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Some Reflections on Whewell's Scientific Methodology

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In this essay the focus will be given on the most important philosophical aspect of Whewell's works: his scientific methodology, including his views of induction, confirmation, and necessary truth; his view of the relation between scientific practice, history of science, and philosophy of science. Whewell's scientific methodology deserves equal importance and significance like that of Newton, Mill, Brodie, Earnst Mach, Pierre Duhem and so on of the contemporary methodologists. His philosophy of science was attacked by John Stuart Mill in his *A System of Logic*, causing an interesting and fruitful debate between them over the nature of inductive reasoning in science, moral philosophy, and political economy. This essay will also try to analyse the intellectual debate that happened between Whewell and Mill specifically on the concept of methodology. Moreover the significance of Whewell's view regarding the nature of methodology, nature of necessaey truth, confirmity of scientific hypothesis will be examined and commented upon.

The Concept of Methodology

Methodology is defined sometimes as "a body of methods, rules, and postulates employed by a discipline", or "a particular procedure or set of procedures", or "the analysis of the principles or procedures of inquiry in a particular field." The common idea here is the collection, comparative study, and the critique of the individual methods that are used in a given discipline or field of inquiry. Inducton is one of the basic scientific methods. Throughout the ages "Induction has also been used to name a more specific kind of scientific argument i.e.one where we argue from several particular cases to the truth of a generalization covering them."[1] Like induction there are also diferent methods that are widely used in respect of scientific inquiry. Methods used not only in scientific i.e. naturel sciences but also in the field of social science to find out the required solution of a certain social problem. In all these respects both analysis and logical predicton play the vital role. Therefore it can be said that method is the name of procedure and methodology is the name of the subject that study on method.

The scientific method is the process by which scientists endeavor to construct an accurate that is, reliable, consistent and non-arbitrary, representation of the world. It attempts to minimize the influence of bias or prejudice in the experimenter when testing an hypothesis or a theory. Generally, the scientific method has four steps, a) Observation and description of a phenomenon or group

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of phenomena. b) Formulation of an hypothesis to explain the phenomena. In physics, the hypothesis often takes the form of a causal mechanism or a mathematical relation c) Prediction i.e.use of the hypothesis to predict the existence of other phenomena, or to predict quantitatively the results of new observations and d) Performance of experimental tests of the predictions by several independent experimenters and properly performed experiments. But I.M.Copi showed that there are seven steps of scientific investigation.[2] If the experiments bear out the hypothesis it may come to be regarded as a theory or law of nature . If the experiments do not bear out the hypothesis, it must be rejected or modified. Thus the task of the scientists become meaningful as they introduce a suitable method for their research and investigaton.

The scientific method is intricately associated with science, the process of human inquiry that pervades the modern era on many levels. While the method appears simple and logical in description, there is perhaps no more complex question than that of knowing how we come to know things. The scientific method distinguishes science from other forms of explanation because of its requirement of systematic experimentation and in this respect the methodology of science plays the vital role. For example the the main issue that distinguishes science from philosophy is the method generally used by the respective subjects, though both origined from the same root, have the same target point (finding out the real truth).

It is universally held that the essence of the study of philosophy of science is methodology. The philosophy of science attempts first to elucidate the elements involved in scientific inquiry - observational procedures, patterns of argument, methods of representation and calculation and metaphysical presuppositions - and then to evaluate the grounds of their validity from the points of view of formal logic, practical methodology, and metaphysics. The philosophy of science is thus a topic for explicit analysis just as are other subdivisions of philosophy. They study, from a philosophical perspective and the elements of scientific inquiry and of their validity. Among the methods used in science are the methods of induction, deduction, causation, experiment, observation and so on. Philosophy of science deals with whether the methods used by the scientists are logically valid or not, whether science requires the necessary truths or not, whether the truth dealt by the scientists are universal or merely particular. Therefore historically speaking we can conclude that philosophy of science deals with the views of F. Bacon, William Whewell, J. S. Mill, I Kant, Carnap, Otto Neurath, Karl Popper, T. S Kuhn, I. Lakatos, P. Fayeraband and so on regarding methodology. In this paper the methodology suggested by William Whewell in respect of scientific investigation will be examined and commented upon.

A. Whewell's View on Epistemology

William Whewell's view regarding induction is found in his epoch-making book "Philosophy of Inductive Sciences(1857)","On The Philosophy of Discovery (1856)", "The History of Scientific Ideas (1858)" and in the "Novum Organon

Renovatum (1858)". One of his inspiring force for such thinking is the Philosophy of F. Bacon. Throughout the writings of Whewell, we get his view regarding one of the most important methods of scientific inquiry i.e. induction. William Whewell "spoke of the inductive science simply to contrast them with the deductive science of logic and the various branches of mathematics."[3]

According to Whewell, knowledge of all kinds has two dimensions: subjective and objective. He called this the "fundamental antithesis" of knowledge. Whewell explained that "in every act of knowledge ... there are two opposite elements, which we may call Ideas and Perceptions."[4] "Knowledge, Whewell thought,was not derived from the senses but was a product of sensations and ideas"[5]. Like Francis Bacon, Whewell sought a "middle way" between pure rationalism and ultra-empiricism. He believed that knowledge requires attention to both ideal and empirical elements, to ideas as well as sensations.

Whewell thinks that a particular fundamental idea is needed in every science to organize the facts with which that science is concerned; thus, in geometry the Fundamental Idea is Space, Cause is the Fundamental Idea of mechanics, and Substance the Fundamental Idea of chemistry.. Whewell also says that each Fundamental Idea has certain "conceptions" included within it; these conceptions are "special modifications" of the Idea applied to particular types of circumstances. For example, the conception of force is a modification of the Idea of Cause, applied to the particular case of motion[6]. The Ideas provide a structure by expressing the general relations that exist between our sensations.[7] For Whewell these "Fundamental Ideas," are "supplied by the mind itself" — they are not exclusively depends on our observations of the world. Whewell explained that the Fundamental Ideas are "not a consequence of experience, but a result of the particular constitution and activity of the mind, which is independent of all experience in its origin, though constantly combined with experience in its exercise."[8] The multitude sensation that we experience are formed through the fundamental ideas like Space, Time, Cause, and Resemblance. Thus, the Idea of Space allows us to apprehend objects as having form, magnitude, and position. Whewell held, then, that observation is "idea-laden;" all observation, he noted, involves "unconscious inference" using the Fundamental Ideas.[9]

From such discussion of the Fundamental Ideas some commentators like Robert E.Butts, and Gerd Buchdhal argue that Whewell's epistemology is a type of Kantianism. However, this interpretation ignores several crucial differences between the two views. ***Firstly*** Whewell did not follow Kant in drawing a distinction between "precepts," or forms of intuition, such as Space and Time, and the categories, or forms of thought, in which Kant included the concepts of Cause and Substance. ***Secondly*** Whewell included as Fundamental Ideas many ideas which function not as conditions of experience but as conditions for having knowledge within their respective sciences: although it is certainly possible to have experience of the world without having a distinct idea of, say, Chemical Affinity, we could not have any knowledge of certain chemical processes without it. ***Thirdly*** Whewell did not attempt to give an exhaustive list of these Fundamental Ideas as done by Kant; indeed, he believed that there are others which will emerge in the course of the development of science. ***Fourthly*** Whewell rejected Kant's claim that we can only have knowledge of our "categorized experience." The Fundamental Ideas, on Whewell's view, accurately represent objective features of the world, independent of the processes of the mind, and we can use these Ideas in order to have knowledge of these objective features. ***Sixthly***, Whewell's justification for the presence of these concepts in our minds takes a very different form than Kant's transcendental argument. For Kant, the categories are justified because they make experience possible. For Whewell, though the categories *do* make experience (of certain kinds) possible, the Ideas are justified by their origin in the mind of a divine creator. And ***Finally***, the type of necessity which Whewell claimed is derived from the Ideas is very different from Kant's notion of the synthetic a priori. Therefore it is hardly right to tell that the view regarding epistemology of Kant and Whewell is symmetrical, though both of them emphasised on empirical as well as rational faculty of knowledge.

Whewell on Induction

In his *Philosophy of the Inductive Sciences* Whewell first explicitly discussed about the nature of induction. Basically it is that which is founded upon the historical aspect of the law of induction. The book was originally published in 1840 (a second, enlarged edition appeared in 1847, and the third edition appeared as three separate works published between 1858 and 1860). Regarding the nature of induction he puts that "...in Deduction we infer particular from general truth; while in induction we infer general from the particular"[10] He called his induction "Discoverers' Induction" and explained that both phenomenal and causal laws can properly be discovered through this method. Considering himself as a follower of Bacon, Whewell claimed to be "renovating" Bacon's inductive method; thus one volume of the third edition of the Philosophy is entitled *Novum Organon Renovatum*. "by induction ,by simple enumeration Bacon means something like the induction from the observation of several thousand white Swan to the conclusion that the next Swan will be white."[11] Like Bacon Whewell rejected the standard, overly-narrow notion of induction that holds induction to be merely simple enumeration of instances. Whewell contends that, in induction, "there is a New Element added to the combination [of instances] by the very act of thought by which they were combined."[12] This "act of thought" is a process Whewell called "colligation." According to Whewell, Colligation is the mental operation of bringing together a number of empirical facts by "superinducing" upon them a conception which unites the facts and renders them capable of being expressed by a general law.

For example, the known points of the Martian orbit were colligated by Kepler using the conception of an elliptical curve. Often new discoveries are made, Whewell pointed out, not when new facts are discovered but when the appropriate conception is applied to the facts. In the case of Kepler's discovery, the observed points of the orbit were known to Tycho Brahe, but only when Kepler applied the ellipse conception was the true path of the orbit discovered. Kepler was the first one to apply this conception to an orbital path in part because he had, in his mind, a very clear notion of the conception of an ellipse.

Whewell maintains that "the Ideas, the germs of them at least, were in the human mind before [experience]; but by the progress of scientific thought they are unfolded into clearness and distinctness."[13] He explains this "unfolding" of ideas and conceptions as the "explication of conceptions."Explication is a necessary precondition to discovery which consists in a partly empirical, partly rational process. It is explained as;

> " The addition of new data to the scientist's stock of unexplained facts makes demand upon his stock of conception, which sometimes can be met from the stock on hand, but sometimes not. New data require that concepts be refined, analyzed, made more precise, in what Whewell called the explication of conception."[14]

Scientists first try to clarify and make explicit a conception in their minds, then attempt to apply it to the facts they have precisely examined, to determine whether the conception can colligate the facts into a law. If not, the scientists use this experience to attempt a further refinement of the conception. Whewell claimed that a large part of the history of science is the "history of scientific ideas," that is, the history of their explication and subsequent use as colligating concepts. Thus, in the case of Kepler's use of the ellipse conception, Whewell noted that

> "to supply this conception, required a special preparation, and a special activity in the mind of the discoverer. ...To discover such a connection, the mind must be conversant with certain relations of space, and with certain kinds of figures."[15]

If a conception has been explicated, it is possible to choose the appropriate conception with which to colligate phenomena. But how is the appropriate conception chosen? According to Whewell, choosing an appropriate conception is not a matter of guesswork. Nor is it a matter of observation only. Whewell explained that "there is a special process in the mind, in addition to the mere observation of facts, which is necessary."[16] This "special process in the mind" is a process of inference. Whewell claimed that "We infer more than we see." He allows any type of inference in the colligation, including enumerative, eliminative and analogical.

The second step of Whewell's discoverers' induction is generalization; the generalization of the shared property over the complete class, including its unknown members. After the known members of a class are colligated with the use of a conception this second step is occurred. As Whewell exemplified, once Kepler supplied the conception of an ellipse to the observed members of the class of Mars' positions, he generalized it to all members of the class, including those which were unknown (unobserved), to reach the conclusion that all the points of Mars' orbit lie on an ellipse with the sun at one focus. He then performed a further generalization to reach his first law of planetary motion that the orbits of all the planets lie on ellipses with the sun at one focus.

As Whewell thought of himself as renovating Bacon's inductive philosophy his inductivism does share numerous features with Bacon's method of interpreting nature. Both Bacon and Whewell admits that induction must involve more than merely simple enumeration of instances, that science must be proceed by successive steps of generalization, that inductive science can reach unobservables (for Bacon, the "forms," for Whewell, unobservable entities such as light waves or properties such as elliptical orbits or gravitational forces). But some of the 20th century methodologists such as Butts, Buchdahl, Laudan , Niiniluoto, and Ruse objected that Whewell was an anti-inductivist in the Popperian shape. It is claimed that Whewell endorses a "conjectures and refutations" view of scientific discovery like K.Popper.[17] However, it is clear from the above discussion that his view of discoverers' induction does not resemble the view asserting that hypotheses can be and are typically arrived at by mere guesswork. Moreover, Whewell explicitly rejects the hypothetico-deductive claim that hypotheses discovered by non-rational guesswork can be confirmed by consequentialist testing. For example, in his review of his friend Herschel's *Preliminary Discourse on the Study of Natural Philosophy*, Whewell argued, against Herschel, that verification is not possible when a hypothesis has been formed non-inductively.Yet, surprisingly, the received view of Whewell's methodology in the 20th century has tended to describe Whewell as an anti-inductivist in the Popperian mold.[18]

Whewell's philosophy of science cannot be described as the hypothetico-deductive view according to which "if the predications of a theory match with what is observed then those observations confirm the theory."[19] It is an inductive method; yet it clearly differs from the more narrow inductivism of Mill. Whewell's view of induction has the advantage over Mill's of allowing the inference to unobservable properties and entities. The hypothetico-deduction is also explained as "the thesis that science proceeds by hypothizing general statements, deriving observational consequences from them, testing these consequences to indirectly confirm the hypothesis."[20]

A. Whewell's view on the laws of confirmity of Science

Confirmation plays the symmetrical role as justification plays in respect of epistemology. Now a days the main problem of epistemology is the problem of the justification of the statement that expresses the definiton of knowledge.

Without being justified by no statement can be accepted as a proposition of knowledge. Whewell thinks that the theory that has been invented by the discoverers' inducton, must pass a variety of tests before it can be considered as an empirical truth. These tests are

i) the test of prediction

ii) the test of consilience

iii) the test of coherence.[21]

B.1 The test of prediction

Prediction is necessary both in respect of science and logical reasoning. Sometimes the act of prediction and that of inference are used as synnonymus. Prediction is necessary for hypothesizing. It is one of the basic steps of hypothesis. Whewell says that since our hypotheses are in universal form, a true hypothesis will cover all particular instances of the rule, including past, present, and future cases. As he asserts that,

> "Our hypotheses ought to foretell phenomena, "at least all phenomena of the same kind," Whewell explained, because "our assent to the hypothesis implies that it is held to be true of all particular instances. That these cases belong to past or to future times, that they have or have not already occurred, makes no difference in the applicability of the rule to them. Because the rule prevails, it includes all cases."[22]

He claims that successful predictions of unknown facts provide greater confirmatory value than explanations of already-known facts. Thus he held the historical claim that "new evidence" is more valuable than "old evidence." He believed that "to predict unknown facts found afterwards to be true is ... a confirmation of a theory which in impressiveness and value goes beyond any explanation of known facts."[23]

Whewell also maintains that if the theory is true then there will obviously be an agreement between the prediction and the occurance i.e. the prediction will turn to be true or correct. But if the theory fails to be true, it will be quite unaccountable. For example, if Newtonian theory were not true, he argued, the fact that from the theory we could correctly predict the existence, location and mass of a new planet, Neptune (as did happen in 1846), would be bewildering, and indeed miraculous.

B.2 The test of consilience

According to Whewell, the second and the most valuable criterion of confirmation of scientific hypothesis is that of "consilience." Whewell explained that

> "the evidence in favour of our induction is of a much higher and more forcible character when it enables us to explain and determine [i.e., predict]

> cases of a *kind different* from those which were contemplated in the formation of our hypothesis. The instances in which this have occurred, indeed, impress us with a conviction that the truth of our hypothesis is certain."[24]

Whewell identifies this type of evidence a "jumping together" or "consilience" of inductions. An induction, which results from the colligation of one class of facts, is found also to colligate facts successfully belonging to another class. Whewell's notion of consilience is thus related to his view of natural classes of objects or events.

This confirmation criterion can be better understood by schematizing the "jumping together" that occurred in respect of Newton's law of universal gravitation. Whewell says that it was a case of consilience. He thought that Newton used the form of inference -the "discoverers' induction" in order to reach his universal gravitation law, the inverse-square law of attraction . The process of reaching at such law is explained by Newton in his Principia where he produced some propositions regarding the formulation of the law. These propositions are empirical laws that are inferred from certain "phenomena". The first such proposition or law is that "the forces by which the circumjovial planets are continually drawn off from rectilinear motions, and retained in their proper orbits, tend to Jupiter's centre; and are inversely as the squares of the distances of the places of those planets from that centre." The result of another, separate induction from the phenomena of "planetary motion" is that "the forces by which the primary planets are continually drawn off from rectilinear motions, and retained in their proper orbits, tend to the sun; and are inversely as the squares of the distances of the places of those planets from the sun's centre." Newton saw that these laws, as well as other results of a number of different inductions, coincided in postulating the existence of an inverse-square attractive force as the cause of various classes of phenomena. Whewell views, Newton saw that these inductions "leap to the same point;" i.e., to the same law. Newton was then able to bring together inductively (or "colligate") these laws and facts of other kinds of events (e.g., the class of events known as "falling bodies", into a new, more general law, namely the universal gravitation law: "All bodies attract each other with a force of gravity which is inverse as the squares of the distances." By seeing that an inverse-square attractive force provided a cause for different classes of events — for satellite motion, planetary motion, and falling bodies — Newton was able to perform a more general induction, to his universal law.

Finding of Newton was that these different kinds of phenomena — the circumjovial orbits, the planetary orbits, as well as the falling bodies — share an essential property, namely the same cause. Whewell maintains that What Newton did, in effect, was to subsume these individual "event kinds" into a more general natural kind comprised of sub-kinds sharing a kind essence, namely being caused by an inverse-square attractive force. Consilience of event-kinds therefore results in *causal unification*.

Phenomena that constitute different event kinds, such as "planetary motion," "tidal activity," and "falling bodies," were found by Newton to be members of a unified, more general kind, "phenomena caused to occur by an inverse-square attractive force of gravity" (or, "gravitational phenomena"). In such cases, according to Whewell, we learn that we have found a "vera causa," or a "true cause," i.e., a cause that really exists in nature, and whose effects are members of the same natural kind. In addition. when we find a cause 'shared by phenomena in different sub-kinds', we become able to colligate all the facts about these kinds into a more general causal law. Whewell claimed that

> "when the theory, by the concurrences of two indications ... has included a new range of phenomena, we have, in fact, a new induction of a more general kind, to which the inductions formerly obtained are subordinate, as particular cases to a general population."[25]

He noted that consilience is the means by which we effect the successive generalization that constitutes the advancement of science.

B.3 The test of coherence

The third test of a theory's truth as dicussed by Whewell is "coherence." Whewell claimed,

> "the system becomes more coherent as it is further extended. The elements which we require for explaining a new class of facts are already contained in our system....In false theories, the contrary is the case."[26]

The test of coherence is occurred when we tend to extend our hypothesis to colligate a new class of phenomena without ad hoc modification of the hypothesis. For example, When Newton extended his theory regarding an inverse-square attractive force, which colligated facts of planetary motion and lunar motion, to the class of "tidal activity," he did not need to add any new suppositions to the theory in order to colligate correctly the facts about particular tides. But Whewell says that when phlogiston theory, which colligated facts about the class of phenomena "chemical combination," was extended to colligate the class of phenomena "weight of bodies," it was *unable* to do so without an ad hoc and implausible modification[27] (namely, the assumption that phlogiston has "negative weight") Thus coherence can be seen as a type of consilience that happens over time; indeed, Whewell remarked that these two criteria — consilience and coherence — "are, in fact, hardly different."[28]

B. The nature of necessary truth

Logically truths are of two types- contingent and necessary. According to the first, a statement is true contingently "whose truth is dependent on the way things actually are in nature, and not dependent on purely logical or other grounds we could know about without experience."[29] The reverse of it is the necessary truth. One of the most significant aspects of Whewell's philosophy of science is his claim that empirical science can reach necessary truths. Whewell explained that,

> "Necessary truths are truths which can be known a priori; they can be known in this way because they are necessary consequences of ideas which are a priori. They are necessary consequences in the sense of being analytic consequences; Whewell explicitly rejected Kant's claim that necessary truths are synthetic. Using the example "7 + 8 = 15," Whewell claimed that "we refer to our conceptions of seven, of eight, and of addition, and as soon as we possess the conceptions distinctly, we see that the sum must be 15." That is, merely by knowing the *meanings* of "seven," and "eight," and "addition," we see that it follows necessarily that "7 + 8 = 15."[30]

Once the Ideas and conceptions are explicated, so that we understand their meanings, the necessary truths which follow from them are seen as being necessarily true. Thus, once the Idea of Space is explicated, it is seen to be necessarily true that "two straight lines cannot enclose a space." Whewell suggested that the first law of motion is also a necessary truth, which was knowable a priori once the Idea of Cause and the associated conception of force were explicated. This is why empirical science is needed to see necessary truths: because, as we saw above, empirical science is needed in order to explicate the Ideas.

Whewell firmly insisted that the relations which hold among conceptions and ideas are necessary.that the light travels through the straight line, that heat is aform of energy, that action is equal and opposite to reaction were all necessary truth for whell, sincethey express relations between ideas ane between conceptions. He also says that the relation may be a contingent one when the related facts are colligated. Therefore, facts or relations are either necessary or contingent. He thinks that each branch of science has its axioms and definitions which are in themselves necessary truths e.g. axioms in Geometry; but whether they are the appropriate axioms and definitions to bring order to a field of phenomena is contingent.[31]

Whewell also claimed that, in respect of science, truths which at first required experiment to be known are seen to be capable of being known independently of experiment. That is, once the relevant Idea is clarified, the necessary connection between the Idea and an empirical truth becomes apparent. Whewell explained that

> "Though the discovery of the First Law of Motion was made, historically speaking, by means of experiment, we have now attained a point of view in which we see that it might have been certainly known to be true independently of experience."[32]

Science, then, consists in the "idealization of facts," the transferring of truths from the empirical to the ideal side of the fundamental antithesis. He described this process as the "progressive intuition of necessary truths."Although they follow analytically from the meanings of ideas our minds supply, necessary truths are nevertheless informative statements about the physical world outside us; they have empirical content.

Whewell drew no distinction between truths which can be idealized and those which cannot; thus, potentially, any empirical truth can be seen to be a necessary truth, once the ideas and conceptions are explicated sufficiently. For example, Whewell suggests that experiential truths such as "salt is soluble" may be necessary truths, even if we do not recognize this necessity (i.e., even if it is not yet knowable a priori). Whewell's view thus destroys the line traditionally drawn between laws of nature and the axiomatic propositions of the pure sciences of mathematics; mathematical truth is granted no special status.

B. Whewell-Mill Debate

Both Whewell and Mill are inductionist. Both were the follower of F. Bacon- the father of modern methodology of science. Both of them maintain that induction is the proper method of scientific inquiry. Induction, hypothesis etc. are the necessary steps for scientific investigation, for finding out the causal relation among the phenomenon, as hold by both Whewell and Mill. "For Mill, the central problem in the Philosophy of Science was to give a correct account of the function of the particular facts of observation and experiment; for Whewell, it was to give a correct account of the functon of theory. For Mill, all knowledge was sensory in origin; for Whewell some part of the items of knowledge was contributed by the knower."[33]

Whewell and Mill disagreed upon two major issues. Those are , firstly, the matter of the necessity of the relation among ideas and conceptions and secondly, in respect of the nature of the relation between theories and facts. Whewell accepted the possibility and significance of necessary truth in case of natural sciences and mathematics though he contended that the source of these necessary truth is empirical analysis. He holds that necessary propositions are involved in the foundation of all sciences. On the other hand, Mill was not prepared to concede even the axiom of mathematics as necessary truth. For him those are extremely well grounded gwnwraliation of experience.i contrast to Whewell, Mill says that conceptions are not added to the facts but seen in them. He cited kepler's investigation in favour of his view. He argued that kepler didn't approach the jumble of Martian observations with the ellipse and then find that this concept unified the data rather he eventually saw that ther is no necessary of the kind Whewell believed in.

Mill thought scientists seek to explain as well as predict and describe the facts of nature. For him, explanaton involved postulation of causation and the root to both explanation and act of predication is the rendering particulars general by induction. He thinks that the tasks of the logicians was to identify the schemeta by whichgeneralization can be drawn properly from the particular. He rejects the idea that explanation and prediction is logically identical. Whereas Mill says that induction is a process of discovering and proving the general proposition, Whewell contends that induction is the process of discovering and and buiding up general proposition. For Whewell, "All As are Bs" is not a general proposition if it is a mere juxta-proposition of particular case rather there is some general ideas introduced by mind not by the phenomena. He contends that though "All As are Bs" is a general proposition in the sense that it applies to all relevant instances, it does not connect or unify the facts i.e. it does not colligate the facts. Therefore, Whewell's view of induction differ from that of Mill accepted as the standard view of inducton.the view of Whewell and Mill is differrent in respect of the nature of induction. A scientific example may help us to understand it.

Whewell and Mill argued over Kepler's discovery of the elliptical motion of Mars. Kepler started with observations of the position of Mars relative to the sun at various times. These observations might be represented as points scattered around the sun, from which Kepler inferred that Mars's orbit is an ellipse. As in any example of curve-fitting, the data points are the pearls and the curve is the string. Whewell and Mill can agree that the conclusion of the inference is that "All positions of Mars lie on ellipse b", where b is the name of a particular ellipse. So, in this example, the predicate A is "is a position of Mars" and B is "lies on ellipse b." But Mill has to say that the data are of the form "at time t1 Mars lies on ellipse b, at time t2 Mars lies on ellipse b, and so on." For Mill, the predicates that appear in the general proposition also appear in the description of the data. On the other hand, Whewell considers the data to contain no mention of the ellipse b, or any ellipse, so "lying on ellipse b" is a new conception that colligates the data. The data are "at time t1 Mars is at position x1, at time t2 Mars is at position x1, and so on. For Whewell, the facts and the conception are then bound together so as to give rise to those general propositions of which science consists. So, Kepler's conclusion is general in the sense that the general conception of an 'ellipse' is "superinduced" upon the facts, and is not a "mere union of parts" or a "mere collection of particulars." (Butts, 1989, p. 163.) That is why Whewell sees Kepler's inference as a colligation and therefore, a genuine induction. So, Mill and Whewell have substantively different view though both agree that it is an induction[34].

Whewell introduced the term "colligation" to refer to the process of conceptualizing observational data. This is the *essential* part of induction for Whewell and he used the terms "induction" and the "colligation of facts" interchangeably. Mill agreed with most of what Whewell had to say about colligation, but viewed this as a process that occurs separate from and prior to genuine induction. Whewell claims that the colligation is an essential to the consilience of inductions, which is essential to the *justification* of scientific theories.

Colligation, for Mill, is a part of the *discovery* process, or the process of invention, whereas induction is relevant to questions of justification. Whewell's characterization of induction, Mill objects, belongs to (what we might call) the 'context of discovery,' and Mill thinks that Whewell confuses them. Accordingly Mill charges that "Dr Whewell calls nothing induction where there is not a new mental conception introduced and everything induction where there is." "But," he continues, "this is to confuse two very different things, Invention and Proof." "The introduction of a new conception belongs to Invention: and invention may be required in any operation, but it is the essence of none." Abstracting a general proposition from known facts without concluding anything about unknown instances, Mill goes on to say, is *merely* a "colligation of facts" and bears no resemblance to induction at all[35].

Though it is true that Whewell thinks that mental acts are essential at every stage of scientific progress, and that mental acts are essential to invention or discovery but to say that they are essential to discovery does not imply that they are not also essential to justification. So, Mill has no good reason to accuse Whewell of confusing invention and proof. In fact, Whewell concerns himself extensively with delineating between invention (i.e. colligations) and justification (i.e., Consiliences of Inductions). As we shall see below, Whewell's notion of consilience requires that the conceptions involved in an induction have to agree, or jump together, in order for a consilience to occur. For Whewell, colligation is the essential feature of any induction, and is therefore essential to any consilience *of inductions*, and therefore essential to the justification of theories since consiliences constitute such justification. This is why the context of discovery is an inseparable part of the context of justification for Whewell. But Whewell never confuses discovery and justification; he is clear in his view that a colligation is not justification by itself.

The act of conceptualization is necessary is respect of induction. Though Whewell and Mill differ in their position, both of them thinks that it is important in case of justification of scientific statement. Mill holds that conceptualization occurs prior to an induction but Whewell thinks that it occurs during the induction. The issue is significant as, if conceptualization is prior to experience, then it plays a very important role in scientific hypothesis. For Whewell, Conceptualization plays an essential justificatory role, but not for Mill.

There is another closely related issue that is relevant. Mill claims that the property of "lying on ellipse *b*" is determined by and read from the data themselves. If this empiricist view of concepts is correct, then it is hard to see why conceptualization should matter to theory comparison, because all competing theories will be on the same footing. According to Mill (Mill's emphasis):

> Kepler did not *put* what he had conceived into the facts, but *saw* it in them... A conception implies, and corresponds to, something conceived: and though the conception itself is not in the facts, but in our very mind, yet if it's to convey any knowledge relating to them, it must be a conception *of* something which really is in the facts . . ."[36]

Whewell does not deny that the regularities in nature exist before we perceive *or* conceive them; he does not reject the claim that the orbit of Mars was elliptical before anyone knew that to be true. Rather, Whewell thinks that Kepler placed the data "in a new system of relations with one another" was not determined by the data themselves. The interpretation of the data is theory-dependent. This is especially clear in curve-fitting examples, which Whewell talks about in some detail. According to Whewell, "the Colligation of ascertained Facts into general Propositions" consists of (1) the *Selection of the Idea*, (2) the *Construction of the Conception*, and (3) the *Determination of the Magnitudes*. In curve fitting, these three steps correspond to (1) the determination of the *Independent Variable*, (2) the *Formula*, and (3) the *Coefficients*[37]. In the Kepler example the independent variable is 'time'. The data are observations of Mars at various times, and the aim of the induction is to characterize all positions as a function of time. The second step is the conception of an ellipse. Here, it is claimed that the orbit of Mars is *some* ellipse. In the third step, the family of ellipses is fitted to the data, and the measured parameters (or coefficients as Whewell calls them) are those characterizing the best fitting ellipse. This is ellipse *b*, and this third step yields the specific claim that all points on Mars' orbit lie on ellipse *b*. There are two important points to notice. First, the data first enter the process in step 3, but this process makes no sense unless the formula is already fixed because the "best fitting curve" means "the best fitting curve *in a family*." If a different formula were chosen, then the resulting orbit would not be an ellipse. Moreover, it is always possible that a different family, or formula, could yield a curve that fits equally well. So, there is no sense in which the data determines the formula. Mill's idea of the data is that "all observed positions of Mars lie on ellipse *b*" has no logically or historically basis.

We have seen that there are fundamental and important differences between Mill's and Whewell's philosophy of science and that the nature and the substance of those differences are not merely terminological or as obvious as they may seem at first glance. Though they differ in many aspects of philosophy of science, of methodology, they are convinced that for scientific progress and advancement in science, sociel science it bears the most important role.

Comment and Conclusion

As we have seen, Whewell thinks that all empirical knowledge has a perceptual and a conceptual component. Unlike Bacon, induction for Whewell was not by simple enumeration, but by conceptual innovation -- concepts are 'superinduced' upon the facts. This was brought about by an act of thought Whewell called *colligation*, which introduced schemata providing precision, meaning, and structure to vague physical notions. Whewell was a realist; his concepts didn't summarize experience, but were exemplified by experience. Whewell introducd the view that induction involved a mental operation linking a number of empirical facts through the addition of a concept that unites them under a general principle. Facts become scientific knowledge when a scientist interpreted them under a new conception to demonstrate the true bond of unity by which the phenimena are held together. "Whewell realized that all scientific propositions whether a priori or a posteriori, are equally theoretical; they are equally probable."[38] Whewell's view has gained significant acceptance in the field of scientific research and explanation in contemporary scientific world. Contemporary scientists hols that in every aspect of knowledge the researchers must have a conceptual clarification of regarding their field of research, and it is important for scientific development.

Similar to Kant, how empirical science reaches necessary truths was described by Whewell as the ultimate problem of philosophy. Scientific laws have necessity, but are discovered empirically. Whewell introduced a form of appliative necessity, where qua colligators of phenomena, every law must be necessarily true, but they are only contingently known of the facts. Whewell's philosophy of science, while it never formed a school, influenced individuals from C.S. Peirce to James Clerk Maxwell. In addressing non-Baconian questions of becoming, Whewell's position seems like philosophical catastrophism. In this respect we see that Whewell tells about the strategic nature of induction where his conception of 'progressive intuition' appears. As he says,

> "Whewell hold that theories are developed by trial and error-in the 'preludes to the inductive eposhes'. The best one among them are then 'proved'- during the inductive epochs- by a long primarily a priori consideration which he called 'progressive intuition'. The inductive epochs are followed by 'sequels to the inductive epochs'; cumulative developments of auxiliary theories."[39]

He was in a position to think that theories, specially the scientific theories are developed through a sequence of induction. His conception of progressive intuition plays a vital role in case of scientific discovery and progress which can never be underminded. Josheph, one of the contemporary British logician while commenting on the inductive method of Whewell, says that

> "Whewell attached more importance to the framing of such theses than to any other of the operation connected with induction reasoning. He held that this step was the induction; and that the history of the inductive sciences could be presented as the preparation, elaboration and the diffusion of successive hypotheses....."[40] He continued, "He preferred to use conceptions

> to hypotheses. For him, the colligation of facts by means of appropriate conceptions is the essence of induction."[41]

From the above assertion of Joseph, we can easily infer the importance of Whewell's methodology in the field of logic and science. It is to be mentioned that such methods are not only significant in science or philosophy i.e.logic but firmly applicable also in fruitful research in social development mainly conducted by the social scientists allover the world.

The contemporary methodologists like Earnst Mach, Karl Popper, Thomas Kuhn raised their objecton regarding the standard view of induction which was introduced by William Whewell. They told about the certainty and confirmity about the scientific statements as well as regarding the method that is used to reach at this universal proposition. The problem of justification and sequence of induction are the basic related issues of the contemporary methodologists. For example, the logical positivists' formulation for meaningfulness of statement demands verification aiming to make the assertions of knowledge acceptable. Most of them proposed the conception of basic statement or elementary proposition to build up a chain of induction. It was proposed by William Whewell in 19th century. Therefore it can both logically and empirically told that Whewell's contribution in case of methodology and logic still deserves proper acdemic importance.

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