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Scientific Realism for the Contemporary Materialist

T. Jayaraman

In this extended note we discuss some trends and developments in the philosophy of science and related questions that are potentially of substantial interest to Marxists.

The benefits of a fruitful dialogue between scientific realism and dialectical materialism, which would assist in elaborating a Marxist view of science, have been elegantly alluded to in a remarkable essay by the American philosopher, Roy Wood Sellars.[1] In a brief sympathetic survey[2] of dialectical materialism written in 1944, Sellars credits Marxism as the only intellectual force that steadfastly stood up to positivism for several decades despite its origins outside academia and its relative lack of academic acceptance for several decades. However with the growth of realist trends in academic philosophy itself, Sellars writes of the positive contribution that could be made to advance the insight available in Marxist classics such as Lenin's *Materialism and Empirio-Criticism* by utilizing the technical advances of philosophy. Sellars' own pursuit of this engagement in subsequent years resulted in the volume of essays titled *Philosophy for the Future: The Quest of Modern Materialism*[3] edited by him together with V.J. McGill and Marvin Farber. This fascinating volume contains not only essays by Sellars and his son, the (better known) philosopher Wilfrid Sellars, but also those of a host of Marxist contributors including J.D. Bernal, Maurice Cornforth, Benjamin Farrington, J.B.S. Haldane and Maurice Dobb.

There is another, more proximate reason, for Marxists to follow the fortunes of contemporary scientific realism. For several years now, a section of Indian intellectuals, both in academia and outside, following in part similar trends elsewhere, have been seized by a sharply negative perception of science, a view that some of them have propagated with polemical vehemence. The intellectual origins of these views are many. But one of the key trends that these views draw on for support is a broad current of anti-materialism in philosophy, which has shown renewed vigour in academic and intellectual circles, both in India and abroad. These philosophical currents have had a significant influence, particularly in the study of the sociology and the history of science. These anti-materialist currents have also been consciously embraced in the formation of the disciplinary area known as science studies (and later science and technology studies). This is an area that often appears to adopt an anti-materialist attitude to demarcate itself from

[1] This philosopher, though typically ignored by mainstream philosophy, is interesting to study as part of a larger recovery of the tradition of the materialist thought of the 20th century including, but not restricted to, dialectical materialism. Fortunately some of Sellars most interesting writings are available on the internet.

[2] Sellars 1944.

[3] Sellars 1949.

earlier work on the history and sociology of science by adopting this attitude. As we shall have occasion to see later on, these anti-materialist philosophical currents themselves have begun to be influenced by corresponding trends in the sociology and history of science.

On reading the academic literature in these areas, an unwary reader, such as this writer some time ago, may be left with the impression that the anti-science, anti-materialist positions have indeed carried the day, creating a set of arguments that have not received any convincing replies or refutations. It is of course unsurprising that there should always be a current of anti-materialist thought in the realm of philosophy that influences other disciplines. Nor can Marxists allow themselves to be constrained entirely by the winds of academic fashion, however strong they may be. But in the current era, there has been a new triumphalist edge to the currents of anti-realism, proclaiming the eclipse of science and consequently the end of a vital aspect of the materialist viewpoint in philosophy. In the case of science in India this is particularly true with the regard to the view of the history of science in India, especially of the colonial era, or generally in the study of science, technology and society in the Indian context.

These anti-materialist positions have often been presented with a radical veneer, and have been sought to be likened to a version of Marxism that is less 'materialist' and more 'dialectical' in nature. In this 'radical' account, all materialist positions are sought to be equated to positivism or an ambiguous category labeled 'bourgeois science'. Science is therefore all or mostly ideology. Equally, Marxism is sought to be made 'responsive' to the latest academic 'trends' (when indeed they are often fashions), by the admission of appropriate correctives. This ignores precisely those trends in academic philosophy that support or contribute to the further elaboration of the Marxist viewpoint.

The aim of this note is a modest attempt to redress this imbalance in the reading of the trends in the academic philosophy of science. We underline the fact that idealist or neo-positivist positions have not received a uniform welcome and that their positions in the philosophy of science have been severely contested and challenged. Realist philosophy of science (which has the same position as dialectical materialism on many issues relating to science) has been in vigorous health and has provided a consistent, sophisticated and sound response to the new challenges posed by idealism and positivism. These advances constitute a valuable resource for the further evolution of a Marxist perspective on science.

We begin this note by sketching very briefly some broad features of the philosophical position referred to commonly as scientific realism.[4] We then discuss a series of critical attacks that have been made against this position. Subsequently we describe how developments in the standpoint of scientific realism have made possible a coherent response to these critical attacks. Our account will be neither strictly chronological nor strictly logically structured,

[4] This note is based primarily on the writings of Roy Bhaskar, Christopher Norris, Ilka Niiniluoto, and Richard Boyd. The specific references will be noted as appropriate in the text.

in the sense of the philosophical questions involved, partly due to the writer's inexperience and partly in order to present a more readable narrative.

What is scientific realism?

Following (and partly paraphrasing) the work of the noted contemporary realist philosopher, Christopher Norris, one may describe scientific realism as follows.[5] Scientific realism, broadly speaking, accepts the existence of objective reality as a fundamental premise. This objective reality exists independent of our theories and descriptions, and beliefs and thoughts concerning the same. These theories and descriptions acquire the status of truths or falsehoods depending on how they stand with respect to that objective reality, rather than on whether they coincide with systems of beliefs, some favoured paradigms and the like. Among this limitless set of truths, there are some that we know now, some that we don't know now and will find out later and some that may lie beyond the furthest reach of our knowledge-seeking powers. These truths occur at every spatial and temporal scale, including (for instance) the microstructural properties of matter, astrophysical or cosmological phenomena, and prehistoric phenomena ranging back in time to the origins of our universe, laws of nature, and so on.

Our knowledge of these truths is acquired through the various procedures of observation, experiment, inductive reasoning, testing of hypotheses and inference to the best (most adequate) explanation. Scientific realism would contend that if these procedures were not 'for the most part' reliable we would have no way of explaining the vast number of successes in the practical application of scientific knowledge in the real world, such as 'curing diseases, getting aircraft to fly, and a great many other achievements'. In other words, if we are not to attribute the obvious and manifest success of science to a constant series of miracles, the obvious recourse is to a view of science that is broadly scientific realist in character. This 'no-miracles' argument is central to the justification of scientific realism though by no means the only argument in realism's favour.

From the realist position that scientific truth is determined by the relation between scientific theories and descriptions and objective reality, independent of the means of its verification, it follows that scientific truth may elude our present means of discovery. Thus scientific knowledge at any given moment is provisional to the extent that it may be falsified in time. Theories may be rejected if they do not stand up to the evidence or indeed the evidence itself may change over time, allowing for instance for the correction of earlier findings or the acquisition of new data.

Thus, a fundamental feature of scientific realism is the separation of questions of existence or being ('what exists?', 'what are its properties, its microstructure?') from questions of knowing about them such as ('what do we know or can assert regarding these potentially real objects and their properties'?). This separation between ontological questions and epistemological questions is fundamental to scientific realism.

[5] See Norris 2004.

One of the major features of many forms of contemporary scientific realism is the realization that a consistently realist view requires also a realist view of causation and explanation. The realist answer to the basic question of what is the meaning of cause and effect denies that the causation is to be viewed (in the fashion attributed to Hume) as regularities that are perceived in Nature.[6] In this view, cause and effect are simply the ordering of events in time, the constant conjunction of events, and there is nothing more to causation than this ordering. However in the realist view, cause and effect are processes that are caused by some mechanisms or properties that are inherent in the particular nature of things. This view, referred to as the idea of causal powers, or causal dispositions provides the basis for a realist appreciation of the role of the laws of nature. Such laws, in the realist view, are just the inherent 'generative mechanisms' or 'causal powers' that are characteristic of matter in various forms. We shall by and large reserve the term scientific realists for those who evaded any commitment to a regularity view of causation, even though it may occasion some discomfort for those familiar with academic philosophy.

We will expand this broad characterization further as we go along. But we turn now to consider the critical attacks that have been made against this general position. Among those that had a bearing on the fortunes of scientific realism in the academic world, some of course originated in the new developments in some of the sciences. Others emerged from other fields of inquiry such as philosophy itself, and, perhaps more significantly, from disciplines such as the history and the sociology of science.

Scientific realism, in the form we know it today, has been shaped, at least in part, by the process of fashioning a response to these critical attacks. Many of these assaults have come by the exploitation of the fact that earlier forms of realism had implicitly allowed key aspects of their philosophical position to be founded on positivist or Humean views on issues such as causation, explanation, the nature of scientific laws and the semantic structure of scientific theories. This undoubtedly reflects the dominant hold of the positivist view of science, or to put it differently, the role of positivism as ideology. Even scientific realism has therefore tended to pick its methodological or structural equipment from the sources ready to hand, which certainly in the modern era have tended to be predominantly positivist in nature.

This dependence has rendered realism vulnerable to positivist critiques (or to a slide into positivist positions) or on the other hand exposing it to, equally anti-realist, anti-positivist critiques (founded on essentially idealist or neo-Kantian positions), presented occasionally with a 'radical' or 'dialectical' label attached. In the latter category must be included Feyerabend's anarchist view of scientific method, Kuhn's paradigm-change view of scientific

[6] Predictably, there are philosophers who are realist in terms of ontology, who nevertheless hold a regularity view of causation. And indeed there are others who may be termed causal pluralists who hold that there are a plurality of modes of causation. Nevertheless scientific realists in the main seem disposed to a powers or dispositional view of causation.

revolutions, and the newer trends such as social constructivism of scientific knowledge and social epistemology. To this writer, one of the significant achievements of contemporary scientific realism is the exposition, by some scientific realists, as for instance Bhaskar or Norris, of the common origins of these anti-realist positions as well as positivism. This is notwithstanding the extent to which anti-positivist critiques of science may appear superficially aggressive or distant from positivism, as in the case of Feyerabend or postmodernists such as Foucault or Lyotard. Thus, the division being made here in this review, between realism and anti-realism, is a coherent, substantive and meaningful one, even if the latter encompasses apparently contradictory positions.

Before we move on, it is important to distinguish between materialism and realism. Avoiding technical definitions we shall take the philosophical position of materialism to specifically imply, among other things, the primacy of matter over mind, with the mind possibly being regarded as an emergent phenomenon. Thus materialism implies a definite position that eschews a dualism of mind and matter. It also more particularly, especially for Marxists, implies that the social superstructure, depends 'in the last analysis' on a material base. Scientific realists need not be committed to these positions. By this token, Roy Wood Sellars was more a materialist rather than simply a realist, while this is not true of many others. However Marxism is not and cannot be neutral to the question of scientific realism and draws on it as a necessary ingredient, even if this often goes unacknowledged in many contemporary accounts of Marxism, of its overall worldview.[7]

From here on in this note, we will examine a few such instances of a realist response to both positivist and idealist critiques that have shaped the sophisticated structure of contemporary scientific realism. Hopefully we will also elucidate the dosely related origins of both the positivist and (essentially) idealist challenges to a realist view of science.[8]

Positivism, its opponents and the 'epistemic fallacy'

The central theme of the logical empiricist attack on realism in the early 20th century was the dismissal of the question of the existence of objective reality as a metaphysical question, where 'metaphysical' here has a negative connotation, indicating a question that has been set outside the pale of meaningful philosophical debate. Thus the realists, and of course dialectical materialists in particular, were chasing a question that was 'out of bounds' as it were for meaningful enquiry. It is of the essence of positivism or logical empiricism not to countenance the existence of things that are not observable.

In this collapse of the world of independently (of the mind or observer that is) existing things to the world of the perceived or the observed, lies the origin of the anti-realism of philosophical viewpoints that may yet formally

[7] See also the entry on Materialism and the one on Realism by Roy Bhaskar in Bottomore 1983.

[8] Before we end this section it would be useful to note a point about terminology. The term realism, without the adjective scientific but other adjectives attached, is often used to denote a realist position on other issues. There could be for instance religious realism. It should be obvious that we are restricting our interest only to scientific realism and hold no brief for other possible realisms.

acknowledge the existence of an objective reality. One of the significant steps in fleshing out an adequate account of scientific realism has been the realization of the ubiquity of this confusion, viz. the confusion between 'being' and the means of 'knowing' in various forms of anti-realism. This 'epistemic fallacy' is characteristic both in positivism, where one may say it originates and in those philosophical trends that claim to be at the forefront of the anti-positivist wave.

One of the sources for a thorough exploration of this issue is the early work of Roy Bhaskar,[9] whose account of scientific realism also provides the necessary philosophical machinery to understand the issue. While emphasizing the central role of the epistemic fallacy, Bhaskar's essay on Feyerabend illustrates the power of the concept in uncovering the common link between the falsificationist view of Popper and the anarchist counter-view of Feyerabend[10] in whose account there exists no possibility of any theory of knowledge for science.

We retrace this argument here briefly.[11] The initial problem at the level of ontology is the question: 'What warrant do we have for supposing that the course of nature will not change.' This in effect asks how we can suppose that nature will be uniform in its behavior. This, in the Humean view, becomes the question 'what warrant do we have to suppose that the regularities in our experience will continue.' This transposition of the question follows on the Humean collapse of the real world to the empirical. More precisely it is the collapse of the 'real', the world of objectively real things and their causal tendencies and generative mechanisms, to the 'empirical', where events actually happen, due to the conjunction of mechanisms and contingent arrangements (such as in a laboratory experiment and generally in scientific practice) such that they take place.

But further, with Hume, there is a consequent reduction of knowledge to the level of experience. In the wake of this Humean confusion, the question is transformed to 'what warrant do we have for supposing some general proposition, statement or theory is true.' Now it is this statement that becomes in the restatement of Popper, 'what warrant do we have for supposing that some general proposition, statement or theory is true or false.' Now in the skepticism of Hume, the answer to the very first form of the question, at the level of being, was 'anything at all'. The anarchism of Feyerabend is the answer that there is no warrant, 'anything goes', to the Popperian form of the question. Thus if Hume's rejection led to the impossibility of knowledge, the displacement of the question to the

[9] The qualification 'early' is necessary to distinguish it from the later work of Roy Bhaskar that has taken an unseemly 'Eastern mystic' turn, with Bhaskar himself being treated like a cult guru by some of his 'followers'. The reference here is to his classic text *Realist Theories of Science* (Bhaskar 1977) and the eminently readable collection of essays *Reclaiming Reality* (Bhaskar 1989).

[10] This is of course Feyerabend, the author of *Against Method*. Feyerabend started out as a logical positivist, moved to a realist view and then finally ended in an anarchist, relativist view of science.

[11] This closely follows the argument from Bhaskar1989, p. 38.

epistemological 'leads to the impossibility of any theory of knowledge, and hence of any criteria of rationality for its production'.[12]

Realism's answer (in particular that of critical realism) to this skepticism lies in the separation of the 'intransitive' and the 'transitive' dimensions in the philosophy of science. Here 'intransitive' refers to the world of unchanging real things that exist independent of the scientific process while the world of changing cognitive objects that are produced within science belong to the 'transitive' dimension. In particular the work of science, including experimental activity, belongs to the transitive dimension, where events or empirical invariances are produced but this is not the world of real things and their causal laws. Thus there is no argument from induction needed, as it were, to generalize from the *regularities* of events. But there are inferences to be drawn from the invariance of empirical *results*, followed by the construction of possible explanations, testing them again empirically and thus identifying the generative mechanism at work and so on. Thus the 'transitive dimension' sustains the work of science, through which the real entities, their tendencies and the generative mechanisms (or causal laws) of the intransitive dimension are understood.

The 'epistemic fallacy' continues to be conceptually useful as in Norris's discussion of the anti-realism of the influential British philosopher, Michael Dummett. Dummett characterizes the difference between realism and anti-realism in science as one instance of a general conceptual strategy that he indicated to distinguish realism from anti-realism in various contexts. In the instance of scientific realism, the cornerstone was the idea that 'gaps in knowledge' corresponded to 'gaps in reality'.[13] The key distinction between scientific realism and anti-realism in Dummett's view is the stand on the verification of the truth of 'statements' regarding nature. Dummett's own position on this issue was on the side of anti-realism, namely that only verifiable statements (or propositions) regarding nature were admissible. Hence an objective reality, independent of observation (or independent of statements and propositions regarding it) and which cannot be grasped by any human epistemic means is to Dummett inadmissible. This view is yet again, as Norris notes, a case of the 'epistemic fallacy.'

The separation of the dimensions of the real and the empirical in Bhaskar's critical realism can be read as an amplification of Marx's celebrated comment that 'all science would be superfluous if the outward appearance and the essence of things directly coincided.' This is also a sentiment common among scientists, as in the case of the Nobel winning biologist, Lewis Wolpert, who discusses at length what he calls the 'unnatural nature of science'.[14]

Equally importantly, the separation between the intransitive and transitive dimensions in science is also the means to sustain a more meaningful account of scientific discovery and theory change, that will

[12] Bhaskar 1989, p. 39.
[13] Norris 2004, p. 23.
[14] Wolpert 2001.

account for how the corrigible fruits of human activity lead to knowledge of a mind-independent objective reality. But before we turn to consider this question, we will consider some key anti-realist arguments that arise from within the so-called analytic tradition to which logical positivism also belongs and the realist response to it.

Anti-Realism from the Analytic Tradition

As we have already noted early on, anti-realism includes those positions that arise in apparent decisive challenge to positivism or empiricism but in the end share some fundamental commonality that binds them inseparably to what they critique. In the broad spectrum of such positions, we shall briefly consider one such philosopher, who is associated with what is arguably one of the central features of such anti-realist arguments.

The work of W.V. Quine heralded a new wave of critique of the positions of logical positivism. One of the lasting contributions of Quine, referred to together with similar observations by Pierre Duhem as the Duhem-Quine thesis, is the observation that contrary to the view of positivism, there is no experimental observation that is entirely free of theoretical presuppositions. Hence there is a measure of theory-ladenness implicit to any empirical observation. This view indeed evokes rather universal acceptance and the conviction that it carries accounts for the declining appeal of old-style logical positivism as a philosophical position, especially in the social sciences.

However Quine's celebrated and deeply influential essay titled 'The Two Dogmas of Empiricism' heralded a thoroughgoing anti-realism that has widely resonated later including in the work on scientific theory change by Thomas Kuhn. The two dogmas that Quine challenged were the following. The first was that there could be a separation between propositional statements in science that were analytic in character and those that were synthetic. To put it in more intelligibly, this was the distinction between statements that were true by virtue of the meanings of their words and others that were true by virtue of their relationship to facts.

Quine argued that this distinction could not be credibly maintained. The second dogma that Quine referred to was the idea that independent statements of theory could be separately verified. On the contrary, Quine contended, it was science in entirety that was tested all at once. All scientific statements were interconnected, with no meaning attached to asking for the empirical content to individual statements, with no particular distinction between logical statements and statements of fact.

For Quine therefore, science was a 'web of belief' that was only constrained on its boundaries by empirical data, and the fabric was by and large amenable to re-fixing in view of any change in the empirical data. This leads on to the view of the underdetermination of theories by empirical data, since the challenge posed by changing data could always be overcome by changing other statements and propositions elsewhere in the web of belief.

This led Quine to an ontological relativism, whereby the same underdetermination is reflected in our talk of entities.

In Quine's view, as he concludes in his essay, 'Two Dogmas of Empiricism', 'As an empiricist I continue to think of the conceptual scheme of science as a tool, ultimately, for predicting future experience in the light of past experience. Physical objects are conceptually imported into the situation as convenient intermediaries not by definition in terms of experience, but simply as irreducible posits comparable epistemologically, to the gods of Homer . . . For my part I do, qua lay physicist, believe in physical objects and not in Homer's gods; and I consider it a scientific error to believe otherwise. But in point of epistemological footing, the physical objects and the gods differ only in degree and not in kind. Both sorts of entities enter our conceptions only as cultural posits'.

What the last lines of 'Two Dogmas' indicate, as has been argued in various responses, is that ultimately Quine fails to challenge the *real* dogma of empiricism.[15] When it comes to acknowledging what really science is about, despite its lack of any special epistemological status, for Quine the task of whatever conceptual scheme that we choose to call science is to deal with or organize 'the flux of experience'. 'Experience' for Quine has the status of reality, and in this he does not let go of the basic idea that our 'language is ultimately based on sense experience and that all our knowledge arises out of this experience.'[16]

The realist response to the empiricist view of the underdetermination of scientific theory by empirical evidence, is an issue that Boyd considers to be central to the defence of scientific realism. In Boyd's view,[17] the underdetermination thesis should be taken as supplemented by other ingredients. These include the possibility that two theories may be distinguished by the use of different auxiliary hypotheses, since rarely do theories match the real world without auxiliary hypotheses. Secondly, it rests on the assumption that all knowledge is derived from facts of experience and more importantly that experience is the only basis for justifying beliefs about matters of fact. While the first part of the statement is no longer widely held, the second is virtually an article of faith for realists as well. Thirdly, the aim of the positivist or empiricist enterprise in relation to science was the reconstruction of scientific theories without any commitment to unobservable entities while still holding to scientific practice as the source of knowledge.

The first point to note of course is that the notion of observable phenomena cannot, in any reasonable way, in contemporary science be restricted to mean the senses. The senses are vastly extended by instrumentation of increasing complexity that constantly pushes back the limits of the unobservable. Of course this is necessarily at the price of increasing the extent of theory dependence and opening the door to further underdetermination.

[15] Dilman 1984, p. 116. See also Norris 1999.
[16] Dilman 1984, p. 112.
[17] Boyd 2002.

But the central point of the challenge is (to restate the underdetermination thesis somewhat differently) the statement that there is no way to distinguish two theories that are indistinguishable on the basis of empirical data. The common point of the realist answer to this challenge has been to insist on the explanatory power of scientific theories as evidence in their favor, while rejecting the characteristic logical empiricist standpoint that explanation is equivalent to prediction. In this story it is crucial that there is no infinity of hypothesis waiting to be confirmed simultaneously in a new theory. There is only a finite set of new hypothesis, whose content is determined partly by judging their plausibility, based on prior scientific knowledge, as well as by a judgment of the need for some continuity with prior theories that have had explanatory power.

Thus the characteristic moves in validating a new theory begin with the determination of theoretically plausible hypothesis (based on the prior scientific knowledge) and using suitably designed observations (based again on prior scientific knowledge) to confirm predictions and/or the validate explanations. Alternative theories are then confronted with observation on the same basis as the original proposal, both in prediction and in explanation. Thus we have the means to adjudicate between alternative theories and at least in some instances, we can also obtain knowledge inferentially about unobservables. This, the general strategy of inference to the best explanation, is the nub of the realist answer to the dilemmas posed by Quine and others.

We may note here that the notion of extending earlier scientific knowledge by the introduction of a finite number of new hypotheses, based on safeguarding the explanatory and predictive power of earlier scientific theories, clearly implies a notion of the approximate truth of scientific theories. We shall comment on this again in the next section.

Scientific Revolutions, Paradigm shifts and Theory change

One of the most powerful critical assaults on the realist view of science emerged from the considerations of the process of radical change of scientific theories. Its roots lie in the pioneering work of Norwood Russell Hanson and Gaston Bachelard that pre-date the work of Thomas Kuhn, the most celebrated author on this question. The general wind of anti-realism that has followed this line of work continues to have much influence even today, forty-five years after the initial publication of Kuhn's best-known work, *The Structure of Scientific Revolutions*. The qualified anti-realism of the pioneers was to turn into the sweeping anti-realism of Kuhn, that has continued to feed other streams of anti-realism that emerge from tendencies like postmodernism or in the programme of the sociology of scientific knowledge (SSK).

The essence of the argument as exemplified in the work of Kuhn is that science evolves through a series of discontinuous jumps, the scientific revolutions of the title of Kuhn's book, followed by extended periods of the practice of 'normal' science. What changes across the jump is the scientific view of a phenomenon or a class of phenomena through adoption of a new

'paradigm' as opposed to the earlier 'paradigm'. For Kuhn the paradigm shift was originally in the form of a 'gestalt switch' (a switch of basic perspective in some intrinsically mental and psychological sense) but he later shifted his view to that of an incommensurate set of meanings of scientific terms before and after theory change.[18] Kuhn leaves quite unclear as to what the origins of the change are though he himself was disposed towards an entirely anti-realist view. Through this ambiguity Kuhn has paved the way for the rise of an entire array of anti-realist views of scientific change, including perhaps at times an unwary Marxist who sees in this ambiguity the means to anchor scientific change to social transformations that are, in particular, related to the changing class character of society.

There are some important points to be made with reference to Kuhn's account. Kuhn, it must be remembered, wrote as a historian of science, deciphering, as it were, from the historical record a credible account of the process of scientific discovery. Thus Kuhn purported to illustrate the consequences of the historical account of how science was really done for the philosophy of science. Kuhn, it must be emphasized, went further than suggesting that science, in particular scientists, adopted a new 'paradigm' about the natural world. For Kuhn, the new 'paradigm' places the scientist in a new world, different from the previous one, where the familiar objects (joined perhaps by new ones), but nevertheless the scientist sees them in an entirely new light. To go further the new paradigm dictates as well what the scientist determines to be data. Thus Kuhn argues, 'there is a sense in which paradigms are constitutive of nature'. Some indeed have been tempted to take this qualification as purely metaphorical in nature, and argue that there is no unbridgeable gulf between the realist, for whom scientific theories make no causal contribution to nature and Kuhn's actual meaning.[19] But nevertheless it is clear from Kuhn that this notion of reality extends only to the sense-data and experiences whether old and established or new. Thus the paradigm is a new way of seeing old things, a guide perhaps to the new, but there still remains the unknowable Kantian realm of the 'thing-in-itself' that scientific theories have little to say about.

The themes that were to figure later in Kuhn's more popular exposition of theory change were pre-figured in the work of Hanson and independently in the work of Bachelard. Hanson's argument went farther and more consistently than those of Kuhn in some respects, while Bachelard paid substantial attention to the precise nature of the transition from the old to the new scientific theory (the 'epistemic break'). The essence of Hanson's argument was that there was an unbridgeable gap between the old and the new. In a celebrated passage in his work *Patterns of Discovery*[20] Hanson imagines Tycho Brahe and Kepler together viewing the rising of the sun, the former wedded to Ptolemaic and Aristotlean conceptions and the latter to the heliocentric view of the solar system. The question for Hanson is: 'Do they

[18] Boyd 2002.
[19] Sismondi 1992.
[20] Hanson 1958.

both see the same thing?' This is recognizably the same argument as the different worlds' argument of Kuhn and Hanson's response essentially presages Kuhn's. But in doing so, Hanson, in the view of Norris, provided a considerably more nuanced and less dogmatic account of theory change than Kuhn was to provide later.[21]

Of course, the decisive realist answer to Kuhn is best framed by a critique of Kuhn's examples of theory change that he describes in his book. While that would be interesting, we will stay here with a critique on purely philosophical grounds.

The realist response to the Hanson-Quine-Kuhn argument has come in two forms. The first is more directly from within the analytic tradition of analysis of the propositional structure of scientific theories. As Boyd points out, Kuhn implicitly relies on the view that terms in scientific theories acquire their meaning from the basic definitions that use the term (a point of view known as 'descriptivism'). In this view, as we had noted earlier, with the change of theory, all such terms acquire new meanings that are incommensurable (or incapable of comparison) with the earlier meanings. The effect of the Kuhnian view was to provide the impetus for the reconsideration of 'descriptivism' and the development of alternative theories of reference. Following the lead from the work of Kripke and Putnam, causal theories of references were developed, where scientific terms acquired their meaning by virtue of their association to 'real essences'. To put it differently, scientific kinds or categories possess *real* definitions. In this view then, scientific terms do not become incommensurable between the old theory and the new theory.

With this machinery, the notion of scientific progress being manifest, at least in part, through the development of successive approximations to the truth becomes viable, even in the case of scientific revolutions. Despite our earlier argument for sustaining the notion of approximate truth, if scientific theories were genuinely incommensurable before and after a scientific revolution, then such an argument would be untenable. Hence the extra impetus provided by causal theories of reference is clearly welcome. Those acquainted with Marxist perspectives on science would also recognize the closeness of the notion of approximate truth to a similar one from Lenin's text *Materialism and Empirio-Criticism*.

A thoroughgoing analysis, with a somewhat different thrust, of the question of scientific revolution is also available from the transcendental critical realist perspective. In this account, typically, scientific change, including scientific revolutions, is sustained by the differentiation and stratification of the 'real'. Thus the presence in the intransitive dimension of the stratification of objective reality, leads in the transitive dimension to radical change in scientific theories, through the active process of science as 'labour'.

Thus in Hanson's dialogue between Tycho Brahe and Kepler, the commonality of their observation, that of the rising sun, belongs to the realm of the 'empirical'. But in the realist view, Kepler is possessed of a deeper view

[21] Norris 2004.

of the ontological realm, a heliocentric view that corresponds to a 'real' state of affairs. Thus they 'see the same phenomena with different eyes', but they both inhabit the same intransitive realm, of which the latter knows more than the former in the transitive dimension.

For another example of changing scientific theories, we could consider the role of atoms in chemistry. In the first instance we have the initial atomic hypothesis of Dalton which was soon extended in its use in explaining various results in the realm of chemical phenomena. The next major shift is from this naïve atomism to the understanding of the atomic structure due to Bohr (the first quantum revolution) that explained the regularities of the periodic table due to Mendeleev. And then we have the shift to the full quantum theory of atomic structure that was used by Linus Pauling to provide the first comprehensive view of the nature of chemical bonds. Thus we have discontinuities at the level of scientific theories and in the overall 'scientific view' of atomic structure and the origin of chemical bonding, but this is sustained by the objectively real stratification of the atom which has been uncovered by the labour of science over time.

Thus in this realist view there is scope to sustaining the meaning of scientific advance without any relapse to a judgmental relativism, that renders the new theory merely a shift of conceptual scheme or paradigm (as with Kuhn), or a remaking of a part of the 'web of belief' with new 'cultural posits' (as with Quine). This is because the real possibility of change is based on the differentiation and stratification of reality. At the same time, it sustains the corrigibility of scientific knowledge, since these levels are known over time, by the hard labour of experimental and theoretical work of science that is part of the transitive dimension. The apparent incommensurability of scientific terms, before and after theory change, can be most satisfactorily accounted for here, utilizing both a causal view of reference together with the grasp of the 'real' that is provided by the notion of the structured nature of objective reality.

Social Construction of Scientific Knowledge

We have already partly anticipated in the previous discussion of the relativism of Quine and Kuhn another major trend in the critique of scientific realism. This broad current of opinion, referred to as the social constructivist view of science includes several tendencies which we will consider to some extent separately. However, over and above individual differences in these views of science, there are nevertheless some broad features that will enable us to underline the realist response to these issues without dealing with all the niggling details of individual approaches.

While much of the philosophy of science, as in the case of epistemology in philosophy as a whole, dealt with individual agents rather than social ones, it was recognized by some philosophers that there was a need to study the role of the scientific community too in understanding science. We shall not extend our brief here to comment on all sociology of science but only to the

extent of discussing some anti-realist positions on science arising from this discipline.

Kuhn's contribution is an important influence in the post-1960s sociology of science as it assigned to the scientific community a critical role in the understanding of science, especially in determining the acceptance of a new paradigm. Apart from Kuhn, other influences that are typically cited include the work of Karl Mannheim on the sociology of knowledge, the phenomenological theory of the 'social construction' of reality and the relativism of the later Wittgenstein. Another notable source of influence have been the Marxists, who have since the time of Marx and Engels discussed the influence of the economic structure of society on the nature of scientific activity. Following on the inspiration of the lectures of the famous Bukharin-led delegation to the British Association for the Advancement of Science Conference in 1932,[22] and the publication some years later of Engels' text, *Dialectics of Nature*, British scientists, notably J.D. Bernal and J.B.S. Haldane among others, pioneered the task of understanding science and its role in society.[23]

The early Marxist approach to the history and sociology of science cited here is typically referred to as an 'externalist' approach as opposed to 'internalist' approaches deriving from considerations of impulses internal to the science in question, such as accumulating evidence, and rational arguments in favour of competing theories. In Kuhn, externalist influences appeared to dominate the scientific revolutions while the period of normal science appeared to be dominated by internalist influences. The internalist approach was clearly the dominant one in the positivist view of science.

One of the notable influences in the new wave in the sociology of science is the so-called 'Strong Programme' associated with the Edinburgh School (the prominent names from there including David Bloor, Barry Barnes, Steve Shapin). Among its aims is the provision of a scientific explanation of the 'very content and nature of knowledge', where knowledge refers to whatever the scientists collectively take to be knowledge.[24] Its key principles were: *i*) causality, meaning thereby that the explanation of scientific beliefs should use the same causal idiom as any other science; *ii*) impartiality, meaning thereby that all beliefs, whether true or false, and whether rational or irrational, should all be causally explained; *iii*) symmetry, whereby both types of beliefs as above should be explained by the same factors, and finally; *iv*) reflexivity, whereby the programme should apply to itself. It appears too that the Strong Programme was extended in the work of Bloor to include a general principle of *social externalism*, that does not follow from the above four principles. By this account, the only explanation of beliefs permissible in the sociology of science are those that attribute the causes of such beliefs to

[22] Some of the lectures of that delegation are available on the web at http://www.marxists.org/subject/science/index.html.

[23] See for instance, Bernal 1939. We shall not discuss the Marxist trend in the history and philosophy of science in detail as it merits more extensive treatment than we can provide in this essay.

[24] The following account of the Strong Programme and other social constructivisms follows the one given in Niiniluoto 2002.

external factors. In this case of course the issue has already been settled against internal explanations from the outset.

Many of these principles were of course formulated in response to what was often perceived to be a triumphalist account of science. In such accounts the history of science was the story of a continuous account of success, driven by the internal impulses of the scientific discipline or quest in consideration, while at the same time the 'externalist' explanation was reserved for those explanations and theories that fell by the wayside.

But while this may have been a laudable motivation, the actual practice of the 'Strong Programme' and its ideology is open to strong criticisms.

In the actual case studies in the history of science produced by the Edinburgh School it appears that the method that they use is one that seems almost old-fashioned—it is positivist, empiricist and causalist in character. But, as Niiniluoto notes, 'the same methodology is denied an explanatory role for the work of science itself and its methods, results and objectivity are relative only to social interests and causally influenced by social factors.'[25]

Thus reflexivity and causality appear equally denied in the actual practice of the 'Strong Programme'. The second, more problematic issue, appears to be the symmetry thesis. We shall have more to say on this shortly. The third issue is whether for externalist influences one can indeed establish any kind of causal explanatory role. One could establish certain conjunctions between social factors and happenings in science, but it is unclear whether, except in rare cases, anything more could be achieved. This indeed is a problem for the Marxist version of externalist influences too.

While in their most recent writing the Edinburgh school appears to have retreated from the 'highly misleading' original formulation (this in Niiniluoto's charitable reading), there are nevertheless other schools of the sociology of science that have more extreme positions. For instance Collins adopts a position that 'the natural world has a small or non-existent role in the construction of scientific knowledge'.

There is also the constructivist school, including notably Latour and Knorr-Cetina, who have studied the work of scientists in their laboratory, using anthropological methods, or the social epistemology school of Steve Fuller and others. We shall not proceed further at this point with a detailed account of these other schools.

What we will undertake briefly now is a general overview of the philosophical positions in these schools and their implications from the viewpoint of scientific realism.

Following Boyd's account closely,[26] we may distinguish three general variants of the 'social constructivist' viewpoint. The first is the one where the acceptance of a scientific paradigm successfully imposes a quasi-metaphysical causal structure on the phenomena scientists study. The second is the science-as-social process account, of which the earlier Marxist externalist accounts of science could be considered a part. In this view, the production of scientific

[25] Niiniluoto 2002.
[26] Boyd 2002.

knowledge is a social process subject to the same sort of influences that would influence any other social process. The third is the radical position (due to Collins as mentioned earlier and others like Woolgar) according to which *the results of science* are determined not by the 'facts' but by the power relations within the scientific community and the broader social context of their work.

The first and third positions are incompatible, since the latter clearly espouses a radical ontological relativism that is not present in the first. The second, in its ambiguity, could be fitted up to be compatible with the first or the third, or with logical empiricist or realist accounts. The work of Bernal would clearly fall in this category. Boyd notes though that all three are commonly conflated in the typical science studies or postmodernist influenced accounts. In an amusing remark, he notes that many in science studies adopt a kind of 'quantum superposition' of the first and third views. We may add that the conflation with the second variant typically adds the radical, protest or subaltern flavour that is common to these accounts while peddling in effect a thoroughly anti-realist position.

In the matter of social constructivism though, realists and positivists have often found themselves on the same side of the fence against the corrosive skepticism, veriphobia (fear of truth, a characterization developed in detail by Goldman[27]), or plain sloppy thinking emerging from science studies. However to the more substantive questions raised by a realist version of the second type of social constructivism, one may note that not all variants of scientific realism may provide the resources to deal with the issues successfully. The variants that are closer to positivism may be inclined to fall back on the standard argument that 'the context of discovery' is different from 'context of justification'. Thus while external factors may play a significant role in dictating the choice or mix of theories that are accepted, these factors do not in any way enter into deciding which scientific theory is correct. Obviously this need not be true, though it is a matter of concrete historical and sociological study how and when this phenomenon occurs.

However in the critical realist take on this question, it is equally plausible that there are external influences in both contexts, that of discovery as well as justification. However these as always are issues in the transitive dimension of science, whereas the 'real' belongs to the intransitive dimension. Thus scientists may pursue an *objectively* illusory theory due to external factors and it may be that considerable time would elapse before the course is set right and the scientific theory in the transitive dimension aligns with the reality of the intransitive dimension.

It bears repetition that the matter in every individual instance needs to be settled by historical or other studies, but the issue poses no great threat to a scientific realist view. For instance, the critical realist view offers a much better perspective on the long-standing contradiction at the heart of the formulation of quantum mechanics. Nor does this view sanction the extremist slogan that 'all science under capitalism is bourgeois science'. The no-miracles argument should already make one view this slogan with suspicion.

[27] Goldman 2003.

Curiously, Boyd would appear to accept the symmetry thesis of constructivism, albeit in the context of a naturalistic scientific realism, arguing that the thesis is ubiquitous in the history of science. However this appears to give away too much. In any version of realism, whether critical realist or otherwise, the rejection of judgmental relativism is an essential feature. A superficial reading of the symmetry thesis would suggest that both true and false theories could be judged by internal as well as external criteria for their choice. But typically the thesis is taken to imply precisely that the truth or falsity of theories should not be relevant to an account of the acceptance of one and the rejection of the other. It does little damage to the scientific realist reading if the truth and falsehood of competing theories were part of the explanatory schema. But its outright rejection would be clearly an anti-realist view that would not only lack any capability to explain the development of science but would fly in the face of several counter-examples from the history of science.

Scientific Realism and Quantum Mechanics

While anti-realism is not going to wither away anytime soon, it would nevertheless appear that it must have a rather more restricted appeal than what we see today. While this is a social phenomenon that deserves independent exploration, it is of interest to see whether there are weaknesses in the realist argument at the theoretical or philosophical level that feed the social reproduction of anti-realism.

Scientific realism at the beginning of the twentieth century received considerable support from a series of scientific developments that led to the downfall of the Machian version of positivism, a philosophical viewpoint that had considerable appeal, especially amongst scientists, at the end of the 19th century. This variant of positivism maintained that entities such as atoms or electrons could not be held to be real and that at best they were useful theoretical constructions that assisted in the logical order of scientific theories regarding the structure of matters. The experimental isolation of atoms and the study and the delineation of their properties (that began with the discovery of radioactivity) spelt an end to an anti-realism that would not countenance the question of the knowability of the 'thing-in-itself' and dismissed the question of its existence as a 'metaphysical' question. This extreme version of positivism has never again found the same favour among scientists, especially physicists that it enjoyed in the pre-atomic era, even though it has been resurrected in the field of philosophy.[28]

Nevertheless, after a brief interlude, anti-realism with a different emphasis mounted a challenge yet again with the advent of quantum mechanics. This revolution in physics that was realized in the 1930s posed a number of challenges to a realist view, particularly given the radical departure from classical physics that was implied by these new developments. This was not the least due to the fact that the leading figures of its development, particularly the figures of Niels Bohr and Werner

[28] See, for instance, Van Frassen 1980.

Heisenberg, pushed an interpretation, referred to commonly as the Copenhagen Interpretation, that was starkly anti-realist in character. The well-known debate between Bohr and Einstein, in which the latter challenged the Copenhagen Interpretation from a realist perspective, resulted in a general consensus that the matter had been settled in favor of Bohr.

Quantum mechanics posed a number of problems to the existing views of physicists and in so doing challenged several implicit ontological and epistemological assumptions in the philosophy of science. One of the key issues was to understand the ontological meaning of statements such as wave-particle duality. Another was whether the inability to determine the exact trajectory of quantum particles while at the same time keeping exact account of their momentum, constituted merely a surrender of determinism or was a failure of realism, whatever that meant. If these problems were sought to be circumvented by a new mathematical framework, there were then questions of logic that appeared to need settling. While acceptable solutions to these issues have been found, they have left behind a fundamental residue of contradictions, primarily in the failure of the local nature of causality. To put it differently, there exists a contradiction between quantum mechanics and the notion of locality following from the special theory of relativity, while maintaining the probabilistic aspect of the quantum theory.

The advent of quantum mechanics heralded another wave of positivism in the physical sciences. Following Bohr, a large number of physicists eventually appeared to accept a partially realist philosophical position,[29] where they would certainly accept 'entity realism', to use current philosophical jargon, meaning thereby the acceptance of the objective reality of the entities constituting the fundamental micro-structure of matter. Indeed physicists have no difficulty in accepting the existence of quarks (the building blocks of particles such as protons or neutrons), even though in terms of the currently accepted theory (that has been substantially verified), they never exist in an isolated or individual state, but only as a combination with other quarks.[30]

However in terms of the structure of quantum mechanics, physicists by and large live with the contradictions between the standard view of quantum theory and the implied contradiction that this has with Einstein's special theory of relativity. In doing so, at least some scientists have also argued that this implies the surrender of a realist view of cause and effect.

The long-term realist response to the Copenhagen Interpretation has come in several flavours. There was, for instance, a consistent attempt by the physicists in the erstwhile Soviet Union (inspired by Marxism) to understand which of the interpretational features of quantum mechanics would be compatible with a realist view without negating the positive advances

[29] That is insofar as they paid attention to the philosophical foundations of their discipline, since by and large the discipline is currently characterized by a highly pragmatic (in the commonsense use of the term) view of such issues.

[30] The appropriate analogy here to illustrate the point is to think of a species of 'atoms' that exist only as constituents parts of 'molecules' but never independently.

registered by its development. In the West, the first, most notable, amongst such efforts was that of David Bohm, who, inspired by the early opposition of Einstein, Podolsky and Rosen, developed an interpretation that was explicitly realist and at the same time preserved determinism. This effort later motivated the British physicist John Bell to design criteria that would help to distinguish between the standard interpretation of quantum mechanics and the 'hidden variables' approach of Bohm. These criteria were capable of being implemented experimentally.

But at the same time, the Copenhagen Interpretation has been recognized even by several mainstream physicists to be highly problematic. The counterview that has gained the most adherents appears to be the 'many worlds' approach in a modified form, known as the 'decoherence' or 'consistent histories approach'. The essence of the idea is that all the possible worlds allowed by the probabilistic nature of quantum mechanics do branch off at various points of time, though the picture has to be supplemented by rules that allow the calculation of the probabilities associated to the occurrence of definite processes. This formulation does not explicitly resolve the apparent contradiction between relativistic causality and quantum mechanics.

There also appears to be a consensus that the available experimental evidence does not rule out the hidden variables approach either despite the initial impression that this was indeed the case. Nevertheless, the hidden variables approach appears to most scientific experts as a more cumbersome and complicated theory, that introduces many new structures that do not appear to play any essential role. Interestingly, the lure of overcoming the problems of quantum mechanics by constructing an underlying theory that is deterministic in character continues to fascinate the best minds in physics. The latest to succumb to this lure is the Dutch theoretical physicist Gerard 't Hooft, a physicist who won a Nobel Prize for his work on the fundamental structure of matter.[31] Clearly, the issue of a satisfactory resolution of the issue of quantum mechanics remains an open problem of some importance in the world of physics.

The problems of arriving at a satisfactorily realist understanding of quantum mechanics is quite predictably often cited in defence of anti-realist attitudes, even if the basic motivation for the anti-realism can be discerned in other philosophical or sociological tendencies. Hanson, for instance, clearly was on the side of the Copenhagen Interpretation of quantum mechanics and the apparent incommensurability of quantum mechanics and classical mechanics clearly lent weight to his own view of theory change. Quantum mechanics has been cited by others in the cause of anti-realism, including, for instance, Lyotard in his book, *The Post-Modern Condition*. Norris has provided a valuable contemporary realist assessment of the situation with quantum mechanics. He has also provided a detailed philosophical critique of at least the extreme versions of the 'many worlds' approach.[32] It would certainly

[31] See for instance 'tHooft 2001.
[32] Norris 2000.

benefit the scientific realist view when the outstanding problems with the interpretation of quantum mechanics are resolved and our understanding attains a far more definitive state than the one which obtains today.

Man and Nature—The Necessity of Materialism

This account of contemporary realism will however not be complete without at least a brief mention of two important contributions to contemporary materialism which are particularly relevant from the Marxist viewpoint. In this section we first refer briefly to the work of John Bellamy Foster.

Foster's text *Marx's Ecology*[33] is on the one hand a dedicated attempt to recover the materialist emphasis in dialectical materialism that has been under threat from the Hegelian turn in Marxism (by and large this refers only to academic Marxism) under the influence of the broad anti-realism of various 'post-isms'. At the same time it is a profound attempt to recover the essential trends in Marx's analysis of the relationship between humankind and Nature. While this of course cannot be the end-point of a Marxist view of the ecological questions and related issues, this work clears the underbrush of trends in political ecology that portray Marx as unreflective on the question of man and Nature thus implying that Marxism lacks the foundational theoretical resources to deal with the problem.

Foster's account emerges through the revisiting of the work and influence of three figures central to any recovery of the materialism emphasis of Marxism. In the first instance, Foster deals with the figure of Epicurus, the philosopher of ancient Greece, who has been something of an iconic figure in the history of materialism. If he was a hero to the materialists throughout history, he was also the lightning rod in the history of philosophy that drew the wrath of idealists and positivists throughout history, particularly when questions of the political and social order came to be addressed through the medium of radical philosophical thinking. Thus whether it was the so-called heretics of the Renaissance like Giordano Bruno, or the figures of the Radical Enlightenment, including thinkers like Spinoza, the charge that the clerics laid at their door, was often that of Epicureanism. Foster's account of Epicurus includes the results of recent scholarship on the ancient philosopher based on the latest archaeological evidence. These recent developments impressively confirm Marx's reading of Epicurus by which Marx attempted to overcome the gaps in the texts of Epicurus that were available in his day.

The second important figure in Foster's account is Bukharin. Foster devotes some attention to Bukharin's view of materialism within the framework of dialectical materialism. Bukharin's philosophical position was the subject of intense criticism in his day. In particular, Bukharin's materialism was in fact the target of some very harsh criticism by Gramsci. The critique of Bukharin's work was also the occasion for Gramsci to express his own views on science and materialism in the framework of dialectical materialism. While this essay is not the occasion to undertake a detailed account or re-analysis of Gramsci's view on these matters, we may note that

[33] Foster 2001.

Gramsci's view has been appropriated to bolster the anti-science tendency in Western Marxism in the first instance and later on in critical theory and post-modernism.[34]

Foster underlines the close connection between Bukharin's materialism and the influence of the work of the Soviet-era scientist Vernadsky. Vernadsky, the first president of the Soviet Academy of Sciences, pioneered concepts that are part of the common lore of environmental science today, in particular the idea of the biosphere. Foster's chapter on Bukharin underlines the importance of materialist viewpoint in any understanding of biological, environmental and ecological issues in particular, including but not limited to the question of man and Nature. It is unclear how, without a firm materialist outlook, one could even begin to conceptualize the issues related to humankind in Nature and humans as part of Nature. Gramsci's view of science, in contrast, appears to have, as part of its overly Hegelian character, a very anthropocentric cast to it. The issue of humans as part of Nature rarely makes its appearance in Marxist theory, the work of the Italian Marxist Sebastiano Timpanaro[35] being a noteworthy exception.

If later Marxism has been reticent in recognizing the biological in humankind, this was hardly the case with Marx and Engels. Foster outlines Marx's, following the chemist Leibig, theory of metabolic rift under capitalism based on Marx's idea of the metabolic relation between man and nature. He also discusses the response of Marx and Engels to the publication of the work of Darwin.

Exploring the Nature of Being

The second philosopher that we wish to mention in this very brief section is the French Marxist, Alain Badiou.[36] Though his best-known work is already more than a couple of decades old, its availability in the English language has been relatively recent. The themes of Badiou's philosophical work range over a substantial terrain, including political philosophy and ethics.[37]

But our interest in Badiou's work in the context of this note is in his study of ontology, the subject of his most important work, *Being and Event*, originally written in French almost two decades ago in 1988. In its exploration of ontology, Badiou's is even at a superficial glance (very superficial as this writer will readily admit) quite original and interesting for at least two reasons. The first is the very novelty of the sources of his understanding. Badiou's line of thought sets much store by the initial exploration of the notion of the multiplicity of being (the singular being considered an old-fashioned theological conception) and this leads him to the use of the techniques of axiomatic set theory. The other aspect of Badiou's ontological

[34] For an early account of this problem, see Roy Bhaskar's entries on Materialim, op. cit.
[35] See, for instance, Timpanaro's On Materialism. Timpanaro 1980.
[36] The material in this section is based primarily on a small collection of excerpts from Badiou's writings edited by Oliver Feltham and Justin Clemens, Feltham 2005.
[37] He has also written on questions of political organization from a viewpoint that has both significant agreements and disagreements with the mainstream views of many communist organizations.

view that is interesting is his effort to conceptualize the notion of change at the level of ontology. This undoubtedly is a remarkable step. While the notion of an objective dialectics, immanent in the natural or social world, is certainly not new, it has not (at least in this author's limited acquaintance of the literature) found expression in a foundational study of the nature of events that are associated with change as it were. Conceptions of ontology, as in our discussions above, in the context of scientific realism, have a certain static nature to them. There are entities and causal powers but there is certainly an element of mystery to the question of change and transformation. The point here is that change is not a mystery at the level of concrete scientific ontologies as in the case of evolutionary biology or the class character of society, but in a more abstract philosophical sense.

Conclusions

As we reach the end of this account, it is increasingly evident that there is still a great deal that needs to be told in this story of modern scientific realism that is relevant to modern materialism. One hopes that the weaknesses and limitations of this sketchy account will provoke more detailed accounts that critically examine what is of value to dialectical materialism from current trends in the philosophy, history and sociology of science.

Some specific areas of further interest may include the following. One of the major omissions here is a realist account of the nature of developments in the biological sciences. Since biology shares some commonality with the social sciences, realist approaches in biology would be of some special value. The second issue is that of Marxism and science itself. Various tendencies in Marxism have clearly aligned themselves on different sides of the fault-line of the realism / anti-realism debate. The concrete socio-political contexts in which these views evolved and their subsequent fate is a subject worthy of further detailed study.

The third subject of immediate interest is a more focused account of trends in the history and sociology of science or in the discipline of science studies, in particular in the context of work on science in India.

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