of conjectures can also be conjectural in so far as it involves an objective, practical decision.

https://doi.org/10.1177/039219218403212805 Published online by Cambridge University Press

inconsistent theories do not arise just out of the blue, they too are generated by certain imagination. The condition insists that unless at least two mutually inconsistent theories are in the domain, the theoretical knowledge yielded by the technique cannot be said to be adequate. According to this condition, every theory in question must have its alternative(s) even though there be no puzzling anomalies that force the construction of alternatives. But such a condition is unreasonable and is more likely to stunt the progress rather than promote it. Moreover, it does not stress the idea of improvement of "genetic structure" of theories marking the progress, rather it stresses the idea of proliferation of theories as characteristic of progress. It could perhaps be considered a sufficient condition of adequacy of technique but then, as will be seen, it is likely to work against the conditions of adequacy of theoretical knowledge.[13] In 2-iii Feyerabend rejects the distinction between "the context of justification" and "the context of discovery" and incorporates the *attitude* of creativity and novelty as a necessary condition of adequacy.[14] One must agree with this step which tries to take the knowing subject into account, but this too does not go

13 It appears that Feyerabend in his book either does not accept or confuses the two issues: "What are the characteristics of a scientific practice?" The former is an epistemological issue but the latter is not—it has ethical, cultural, economic implications.

14 But, again, Feyerabend does not seem to be clear about what he means by *anarchist* epistemology. Is this a doctrine of policy towards seeking of knowledge proper? Or, does it insist that there *cannot* be and *is not* one single method in scientific investigation? Or, that there *ought not to be* any law and order in scientific enterprise if it is to *progress freely*? Epistemological *adventurism* (try anything) as it exists in Kuhnian extraordinary science is not the same as epistemological *anarchism*, since the former does not reject at least some of the basic norms of objectivity in science. If every theoretical knowledge is true in its own way and can be tested only *within its internal* structure then Feyrabend comes close to Jain epistemology which says that "everything is true" (though in its own context) and, in effect, makes epistemological enterprise futile.

Further, even if, for certain reasons, proliferation of techniques and theories be allowed, this is bound to arrest progress unless they are subjected to common, objective criteria of adequacy. These must be subject to some "principle of selection" which alone can guarantee progress consisting not in the mere proliferation of theories and techniques but in the improvement of their "genetic structure". Perfection of technique and evolution of theoretical knowledge can best proceed by "random mutations" (extraordinary research, adventurism) and "natural selection" (objective criteria). A single generation of mutations cannot change the theory beyond recognition—for mutually inconsistent theories to come into being long temporal gaps are necessary.

far enough in formulating the conditions under which creativity and novelty will be generated.

Examining conditions (1') and (2') now, we find that these, too, are not quite satisfactory. (1')-i and (1')-ii are suspect because if theoretical knowledge remains acceptable even in the face of a few tolerable falsifiers, and if in the early phases of the birth of a theory it fails to suggest its falsifiers although accepted, then these conditions would seem unreasonable. The adequacy of a theory generally becomes increasingly suspect for various reasons (such as internal inconsistencies, failure to tackle a larger and larger number of anomalies, arrival of a competing alternative in the field)—and it is not rejected just on the grounds of a few falsifications. Similarly, conditions (2') presume earlier conditions (2) which have already been criticised, e.g. they presume the unreasonable conditions of the availability of alternative theories and that incommensurable theoretical knowledges of the same domain are possible. The condition (2')-iv is not strict enough because it only demands that the theoretical knowledge in question unearth novel facts—which it may perhaps do by prediction—and not *explain* them or classify them or show their causes, which indeed is expected of every theoretical knowledge. "To know is to know by means of causes", said Aristotle.

6. Turning now to Kuhn, his central thesis can be summed up as follows:

1) Scientific knowledge cannot be pursued exept by a community of *scientists*;
2) This community works its science and produces theoretical knowledge within the frame of a world view or a disciplinary matrix consisting of certain examplers;
3) Scientific knowledge as an activity is a dynamic process, and as a body of knowledge it is ever changing;
4) This change is of a characteristic kind involving (i) a phase of accumulation, addition, conformism and blowing up, and (ii) a phase of rejection, crisis, revolution and bursting. In the first phase, later knowledge conforms to earlier knowledge; it is routine filling the gaps. In the second phase, later knowledge competes with and shows the inadequacy of the former; it is a striving for the novel; it is random research activity;

5) Anomalous experience is tackled cautiously with a conservative attitude—every attempt is made to preserve the theory. When all attempts fail, the scientists are forced to see things in a new way. The *falsification phase* is long drawn out, consisting of a crisis situation which is a necessary condition of revolution or replacement of one disciplinary matrix by another;
6) The disciplinary matrix determines how the puzzles are to be solved, how the reality is to be viewed, how science is to be done, what values are to be sought, and what the standards and criteria of acceptability of theories are. A new disciplinary matrix gives a fundamental reorientation to science; its world is a different world as the scientist views it differently.
7) Replacement of one disciplinary matrix by another occurs by a rational persuasion. Since each disciplinary matrix has its own shape, there are no common and objective criteria and standards of evaluation for competing alternatives.

According to Kuhn, then:

A technique T of theorisation of knowledge is adequate if, and only if:

i) knowledge is pursued by a community,
ii) the community embraces a disciplinary matrix and examplers, within which to pursue knowledge,
iii) such anomalies are sought to be unearthed as defy explanation within the given disciplinary matrix leading to a crisis situation, random research and proposals for alternative disciplinary matrixes,
iv) revolutions occur resulting in rejection of the old, inadequate disciplinary matrix and embracing of the alternative one .... (3)

And further:

A piece of theoretical knowledge K is adequate if, and only if:

i) it successfully solves most of the puzzles that arise within it and tackles most of the anomalies satisfactorily,
ii) the community of scientists is by and large satisfied with its adequacy ....(3')

In fact, Kuhn's philosophy of science is not as much a theory of

https://doi.org/10.1177/039219218403212805 Published online by Cambridge University Press

scientific knowledge as it is a historical study of the methodology of science. When Kuhn observes that no objective criteria exist for replacement of alternative disciplinary matrixes or that the disciplinary matrix determines the perspective and the values and ideals of the community, his message is primarily of a factual historical nature and it must not be taken as universal characteristic of scientific methodology. In other words, Kuhn is not laying down the strict adequacy criteria which *ought* to be fulfilled by any methodology or theory, rather his emphasis is on the criteria as they are practised. Indeed, scientists have generally not been asking the deeper epistemological questions regarding their methodologies and theories and have generally followed the maxims laid down by the founders.[15] This is primarily because the need for improvements in the methodology itself was never felt since it yielded satisfactory theoretical knowledge. But if the shortcomings of the methodology itself are felt when it would, for instance, fail to yield any further interesting knowledge, the epistemological issues such as are being discussed here may become an essential and central part of the scientific enterprise itself.

The conditions of adequacy that we have extracted from Kuhn's philosophy may then be seen as idealisations of the historical study. Yet Kuhn's criteria succeed in indicating striking features of the knowledge process notwithstanding minor ambiguities here and there. It is perhaps due to these ambiguities that Kuhn's criteria have been called subjectivist. Kuhn's epistemology seems beyond doubt a realist epistemology, although its historical realist foundations give the impression of subjectivism. Indeed, it does not explicitly deny reality, rather it points out the subjectivist features in the activity of the *knowing subject* which, ideally, must be sought to be overcome. The ideal of all knowledge is to overcome error in general and subjectivity in particular but the knowing subjects in the scientific enterprise itself have generally tended to ignore serious reflection on the problem of how best to overcome error.

If we examine criteria 3-i and 3-ii for example, it is not clear whether the community satisfies certain criteria of objectivity and

[15] Perhaps no scientist after Newton has given a serious thought to the adequacy criteria of methodology and theory. See Newton's *System of the World.*

why it embraces a certain disciplinary matrix. The community is itself a subset of a larger community which supports the ideals of the former of seeking objective knowledge. The scientific community in fact begins with a rudimentary world-view acquired historically within a cultural-social setting and seeks its perfection. If the community were to embrace the world-view dogmatically and yet seek its perfection, the situation would be different. The critical attitude, if it were not to dominate, would allow a conservative spirit to prevail, leading to a conventionalist explaining away of major anomalies. Discrepant and embarassing anomalies would then be suppressed, random explorations would not be encouraged and alternative proposals would be taken as cynical attempts at subversion. Thus, unless the ideals of overcoming error and attitudes of scepticism towards the existing world-view were to guide the community, implicitly or explicitly, most of the conditions in (3) would not be met.

Similarly condition (3')-ii presumes such objective attitudes in the members of the community whose judgements will not be affected by political or economic pressures. Their satisfaction with the existing disciplinary matrix must be determined by the major criterion of success in solving puzzles and tackling anomalies and not by epistemologically irrelevant factors.

7. Considering Reichenbach, we can formulate his central contention as follows:

1) The logic that is working in the methods of scientific theorisation is probability logic which, although empty, helps in organising knowledge taken entirely from experience of the real;
2) All knowledge, scientific theory being no exception, is to be taken neither as true, nor as false, nor as probable, but as a posit, the posit with highest probability being the truest. Implicit in every knowledge of events is the frequency with which they occur, even the statements of single events hide this frequency;
3) Our decision to take the higher frequency as more probable, therefore more true, is commensurate with our actions and that is why it leads to greater successes;
4) An important feature of probability knowledge is that it

allows inductive inference from a given frequency to another unknown, future frequency. This inference is actualized by an *inductive procedure* which seeks to find a reasonable limit of every frequency. Inductive procedure lies at the root of the technique of scientific theorisation and fulfills the necessary conditions of finding the highest degree of truth;

5) What is *discovered* in science is the relation between theory and facts. Discovery is the *inductive expansion* of facts into a theory in accordance with the inductive procedures and not by hit-and-miss;
6) A theory can never be proved absolutely true; only a very high probability is conferred on it by the success of its *predictions* which also decide between a good and a bad theory.

According to this contention, then, the necessary conditions that a technique of theorisation must satisfy can be spelled out as follows:

A technique T of theorisation is adequate if, and only if:

i) inductive procedure for seeking the frequency limit is adopted;
ii) theory is acquired by the inductive expansion of observed frequencies;
iii) the theory of highest frequency is selected on the grounds of its being commensurate with actions of human beings .... (4)

The necessary conditions that theoretical knowledge must satisfy for its adequacy may be these:

A piece of theoretical knowledge K is adequate if, and only if:

i) it is a posit with highest frequency,
ii) it has a frequency limit,
iii) it has a high degree of predictability leading to the largest number of successes .... (4')

In these conditions, a remarkable epistemological position is taken that humans must not seek absolute verification or falsification of theories for it is in the very nature of human knowledge to be of a probabilistic character. Truth has only degrees. The metho-

https://doi.org/10.1177/039219218403212805 Published online by Cambridge University Press

dology of science seeks the highest degree of truth and, indeed, it is the only method which has turned out to be the most successful. Reichenbach, however, seems to stress only the methods of *generating* theories so that more and more general theories are constructed by concatenation of inductions, predictability being the major criterion of acceptance of theories. But scientists usually do not and cannot ignore the search for more and more efficient and novel ways of giving crucial experimental tests to the theories. Observations are often made not with an eye on inductive generalisations but on testing. Thus, condition 4(i) seems only partially true. Further, in condition 4(ii) the notion of inductive expansion involves only prolonged study of facts so that after their proper assimilation in the imagination, that theory is generated which has an intrinsic relation with the facts in question. Indeed, this may be the central feature of scientific practice but it is not all. A scientist surveys and assimilates relevant literature, designs experiments and apparatus before embarking upon the gathering of facts and their inductive interpretation. These steps, therefore, are essential features of the scientific technique of theorisation.

Criterion (4')-ii has often been criticised on the grounds that a limit to frequency can never be established. But although the limit be tentative, it can be relied upon if it leads to the largest number of successes in our actions. This, however, is only a reiteration of Hume's position who had agreed that practice is the only guide. Therefore the condition in its present form does not take us an inch farther from Hume. Reichenbach points out that it is not in the powers of human beings to realise the sufficient conditions of adequacy of theoretical knowledge they acquire. However, he does not indicate what those sufficient conditions are and why humans cannot realise them.[16]

These conditions for adequacy of any technique of theorisation (1-4) and for adequacy of theoretical knowledge (1'-4') appear upon

[16] One of the classical Indian texts on technique of spiritual liberation takes up the question of epistemological preconditions of liberation. In the course of this, it provides the necessary and sufficient conditions for the realisation of true knowledge of objects as well as of self. These are called *vrttinirodh* (control of internal perturbation) and *samskar nirodh* (control of inherited and acquired propensities and attitudes). See Patanjali, *Yoga Sutra*. Also see V. Shekhawat, *Yoga: A Technique of Liberation*, New Delhi, Sterling Pub., 1979.

examination to be only partial and they cannot answer the question: when shall any technique of theorisation and the theoretical knowledge yielded by it be *ideally* adequate? It is clear by now that the place of investigator is central in the knowledge process. Scientific research is indeed very sensitive to the psychological state of the scientist. In it only those investigators prove effective who make fewer wrong decisions at the countless crossroads which are confronted during the course of a typical research problem.[17]

Technique of Theorisation and Theoretical Knowledge

8. Scientific research is indeed a very complex activity and its algorithm cannot be worked out. But one can notice the typical major steps that are indispensably involved in it, such as locating, understanding, and formulating the problem, searching and assimilating the relevant literature, designing experiments and apparatus, execution of experiments and collection of facts, precautions in measurement and errors, analysis and classification of data, interpreting them in the framework of a mathematical deductive theory, making numerical computations and reporting the results of research. All these aspects of scientific practice should be implicitly or explicitly incorporated in the adequacy criteria of any technique of theorisation.

The above considerations ought to make it clear that adequacy criteria have to be sought at three levels: at the level of the investigator or the knowing subject, at the level of the technique and at the level of the theory yielded by the technique. The epistemic prerequisites of something having been known properly can be put in the form of necessary and sufficient conditions as follows:

An object of knowledge is known properly if, and only if:

[17] "An exploration into the unknown cannot be planned in advance with the precision of a mass-production process. Nevertheless, some investigators are far more effective than others... We have no way of acquiring the inborn wisdom which is mostly responsible for their success, but perhaps there are a few techniques which we can learn from them". See E. Bright-Wilson, Jr., *An Introduction to Scientific Research*, New York, McGraw-Hill Book Co., 1952, p. iii.

i) the investigator or the knowing subject S is *competent* to know it,
ii) the technique adopted is *adequate* to yield the knowledge of the object,
iii) the knowledge is adequately theoretical .... (5)

Now, the methods adopted in scientific research involve making statements and judging them correctly as true or false; and making decisions and judging others correctly as right or wrong—the latter influencing practice. This intrinsic praxiological element in scientific research makes its epistemology a complex affair. Knowledge is not acquired in a single act but through a protracted process and the ideal of overcoming error demands that statements and decisions be judged *objectively*. If a hypothesis is too dear to one's heart, one will be *inclined* to establish it and subjectivity will permeate judgement. Therefore, unless the investigator constantly strives to overcome the subjective error,[18] he would be an incompetent seeker. Similar considerations suggest the following competence criteria for the knowing subject:

The knowing subject S is competent to know the object of knowledge O if, and only if:
i) S has attained sufficient control over all internal perturbation,
ii) S reasons coherently in the face of doubt and disagreement,
iii) S makes observations and measurements within a reasonable margin of error,
iv) S judges statements and decisions fairly objectively .. (6)

If these conditions are satisfied to a satisfactory level, no disciplinary matrix will be embraced dogmatically and will be supported or rejected on objective grounds which will consequently guarantee fullest confrontation with facts and their objective interpreta-

[18] *Klesas* or impediments to true knowledge constitute the *subjectivity* of the knowing subject and their elimination (*Eklesa han*) amounts to overcoming subjectivity error. The objective errors arising due to the dynamic, unstable and deceptive nature of the object of knowledge are sought to be overcome by measurement. See V. Shekhawat, *Concept of Science and the Yoga Sutra*, private circulation, Philosophy Department, University of Rajasthan, Jaipur, 1982.

tion. The community of competent investigators is the first epistemic requirement which the above conditions make explicit.

Any technique for seeking knowledge proper moves by the ideal of overcoming error in the existing knowledge—such as the world-view embraced at the level of common sense, which inspires the knowing subject to embrace the world-views with less and less error. The error may be quantitative as well as qualitative. During the period of perfection of a certain world-view the error is quantitatively lessened whereas new views are generally embraced because the errors get qualitatively minimised. Apart from this ideal of continuous lessening of error, techniques also move by the ideal of universalism characterised by a set of operations. Any technique of theorisation of knowledge presumes a set of competent investigators who *explore* the facts, *posit* hypotheses or conjectures, *examine* these by further explorations and critical tests and *reject* or *accept* them on objective grounds. The following conditions of adequacy of any technique of theorisation are based on considerations such as these and others:

A technique T of theorisation of knowledge is adequate if, and only if:

i) there are criteria of objectivity within T,
ii) statements and decisions within T are objective,
iii) there are procedures within T of establishing the objectivity of statements and decisions. The procedures are adequate if, and only if:

a) pursued by a community of competent investigators,
b) fullest confrontation with facts is guaranteed (better and better design of experiments and embracing of any disciplinary matrix sceptically),
c) procedures of interpreting the facts are such that they yield the best posit with greatest successes,
d) the posits are critically examined rationally and empirically over and over again,
e) only when anomalous facts accumulate to a degree, the community declares without fail the existing disciplinary matrix inadequate and an alternative is sought .... (7)

Condition (iii)-b makes the existence of incommensurable alternatives unnecessary because if no disciplinary matrix is too dear to one's heart and one continuously entertains the possibility of its being inadequate, the attitude will guarantee fullest confrontation with facts. Condition (iii)-e provides stability to the knowledge process as also it guarantees its dynamics.

Now, all knowledge need not be theoretical; it can be classificatory or merely descriptive. Theoretical knowledge provides us *laws* which other kinds of knowledge do not. It has generally been characterised by its *explanatory power, predicative power* and so on. Since, however, it presumes the principle of causation, its validity cannot be established, following the criticism of Hume, on purely logical grounds. Criteria of correspondence or of largest number of successes in practice or actions are not enough. But theoretical knowledge yields *technology*. That is to say, it provides *control* over the object of which it is the knowledge. This *power of control* must be a proof of its validity, it being valid to the degree to which it provides the control. This may also be called the *causal power* of the theory, which must provide a sufficient condition of its adequacy. These considerations give rise to the following conditions:

A piece of theoretical knowledge K about the object of knowledge O is adequate if, and only if:

i) K has been obtained by an adequate T,
ii) K explains why O, i.e. provides the causes of O, subsumes O under a causal law,
iii) K is consistent or deductively linked with other Ks in the domain,
iv) K is sensitive to error in the domain, i.e. successfully solves puzzles and tackles anomalies in the domain,
v) K has highest degree of predictability leading to the largest number of successes,
vi) K provides the highest degree of control over O ..... (8)

Conditions (8) indicate a conception of theoretical knowledge not absolutist but *optimalist*. If the knowing subject must continuously entertain doubt that the knowledge in question *may or may not* be true, must live with some anomalies and some discrepant facts, then indeed the ideal of absolute elimination of error would be a mere fantasy. But the knowing subject must and can seek optimisation of error which an adequate technique would guarantee. A piece of theoretical knowledge that seeks absolute elimination of error will be too sensitive and therefore will have too many discrepant facts; if it cares too little for error it will be a mere pseudo-theory. A technique of theorisation that seeks absolute elimination of error will have to reject both reason and senses as instruments of knowledge; if it allows too many errors it will yield inadequate knowledge. Condition 8-v above is a sufficient condition of adequacy of any theoretical knowledge and gives indirect support to conditions (7) of the adequacy of the technique that yields such knowledge. A theory need not be unfalsified in so far as it satisfies this condition of control and other conditions in (8). Further, any piece of knowledge which is inconsistent with (8) must provide alternative and inconsistent ways of control if it is to prove its adequacy.

Virendra Shekhawat
(*University of Rajasthan*)

https://doi.org/10.1177/039219218403212805 Published online by Cambridge University Press