Philosophica 15, 1975 (1), pp. 99-127.

FORMS OF REALISM

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1. Philosophy and Science

Philosophy has always had a special relationship with science. They had common origins in early Greek thought. Of the great philosophers Aristotle and Aquinas had an encyclopaedic knowledge of science, and Kant and Hegel an encyclopaedic interest in it; while Descartes and Leibniz were men of brilliant scientific accomplishment. Few philosophers of any significance have failed to relate to the science of their day; and almost all have sought to define this relationship — even if, as in the case of Plato, it was only to deprecate the relative cognitive value of science or alternatively, as in logical positivism, to deny the meaningfulness of anything other than science; to proclaim their coming common dissolution/realisation in the revolutionary action of the proletariat, as in Hegelian Marxism; or merely, as in linguistic philosophy, to situate science as just one activity among others with no special significance for philosophy.

This close relationship between philosophy and science has meant that the attempt of philosophy to carve out a special field for itself has been continually frustrated by the growth of science[1], to which it has itself contributed. Indeed, until quite recently the terms 'philosophy' and 'science' were used interchangeably : chairs of experimental and natural philosophy still survive at the older universities, while Hume's ambition was a moral science based on the experimental method. It was only gradually that it became clear that if it was the task of science to investigate nature, it was the task of philosophy to investigate inter alia man's investigation of nature; that is, that philosophy was a *second-order activity*. As such, it could not be either simply prescriptive or simply descriptive (or reconstructive). Thus if Descartes was a philosophical catalyst of the new physics, Kant was its meta-theoretician. Now philosophy, as so conceived, must include itself as one of its own objects of investigation. In this article, I want to try to show how recent work in the philosophy of science can contribute to the solution of some traditional philosophical problems, and to the elucidation of the nature of philosophical discourse itself. Further, I believe this work is itself a precondition for the resolution of critical conceptual and meta-theoretical problems in the underdeveloped social sciences. If this is so, philosophy would once again be fulfilling its historic role as the midwife of science.

I am going to assume that the attempt to ground the autonomy of philosophy in a special *field* (such as man, culture or language) is mistaken; rather what is characteristic of philosophy is its *method*, and its method is transcendental. The aim of philosophy is the production of transcendental knowledge. Transcendental knowledge is knowledge of the necessary conditions of conceptualised experience[2] (where experience is interpreted in the widest possible sense, i.e. as activity). And such knowledge is yielded by transcendental arguments. Transcendental arguments take as their premiss some recognised feature of human activity or experience and seek to establish their necessary conditions.

Although the form of argumentation employed in this article is Kantian, its conclusion is non-Kantian. Whereas Kant was concerned to analyse the necessary conditions of individual human experience, I am concerned to analyse the necessary conditions of a specific social activity, viz. science; which I intend to argue, despite the continual lipservice paid to it by the entire empiricist tradition, has never been seriously philosophically analysed. Rather philosophers have simply subsumed science under their general concept of knowledge, even where they have accorded it formal priority, without engaging in a philosophical (transcendental) analysis of anything specific to it. The transcendental arguments deployed in this article take as their premisses experimental activity and scientific discovery; and entail realist conclusions — what I shall refer to as *transcendental realist* conclusions. Transcendental realism is opposed to empirical realism; a doctrine which has been uncritically accepted by almost all philosophers of science, and which it is the aim of this paper to attack. In doing so, I wish to reconstitute the possibility of philosophy as a science of ontology.

Transcendental realism may be defined as the thesis that the objects, of which in the social activity of science knowledge is obtained, both exist and act independently of men, and hence of human sense — experience. Now such objects, upon analysis, do not appear as conjunctions or sequences of events, but as structures which are normally out of phase with them. One novelty of this argument is that a transcendent ontology is necessitated by the *empirical practice* of science. Transcendental realism does not imply, as Kant supposed, empirical idealism[3]; on the contrary empirical realism renders impossible an understanding of the role and significance of experience in science.

Now if philosophy is to include itself as one of its own objects of analysis, critical philosophy must submit the doctrine of empirical realism itself to transcendental analysis; that is, it must ask what *its* necessary conditions are. Foremost among these will be seen to be a particular conception of man, which leads to a neglect of the social conditions of the production of knowledge in science. The philosophy of science thus outlined here has two aspects, which justifies our talking of two dimensions — an *intransitive* dimension, in which the objects of knowledge are conceived as existing and acting independently of men; and a *transitive* dimension, in which knowledge of them is seen to be produced in the social activity of science.

It is the aim of this paper to show how science can come to have knowledge of natural necessity a posteriori. But the statements that express the necessary connections that bind some but not other events together in nature cannot be regarded as empirical; they do not express conjunctions of events or experiences, but the activities of mechanisms or the operations of tendencies which need not be manifest in any particular sequence of events or realised in any particular outcome. For this reason I shall characterise them as normic or transfactual (non-empirical) statements[4].

Finally, I should stress that the non-empirical or transcendent entities, implied by the transcendental analysis of scientific activity, are not objects of philosophical enquiry, but of scientific enquiry; they are objects of scientific enquiry, established as such by philosophical argument. They are not Platonic entities; they are forms of *nature*, not *knowledge*. And the forms of nature are not the objects of metaphysics, but the final causes of the social activity of science.

In the next three sections, then, I want to ask what the necessary conditions for experimental activity, scientific discovery and empirical realism are respectively; this will involve the deployment of three transcendental arguments, two in the philosophy of science and one in the philosophy of the philosophy of science. I can then, having vindicated transcendental realism and situated the conditions of the intelligibility of empirical realism, return to the problem of ontology and the question of the relationship between philosophy and science.

2. The Analysis of Experimental Episodes

It will be convenient to structure my argument in this section as a criticism of the theory that causal laws are, or depend upon, constant conjunctions of events or states-of-affairs, which are interpreted as the objects of actual or possible experiences. For the neo-Kantian a constant conjunction is necessary but not sufficient, for the Humean it is both necessary and sufficient; by contrast, for me it is neither necessary nor sufficient. Now I want to argue that the intelligibility of experimental activity in science entails the ontological independence of causal laws (or more generally the real objects under scientific investigation) from the patterns of events experimentally produced and hence from the experiences recorded. If this argument is correct, it follows that the empirical realist analysis of causal laws must be wrong; and, more generally, that the universality implicit in the analysis of laws cannot be explicated in terms of an invariance of experiences.

Now experimental activity depends upon the exercise of men's perceptual (and descriptive), as well as their causal powers. Before analysing the latter in detail, I want to briefly consider the significance of the former.

The intelligibility of sense-perception in science presupposes the independent existence or occurrence of the objects perceived. Many arguments could be used to show this. For our purposes it is sufficient merely to note that both the possibility of scientific change (or criticism) and the necessity for a scientific training presuppose the independence of some real objects, which, for the empirical realist at least, can only be objects of perception. Among such objects are events, which must thus be categorically independent of experiences. If changing experience of objects is to be possible, objects must have a distinct being in space and time from the experiences of which they are the objects. For Kepler to see the rim of the earth drop away, while Tycho Brahe watches the sun rise, we must suppose that there is something that they both see (in different ways)[5].

Events then are categorically independent of experiences. There could be a world of events without experiences. Such events would constitute *actualities* unperceived and, in the absence of men, unperceivable. There is no reason why, given the possibility of a world without perceptions, which is presupposed by the intelligibility of actual scientific perceptions, there should not be events in a world containing perceptions which are unperceived and, given our current or permanent capacities, unperceivable. And of such events theoretical knowledge may or may not be possessed, and may or may not be achievable. Clearly, if at some particular time I have no knowledge of an unperceived or unperceivable event, I cannot say that such an event occurred (as a putative piece of scientific knowledge). But that in itself is no reason for saying that such an occurrence is impossible or that its supposition is meaningless (as a piece of philosophy). To do so would be to argue quite illicitly from the current state of knowledge to a philosophical conception of the world. Indeed we know from the history of science that at any moment of time there are types of events never imagined, of which theoretical, and sometimes empirical knowledge is eventually achieved. For in the ongoing process of science the possibilities of perception, and of theretical knowledge, are continually being extended. Thus unless it is dogmatically postulated that our present knowledge is complete or that these possibilities are exhausted, there are good grounds for holding that the class of unknowable events is non-empty, and unperceivable ones non-emptier; and no grounds for supposing that this will ever not be so.

To turn now to the significance of man's causal activity in experimental episodes. Remember that the empiricist analyses laws as a constant conjunction of events perceived (or perceptions). Now an experiment is necessary precisely to the extent that the pattern of events forthcoming under experimental conditions would not be forthcoming without it. Thus in an experiment the scientist is a causal agent of the sequence of events but not of the causal laws which the sequence of events, because it has been produced under experimentally controlled conditions, enables him to identify.

Two consequences flow from this. First, the real basis of causal laws cannot be sequences of events; there must be an ontological distinction between them. Secondly, experimental activity can only be given a satisfactory rationale if the causal laws it enables us to identify are held to prevail outside the contexts under which the sequence of events is generated; in short, if empirical invariances, i.e. the realisation of the consequents of law-like statements, are not a necessary condition for the assumption of the efficacy of causal laws.

The point has recently been made our active *interference* in nature is normally a condition of empirical regularities[6]. But it has not been seen that it follows from this that there must be as *ontological* distinction between them[7]. Although it has yet to be given an adequate philosophical rationale, the distinction between causal laws and patterns of events is consistent with our intuitions. Thus if a nuclear explosion were to destroy our planet it would not violate but exemplify Newton's laws of motion[8]. And as every research worker and every schoolboy knows, no experiment goes properly the first time[9]. Chemists clung tenaciously to Prout's hypothesis for over a century until the invention of physical techniques for chemical separation made possible its experimental vindication[10]. Only under *closed conditions* are constant conjunctions, repeated or repeatable sequences of events, unique relationships between the antecedents and consequents of law-like statements, available. But, in general, outside astronomy[11] closed systems must be experimentally established. And celestial phenomena too merely provide evidence that bodies tend to act in certain ways. In short, causal laws cannot be identified with those regularities that constitute their empirical grounds.

Of course to say that there is an ontological distinction between causal laws and patterns of events leaves open the question of the real basis of causal laws. To this, I turn in a moment. It is sufficient for our purposes here to note that any other conclusion renders experimental activity pointless. Why, given that a scientist is a causal agent capable of generating various sequences, should he generate the particular sequences he does, lest it be because they cast light on the ways things act independently of his activity, outside the laboratory ? Now once the categorical independence of causal laws and patterns of events is established, then we may readily allow that laws continue to operate in open systems, where no constant conjunctions of events prevail. And the rational explanation of phenomena occurring in such systems becomes possible; so that both the experimental establishment and the practical application of our knowledge becomes intelligible.

In a world without men there would be no experiences and few, if any, constant conjunctions of events. For both experiences and invariances depend, in general, upon human activity. But causal laws do not. Thus in a world without men, the causal laws that science has now as a matter of fact discovered would continue to prevail, though there would be few sequences of events and no experiences with which they were in correspondence. Empirical realism depends in fact upon a barely concealed *anthropocentricity*.

The concept of causal laws as, or dependent upon, empirical regularities involves a double reduction : of events to experiences; and causal laws to constant conjunctions of events. This double reduction involves two category mistakes, expressed most lucidly in the concepts of the empirical world and the actuality of causal laws (the latter presupposing the ubiquity and spontaneity of closed systems). Now this double reduction prevents the empirical realist from examining the critical question of the conditions under which experience is in fact significant in science. In general, this requires both that the perceiver be theoretically informed and that the system in which the events occur be closed. It is only under such conditions that the experimental scientist can come to have access to those underlying causal structures which are the objects of his theory. And not until the categorical independence of causal laws, patterns of events and experiences has been philosophically established and the possibility of their disjuncture thereby posed can we appreciate the enormous effort — in experimental design and scientific training — that is required to make experience epistemically significant in science. (The laboratory and the classroom are the two most obvious, and yet the two most underanalysed, *sites* of science).

In an experiment men put a question to nature. But they must put it both in a language that nature understands and in a form that makes possible an unambiguous reply. Both have to be worked for — *practically*, as well as in thought, depending thus upon the construction and transmission of both new concepts and tools[12].

The intelligibility of experimental activity presupposes then the possibility of a non-human world, i.e. causal laws without invariances and experiences, and in particular of a non-empirical world, i.e. causal laws and events without experiences; and the possibility of open systems, i.e. causal laws out of phase with patterns of events and experiences, and more generally of epistemically insignificant experiences, i.e. experiences out of phase with events and causal laws. Once we grasp the significance of the facts, in the transitive dimension, that knowledge of the causal laws of nature is not spontaneously available but has to be assiduously worked for in the social activity of science; and, in the intransitive dimension, that the causal laws of nature of which knowledge is attained persist and act outside the deliberately created conditions that permit their empirical identification, we can begin to see how the doctrine of empirical realism comes to seriously *understate* both the critical significance and the potential scope of application of science.

Before completing my analysis of experimental episodes, I must go a bit further into the question of the real basis of causal laws. We can best approach this by considering the problem of distinguishing a necessary from a purely accidental sequence of events. Clearly, if such a distinction is to be tenable the analysis of the (lawlike) statement purporting to describe the necessary sequence must contain a 'surplus-element' over and above a description of the sequence of events concerned. Recent work in the philosophy of science has sought to locate it in a theory, backing the statement concerned, at the core of which lies a model, posited in the scientific imagination, of a natural mechanism or structure at work, providing a putative causal or explanatory link[13]. Now if we grant that under certain conditions some postulated mechanisms can come to be established as real (criteria for the ascription of reality will be considered in the next section), we may allow that it is in the working of such mechanisms that the objective basis of our ascriptions of natural necessity lies. The real basis of causal laws consist then of the generative mechanisms of nature, which are in turn nothing other than the ways of acting of persisting (natural kinds of) things[14]. And causal laws may be regarded as their *tendencies*[15]. Tendencies are a class of powers which may be exercised without being manifest in any particular outcome; they are therefore just right for the analysis of causal laws. Tendencies may be possessed unexercised, exercised unrealised and realised unperceived (or undetected) by men.

The point of experimental activity then is to get a single mechanism going in isolation and to record its effects. For outside the laboratory the results of the mechanism's activity will normally be affected by the operation of other mechanisms too; so that crucial experiments become impossible. In an experiment the scientist must perform two essential functions. First, he must trigger the mechanism under study to ensure that it is active; and secondly, he must prevent any interference with the operation of the mechanism. These activities could be designated 'experimental production' and 'experimental control'. The former is necessary to ensure the satisfaction of the antecedent (or stimulus) conditions, the latter to ensure the realisation of the consequent, i.e. that a closure has been obtained. But both involve changing or being prepared to change the 'course of nature'[16]. It can thus be seen that the complement of the anthropocentricity implicit in the empiricist analysis of laws (in the intransitive dimension) and necessary to sustain it is neglect (in the transitive dimension) of the conscious human activity necessary for the production of the knowledge of them. In the intellectual grid within which philosophical ideas are produced the man-dependence of knowledge and the man-independence of the world appears in empirical realism as the man-dependence of the world (its empirical nature) and the man-(or at least activity—) independence of knowledge.

Now it is important to be clear about what philosophical argument can achieve. Thus as a piece of philosophy we can say, given that science occurs and has the features ascribed to it, that some real things and generative mechanisms must exist and act. But philosophical argument cannot establish which ones actually do; or, to put it the other way round, what the real mechanisms are. That is up to science to discover. That generative mechanisms must exist and sometimes act independently of men and that they must be irreducible to the patterns of events they generate is presupposed by the intelligibility of experimental activity. But it is up to actual experiments to tell us what the mechanisms of nature are. Here, as elsewhere, it is the task of philosophy to analyse notions which in their substantive employment have only a syncategorematic use.

It is important to beware of the supposition that because outside closed systems there is no unique correspondence between laws and patterns of events, the law ceases to be applicable. Outside closed systems generative mechanisms endure and, once set in motion, act in their normal way, contributing to the manifest outcome, whether or not, due to the operation of countervailing causes or interfering agents, their consequents are unrealised. Law-like statements make a claim about the activity of a tendency, i.e. the operation of the generative mechanism that would, if undisturbed, result in the tendency's manifestation; but not about the conditions in which the tendency is exercised and hence not about whether it will be realised or prevented. Because the operation of the generative mechanism does not depend upon the closure or otherwise of the systems in which the mechanism acts, the mode of application of law-like statements is the same in both closed and open systems; what does differ is the inference that can be drawn from our knowledge of the applicability of the statements in the two cases (for example, in open systems, we are not warranted in predicting the tendency's fulfilment). To cite a law in the explanation of an event is to say that a generative mechanism was really at work helping to account for, though in open systems not completely determining, what actually happened. To invoke such a law I must have grounds for supposing the generative mechanism at work. These comprise : (a) independent grounds, preferably under experimentally closed conditions, for the mode of operation of the mechanism; (b) grounds for the satisfaction of the antecedent or stimulus conditions for the operation of the mechanism on the particular occasion in question; and (c) the absence of specific grounds for supposing a breakdown or transformation of the mechanism in that case.

The transcendental analysis of experimental activity shows that the objects of scientific inquiry, such as the structures that provide the real basis for causal laws, both exist and act independently of the operations of men and the patterns of events alike. It is to the investigation of this enduring and transfactually active machinery of nature that all the empirical efforts of science are directed.

3. The Analysis of Scientific Discovery

If the premiss employed in the transcendental argument of § 2, viz. experimental activity, has been scandalously underanalysed, few philosophers have doubted its existence and significance in science. The situation is not so simple in the case of our next argument — for the premiss itself is a matter of some dispute, and perhaps even discovery. Thus it is only recently that philosophers have come to realise the existence or at least significance of scientific criticism and change[17]; and, where they have, they have found it difficult to reconcile with the idea of science as involving a growth in our knowledge of things. In view of this situation, I shall first more or less dogmatically sketch a mechanism of scientific discovery, making use of the conclusion already established in § 2, viz. that the objects of scientific discovery are structures and mechanisms, not events and states-of-affairs, or experiences or their epistemological equivalents (such as human operations). I shall then justify my reconstruction of the process of scientific discovery by showing how it can account for both *scientific growth* and *scientific change*[18], the two aspects of *scientific development*. Having established the premiss of my transcendental argument, I shall then be in a position to develop the conditions of its possibility.

In science there is a kind of dialectic in which a regularity is identified, a plausible explanation for it is invented, and the reality of the entities and processes postulated in the explanation is then checked. If the classical empiricist tradition in the philosophy of science stops at the first step, a second neo-kantian tradition sees the need for the second[19], involving creative model-building, in which plausible generative mechanisms are imagined to produce the phenomena in question. But it either denies the need for, or does not draw the full (transcendental realist) implications of the third, in which the reality of the mechanisms postulated in the model are subjected to empirical scrutiny. Transcendental realism differentiates itself from empirical realism in interpreting the first stage of the dialectic as the invariance of a *result* rather than that of a *regularity*; and from transcendental idealism in allowing that what is *imagined* need not be *imaginary* but may be (and come to be known as) real. Here again it should be stressed that though, for transcendental realism, that some real things and generative mechanisms must exist can be established by philosophical argument (their existence, and transfactual activity, is a condition of the possibility of science) it is contingent and the job of science to discover which hypothetical or imagined mechanisms are not imaginary but real; or, to put it the other way round, to discover what the real mechanisms are, i.e. to produce an adequate account of them. It is only if the third step is taken that there can be an adequate rationale for the use of laws to explain phenomena in open systems (i.e. for the idea of the universality of laws) or for the experimental establishment of laws in the first place. The neokantian tradition can sustain a distinction between necessary and accidental sequences. But it cannot sustain the universality of laws, which necessitates a distinction between real structures and the actual pattern of events too.

Most science proceeds by way of a two-tiered method designed to identify invariances in nature, normally under conditions which are experimentally produced and controlled, and to explain them by reference to enduring mechanisms[20]. Thus the observable reactions of chemistry, which are represented in textbooks by formulae such as $2Na + 2HCl = 2NaCl + H_2$, are explained by reference to the atomic hypothesis and the theory of chemical bonding and valency. The patterns which constitute the explananda of the theory of valency are not of course superficially obvious or readily available. Both the concepts and the substances and conditions had, and have to be, worked for, produced in the social activity of science. The theory itself sets out to describe the causal mechanisms responsible for the behaviour of the substances. Once its reality has been established (which justifies our assuming that chemical bonding occurs and the laws of chemistry hold outside the laboratory) and the consequences of the theory have been fully explored, the next step consists in the discovery of the mechanisms responsible for chemical bonding and valency. This is explained in terms of the electronic theory of atomic structure. Once the reality of this explanation has been established, science moves on to the discovery of the mechanisms responsible for what happens in the sub-atomic microcosm of electrons, protons and neutrons; and we now have various theories of sub-atomic structure. The historical development of chemistry may thus be represented by the following schema :

Stratum I $2Na + 2HCl = 2NaCl + H_2$
explained by
Stratum II theory of atomic number and valency — Mechanism 1
explained by

Stratum III theory of electrons and atomic structure Mechanism 2
explained by
Stratum IV (competing theories of sub-atomic structure) Mechanism 3

Both nature and our knowledge of nature, then, are *stratified;* and *ontological depth* is a condition of the development of science. But it should be noted that the historical order of the development of our knowledge of strata is opposite to the causal order of their dependence in being. No end to this process of the successive discovery and description of ever deeper, and explanatorily more basic, strata can be envisaged. Other sciences reveal a similar open-ended stratification[21].

Now the stratification of the world must be assumed by the scientist, working in any field, to be in principle unbounded. But his knowledge may be in practice bounded by semi-permanent technical or conceptual problems, or by the domain assumptions of his particular science; or by the fact that reality is itself bounded at the level knowledge of which he has attained. However, if the stratification of the world has an end, i.e. if there are 'entities' which are truly ultimate and the scientist has achieved knowledge at that level, he can never know *that* the level is ultimate. For it will still remain possible for him that there are reasons, located at a still deeper level, for the causes of the phenomena he has succeeded in identifying and describing.

A general pattern of activity emerges from this. When a stratum of reality has been discovered and adequately described, science moves immediately to the construction and testing of possible explanations for what happens at that level. This will involve drawing on whatever cognitive equipment is available, the invention of new sense-extending equipment and the design of new experimental techniques. Science must thus be seen as a process-in-motion, with the dialectic mentioned above in principle having no foreseeable end. The key move in this process involves the postulation of hypothetical entities and mechanisms, whose reality can be ascertained. Now, for the transcendental realist, the stratification this form of exploration imposes upon our knowledge reflects a *real stratification* in the world. Without this concept we cannot make sense of what the scientist, striving to move from knowledge of one stratum to the next, is trying to do, viz. to discover the reasons why the individuals he has identified at a particular level of reality tend to behave the way they do; without this concept the stratification of science must appear as a kind of historical accident, lacking any internal rationale in the practice of science (if indeed it is not denied altogether in a reductionist and ultimately phenomenalist account of science).

As it is clear that the hypothetical entities and generative mechanisms imagined for the purposes of theory-construction must initially derive at least part of their meaning from some other source (if they are to be capable of functioning as possible explanations at all) theories must be already understood before correspondence rules are laid down for them. Equally this means that the descriptive terms must have initially possessed a meaning independent of them. This enables us to see how meaning-change is possible. Similarly we can see how knowledge of newly discovered strata may correct knowledge of less fundamental strata, as concepts and measurement techniques are refined. Now if changing knowledge of strata is to be possible, the strata must not change with our knowledge of them. Thus the concept of real strata apart from our knowledge of strata is necessary if the idea of scientific change, which is central to recent critical philosophy of science, is to be intelligibly sustained. More generally, acknowledgement of the real stratification of the world allows us to reconcile scientific growth, including as a special case discovery (of new strata), with scientific change (of knowledge of strata).

Now it is in the movement from the identification of invariances to the mechanisms and structures that account for them that the logic of scientific discovery must be found. In the transition between knowledge of any one stratum of reality to knowledge of the next, knowledge of three levels of the objective world order is progressively obtained : of relations between events, of causal laws and of natural kinds. (Causal laws are the tendencies of natural kinds, realised under closed conditions). At the first (or Humean) level we just have the invariance of an experimentally produced result. Given such an invariance, science moves immediately to the construction and testing of possible explanations for it. If there is a correct explanation, located in the nature of the thing whose behaviour is described in the putative law or the structure of the system of which the thing is a part, then we do have a reason independent of its behaviour as to why it behaves the way it does. And the availability of such a reason provides the key for the solution of the traditional problem of induction, and the host of problems and paradoxes associated with it[22]. Now such a reason may be discovered empirically. And if we can deduce the thing's tendency from it then the most stringent possible (or Lockean) criterion for our knowledge of natural necessity is satisfied. For example, we may discover that copper has a certain atomic or electronic structure and then be able to deduce its dispositional properties from a statement of that structure. We may then be said to have knowledge of natural necessity a posteriori. Finally, at the third (or Leibnizian) level we may seek to express our discovery of the electronic structure of copper in an attempted real definition of the substance or thing. This is not to put an end to enquiry, but a stepping stone to a new process of discovery in which science seeks to unearth the mechanisms responsible for *that* level of reality.

If we can have empirical knowledge of the structures and mechanisms generating the phenomena identified at any one level of reality, then we can have knowledge of natural necessity a posteriori. In showing how this is possible the conflicting insights of empiricism and rationalism can be reconciled in a non-Kantian way. (The Kantian is, in virtue of his ontological commitment, restricted to the first level of knowledge of the objective world order). Science, on the view advanced here, is concerned with both taxonomic and explanatory knowledge : with what kinds of things there are, as well as with how the things there are behave. It expresses the former in real definitions of the natural kinds and the latter in statements of their normic behaviour, i.e. of causal laws.

It is clearly essential to the theory of scientific development proposed here that imagined entities and modes of behaviour may come to be established as real. Now an entity may be 'theoretical' either in the sense that its existence is open to doubt (theoretical$_1$), or in the sense that it cannot be directly perceived, either unaided or with the help of sense-extending equipment (theoretical$_2$). Now an entity or mode of behaviour may be theoretical$_1$ at time t_1 and perceived and adequately described at t_2, so it then ipso facto ceases to be theoretical$_1$. The existence of bacteria, initially conceived as minute hostile micro-organisms, and molecules, initially modelled on material objects, came to be established in this way. But if an entity cannot be perceived, i.e. is theoretical$_2$, does this mean that it cannot be known to exist, so that it must be theoretical$_1$? If this were the case all theoretical$_2$ entities would indeed be hypothetical, and our knowledge would be necessarily confined to the domain of observable things, even if this were now regarded as an expanding class. Fortunately this conclusion does not follow. For theoretical$_2$ entities may be known to exist indirectly, viz. through the perception of their effects. The paradigm here is the detection of radio-active materials by a geiger counter, of electricity by an electroscope, of a magnetic field by a compass needle. It should be stressed that in the case of detection that something does exist producing the effect is not in question. Nor is the fact that it exists and acts independently of its detection. In such cases it is not true to say that there is a cause is less certain; it is rather that what we can know about a thing is limited to its causal powers.

It is because we are ourselves material things that our criteria for establishing the reality of things turn on the capacity of the thing whose existence is in doubt to bring about (or suffer) changes in its material constitution or the constitution of some material thing. But we can conceive the possession and exercise of causal powers in ways and at levels for ever unknowable to man. We can never know where we stand absolutely in the chain of being. Despite this cosmic incapacity, science has succeeded in identifying strata of reality. Now the scientist never doubts for a moment that there are reasons for the behaviour he has identified and described. It is in the search for such reasons, at a deeper level of reality, at present known to him only through its effects, that the essence of scientific discovery lies. This search necessitates the construction of both new concepts and new tools (or the resurrection of old or refinement of existent ones). But, as what is produced must possess a material cause, the scientist stands for his essential task, in two systems of social relationships, depending necessarily on the work of others.

Now it is a condition of the intelligibility of scientific discovery that what is discovered is not already known (in the transitive dimension); and that what is discovered exists (as a putative object of discovery) independently of its discovery (in the intransitive dimension). If transcendental realism distances itself from classical empiricism in the first respect, it distances itself from transcendental idealism in the second respect. Scientific discovery is accomplished by means of a process of *work*, immanent to the epistemic order, in the transitive process of science: by the transformation of knowledge-like antecedents. Science operates on given materials, including pre-existing theory and antecedently established facts, with given materials, i.e. by means of an ensemble of intellectual and technical tools, producing new theories and facts. Science is produced by the imaginative and disciplined work of men on what is given to them. But the instruments of the imagination are themselves provided by knowledge. Thus knowledge is a produced means of the production of knowledge (the transitive dimension). But the knowledge produced is *of* things that exist and act independently of its production (the intransitive dimension).

Just as the transcendental analysis of experimental activity showed the necessity for the concept of the independent existence and activity of things, so the analysis of scientific discovery shows the necessity for the concept of knowledge possessing a material cause of its own kind. Now underpinning empirical realism is an *epistemological individualism*, implicit e.g. in the concept of the empirical world. Transcendental idealism marks a major advance on classical empiricism in that it asks for the necessary conditions of individual experience and finds an answer in the intersubjective world of science, in virtue of which it can sustain a transitive dimension. But though it can sustain a concept of science as work, it cannot reveal the object or aim of the work. For if in classical empiricism knowledge is not seen as produced, in transcendental idealism what is produced in science is not knowledge of things (existing and acting independently of human activity). Thus transcendental idealism cannot sustain the idea of *scientific progress* and lapses into a total relativism (with nature subject to the necessities, or whims, of men). Epistemological individualism is manifest in transcendental idealism in the premiss of the transcendental argument employed. By contrast transcendental realism asks for the conditions of the possibility of the social activity of science, finding its answer in the intransitive world of (knowable but man-independent) things. In this way the rationality of scientific transformations can be sustained.

Scientific development consists then in the transformation of social products, antecedently established items of knowledge, which may be regarded as Aristotelian material causes. For example, the material cause, in the sense, of Darwin's theory of natural selection consisted inter alia of the facts of natural variation, the theory of domestic selection and Malthus' theory of population. Science then must be conceived as an ongoing social activity. And scientific knowledge stands to individuals as a social product[23] which, if science is to be ongoing, individuals must reproduce or more or less transform; and which they must draw upon to use in their own critical exploration of nature. In short, scientific activity possesses a material cause. (Research and teaching are the most obvious, yet again philosophically under-analysed, *tasks* of scientists). Men do not *create*, but only *change*, their knowledge (with the cognitive tools at their disposal); and this knowledge stands to them always as a layered structure which cannot be analysed out as a function of individual sense-experience.

4. The Analysis of Empirical Realism

My analysis of experimental episodes and scientific discovery respectively allows me to develop two criteria for the adequacy of an account of science: (i) in the intransitive dimension, its capacity to sustain the idea of the independent existence and activity of the objects of scientific discovery and investigation; and (ii) in the transitive dimension, its capacity to sustain the idea of knowledge as a produced means of production. Knowledge is produced by means of knowledge but it is knowledge of things which exist and act independently of scientific thought.

Now I want to argue that the necessary conditions of the doctrine of empirical realism are : (i) in the intransitive dimension, an ontology of atomistic events and closed systems and (ii) in the transitive dimension, a particular conception of man; an implicit ontology and an implicit sociology (which is the former's condition).

Though transcendental idealism rejects the empiricist account of science, according to which its valid content is exhausted by atomistic facts and their conjunctions, positing as its objects models, ideals of natural order etc., it tacitly takes over the empiricist account of being, in virtue of which it cannot, any more than classical empiricism, sustain the criterion of adequacy in the intransitive dimension developed above. This ontological legacy is expressed in its commitment to empirical realism, and thus to the concept of the *empirical world*. Now, for the transcendental realist, this concept embodies a series of related philosophical mistakes. The first consists in the use of the category of experience to define the world. This involves giving what is in effect a particular epistemological concept a general ontological function. The second consists in the view that its being experienced or experienciable is an essential property of the world; whereas it is more correctly conceived as an accidental property of some things, albeit one which can, in special circumstances, be of great significance for science. The third thus consists in the neglect of the socially produced circumstances under which experience is in fact epistemically significant in science.

To say that the weaknesses of both the empiricist and idealist traditions in the philosophy of science lie in their commitment to empirical realism is of course to commit oneself to the impossibility of ontological neutrality in an account of science, and thus to the impossibility of avoiding ontological questions in the philosophy of science. The sense in which every account of science presupposes an ontology is the sense in which it presupposes a schematic answer to the question of what the world must be like for science to be possible. Thus, suppose a philosopher holds, as both empiricists and transcendental idealists do, that a constant conjunction of events apprehended in sense-experience is at least a necessary condition for the ascription of a causal law and that it is an essential part of the job of science to discover them. He is then committed to the belief that, given that science occurs, there are such conjunctions. As Mill put it, that "there are such things in nature as parallel cases; that what happens once will, under a sufficient degree of similarity of circumstance, happen again"[24].

There are two important points to register about such ontological beliefs or commitments. The first is that they should only be interpreted hypothetically or conditionally, viz. as entailing what must be the case for science to be possible, on which interpretation it is a contingent fact that the world is such that science can occur. But given that science does occur, we can infer — from our analysis of experimental episodes — that the world *must* be structured and differentiated (the latter is a condition of the possibility of experimental science). Though here again it should be stressed that the particular structures it contains and the ways in which it is differentiated are matters for substantive scientific investigation.

The second point to stress is that propositions in ontology cannot be established independently of an account of science. On the contrary they must be established by reference to such an account, or at least to an account of certain scientific activities. However, this essential order of analysis, viz. science → being, *reverses* the real direction of dependency (or, we could say, the real burden of contingency). For it is not the fact that science occurs that gives the world a structure such that it can be known by men. Rather, it is the fact that the world has such a structure that makes science, whether or not it actually occurs, possible. It does not follow from the fact that the nature of the world can only be *known* from a study of science, that its nature is *determined* by the structure of science. Propositions in ontology, i.e. about being, can only be established by reference to science. But this does not mean that they are disguised, veiled or otherwise elliptical propositions about science. What I shall characterise as the *'epistemic fallacy'* consists in assuming that, or arguing as if, they are.

Now the transcendental analysis of experimental activity establishes both that a philosophical ontology is possible and some propositions in it (e.g. that causal laws are distinct from patterns of events and events from experiences). Philosophical ontology asks what the world must be like for science to be possible; and its premisses are generally recognised scientific activities. Ontology, it should be emphasised, does not have as its subject matter a world apart from that investigated by science. Rather, its subject matter just is that world considered from the point of view of what can be established about it by philosophical argument.

The analysis of experimental activity shows that the assertion of a causal law entails that it would operate even if unknown, just as it operates when its consequent is unrealised (or unperceived or undetected by men), i.e. outside the conditions that permit its empirical identification. It follows from this that statements about being cannot be reduced to or analysed in terms of statements about knowledge, that ontological questions cannot always be transposed into epistemological terms. The fallacy that being can always be analysed in terms of our knowledge of being, that it is sufficient for philosophy to "treat only of the network, and not what the network describes"[25] results in the systematic dissolution of the idea of a knowable world independent of but investigated by science. And it is manifest in the prohibition on transcendent (theoretical$_2$) entities and forms of activity, which play an indispensable role in both the growth and application of science. Once we reject what may be styled as the 'epistemological argument' knowledge ceases to be, as it were, an essential predicate of things; and we can begin to do justice to science ... For the transcendental realist the possibility of our knowing it is not an essential property, and so cannot be a defining characteristic, of the world. Rather, on a cosmic scale, it is an historical accident; though it is only because of this accident that we can establish in science the way the world is, and in philosophy the way it must be for science to be possible.

The epistemic fallacy is most marked, perhaps, in the concept of the empirical world. But it is manifest in the criteria of significance and even the problems associated with the tradition of empirical realism. Kant committed it in arguing that the categories "allow only of empirical employment and have no meaning whatsoever when not applied to objects of possible experience; that is to the world of sense"[26]. Similarly, the logical positivists committed it when arguing, in the spirit of Hume, that if a proposition was not empirically verifiable (or falsifiable) or a tautology, it was meaningless[27]. Verificationism indeed may be regarded as a particular form of the epistemic fallacy, in which the meaning of a proposition about reality (which it is wrong to designate as 'empirical') is confused with our grounds, which may or may not be empirical, for holding it. Once the reduction of ontology to epistemology is rejected there is no need to identify the necessary and the a priori, or the contingent and the a posteriori. Or to assume that the order of dependence of being must be the same as the order of dependence of our knowledge of being. Thus we can allow that experience is in the last instance epistemically decisive, without supposing that its objects are ontologically ultimate, in the sense that their existence depends upon nothing else. Indeed, if science is regarded as a continuing process of the discovery of ever finer and in an explanatory sense more basic causal structures, then it is rational to assume that what is at any moment of time least certain epistemically speaking is most basic from the ontological point of view. To be is *not* to be the value of a variable[28]. For, if it were, we could never make sense of the complex processes of identification and measurement by means of which we can sometimes represent things as such.

The epistemic fallacy involves the denial of the possibility of a philosophical ontology. But if transcendental realism is correct, and ontology cannot in fact be reduced to epistemology, then denying the possibility of an ontology merely results in the generation of an *implicit ontology* and an *implicit realism*. The epistemic fallacy thus covers or disguises an ontology based on the category of experience, and a realism based on the presumed characteristics of the objects of experiences, viz. atomistic events, and their relations, viz. constant conjunctions. (I shall suggest in a moment that such presumptions can in turn only be explained in terms of the need felt by philosophers for certain foundations of knowledge). This in turn leads to the generation of a methodology which is either consistent with epistemology but of no relevance to science; or relevant to science but more or less radically inconsistent with epistemology, so that philosophy itself tends to be out of joint with science. Let us see how this happens.

First, the general line of Hume's critique of the possibility of any philosophical ontology or account of being, and in particular his denial that we can philosophically establish the independent existence of things or operation of natural necessities, is accepted. Now it is important to see what Hume has in fact done. He has not really succeeded in banishing ontology from his account of science. Rather, he has merely replaced the Lockean ontology of real essences, powers and atomic constitutions with his own ontology of impressions. To say that every account of science, or every philosophy in as much as it is concerned with 'science', presupposes an ontology is to say that the philosophy of science abhors an ontological vacuum. The empiricist fills the vacuum he creates with his concept of experience. In this way an implicit ontology, crystallized in the concept of the empirical world, is generated. And it is this ontology which subsequent philosophers have uncritically taken over. For whether they have agreed with Hume's epistemology or not, they have accepted his critique of ontology, which contains its own implicit ontology, as valid.

Let us examine the generation of this implicit ontology in greater detail. In Hume's positive analysis of perception and causality experiences constituting atomistic events and their conjunctions are seen as exhausting our knowledge of nature. Now, adopting a realist meta-perspective this means that such events and their conjunctions must occur in nature, if science is to be possible. But from Hume onwards the sole question in the philosophy of science is whether our knowledge is exhausted by our knowledge of such events and their conjunctions; it is never questioned whether they in fact occur. That is, philosophy's concern is with whether our knowledge of the world can be reduced to sense-experience as so conceived or whether it must include an a priori or theoretical component as well; not with whether experience can adequately constitute the world.

But in Humean empiricism two things are done. First, knowledge is reduced to that of atomistic events apprehended in sense-experience. Secondly, these events are then identified as the particulars of the world. In this way our knowledge of reality is literally identified, or at best taken to be in isomorphic correspondence, with the reality known by science. From Hume onwards philosophers have thus allowed, for the sake of avoiding ontology, a particular concept of our knowledge of reality, which they may wish to explicitly reject, to inform and implicitly define their concept of the reality known by science. The result has been a continuing *'ontological tension'* induced by the conflict between the rational intuitions of philosophers about science and the constraints imposed upon their development by their inherited ontology. This has led to a nexus of interminably insoluble problems, such as how we can reason from one experience to another, and to a displacement of these rational intuitions whereby, for example, the locus of necessity is shifted from the objective necessity of the natural world to the subjective necessity of causally-determined or the inter-subjective necessity of rule-governed minds.

Now if transcendental realism is true, and scientists act as if the objects of their investigation exist and act independently of them, then any adequate methodology must be consistent with the realist practice of science, and so inconsistent with the epistemology of empirical realism. It is instructive to look at Hume here. One finds in the *Treatise* an eminently sensible realist methodology in almost total dislocation from, and certainly lacking any foundation in, his radical epistemology. Thus one might be forgiven for wondering what has become of his phenomenalism and the doctrine of impressions when Hume allows that the "understanding corrects the appearances of the senses"[29]. Or what has happened to the idea of the contingency of the causal connection and the problem of induction when he argues that scientists, when faced with exceptions to established generalisations, quite properly search for the 'secret operation of contrary causes' rather than postulate an upset in the uniformity of nature[30]. This is typical. There is a similar dislocation between Kant's *Critique of Pure Reason* and his *Metaphysical Foundations of Natural Science*.

It might be argued in defence of Hume that he is concerned to show that our realist intuitions cannot be justified; that his point is precisely that there is a dislocation between what can be shown and what must be believed (that "there is a direct and total opposition 'twixt our reason and our senses")[31]; and that he leaves the latter intact. But the matter is not so simple as this. Humean empiricism is not neutral in its consequences for scientific practice. Taken consistently, it does generate a methodology. For in the absence of the concept of a world independent of experience, the implicit realism generated implies that whatever is experienced in sense-experience is an event and whatever their constant conjunctions are causal laws. In this way, our current knowledge fills the vacuum left by the dissolution of ontology; and in so doing it squeezes out, metaphorically speaking, the possibility of any substantive scientific criticism. In the methodology of empiricism facts, which are social products, usurp the place of the particulars of the world; and their conjunctions, which are doubly social products (once qua fact, once qua event-conjunction), the place of causal laws. The result is the generation of a conservative ideology which serves to rationalise the practice of what Kuhn has called 'normal science'[32]. Descriptivist, instrumentalist and fictionalist interpretations of theory do not do away with e.g. scientific laws, but by reducing their ontological import to a given self-certifying experience, they serve to exempt our current claims to knowledge of them from criticism.

To be a fallibilist about knowledge, it is necessary to be a realist about things. Conversely to be a sceptic about things is in practice to be a dogmatist about knowledge. For it is only if the working scientist possesses the concept of things and their ways of acting, distinct from his current claims to knowledge of them, that he can philosophically think out the possibility of a rational criticism of these claims. It is thus a mistake to suppose that realist interpretations of scientific theory have consequences for science which are in practice more dogmatic[33]; or that the concept of natural necessity is a survival from the days prior to the apprehension of scientific change[34].

Behind the epistemic fallacy there ran a strong anthropocentric current in philosophy, which sought to rephrase questions about the world as questions about the nature or behaviour of men. But it is not only the doctrine of empirical realism, and philosophers' uncritical acceptance of it, that accounts for the ontological tension within philosophy and the dislocation of epistemology from methodology, of philosophy from science. For the period in which Humean ontology became embedded in the philosophy of science (1750-1900) was, at least in physics, a period of scientific consolidation rather than change. The role of philosophy was seen more and more to be that of showing how our knowledge is justified as distinct from showing how it was produced, can be criticised and may come to be changed. The philosophy of science became the philosophy of justified belief. It was presumed that our knowledge was justified and doing away with ontology left philosophy without any critical purchase on science. Without a concept of a reality unknown, but at least in part knowable, philosophy could not display the creative and critical activity of science, and ceased to be of any practical relevance for it.

The crux of my objection to the doctrine of empirical realism should now be clear. By constituting an ontology based on the category of experience, as expressed in the concept of the empirical world and mediated by the ideas of the actuality of causal laws and the ubiquity of constant conjunctions, three domains of reality, represented in the table below, are collapsed into one. This prevents the question of the conditions under which experience is in fact significant in science from being posed; and the ways in which these three levels are brought into harmony or phase cannot be described.

	Domain of Real	Domain of Actual	Domain of Empirical
Mechanisms	√		
Events	√	√	
Experiences	√	√	√

Note : for transcendental realism $d_r \geqslant d_a \geqslant d_e$ (i)
where d_r, d_a and d_e are the domains of the real, the actual and the empirical respectively
for empirical realism $d_r = d_a = d_e$ (ii)
comment : (ii) is a special case of (i), which depends upon antecedent social activity.

Now these three levels of reality are not naturally or normally in phase. It is the social activity of science which makes them so. Experiences, and the facts they ground, are *social products;* and the conjunctions of events, that, when apprehended in experience, provide the empirical grounds for causal laws are, as we have seen, social products too. It can thus be seen that underlying and necessary for the implicit ontology of empirical realism is an *implicit sociology* in which facts and their conjunctions are seen as given by nature or spontaneously (voluntaristically) produced by men. (This remains the case even where, as in modern dynamised transcendental idealisms, the implicit sociology is explicitly denied). Underpinning empirical realism, in which the natural order is seen are constituted by the correlations of atomistic events or states of affairs (the objects of actual or possible experiences), is thus a model of man in which men are seen as sensors of given facts and recorders of their constant conjunctions; i.e. as passive spectators of a given world, rather than active agents in a complex one.

The conditions of the possibility of empirical realism may thus be summed up as an ontology of atomistic events and closed systems and a sociology defined by that model of man. But in this ensemble of conditions, it is the latter that plays the dominant role. For it is the need felt for *certain* foundations of knowledge that determines the *atomicity* of their ontological surrogates; which in turn necessitates the *constancy* of their correlates, i.e. the closure of the systems within which the events occur. Implicit in empirical realism is a conflation between a ground of knowledge, viz. experience, and the world. If experience is to be capable of playing the role assigned to it of grounding our knowledge (in whole or in part) then the items of which it is composed must be perfectly simple and atomistic, i.e. insusceptible to further analysis or justification. But if it is to define the world then the world must be similarly composed : of atomistic and discrete events (or momentary states) independent of each other. But if atomistic events constitute the world then, for general knowledge to be possible, their relations must be constant, consisting of an unfailing or invariant order of the co-existence of events in space and their succession in time.

The concept of the empirical world is anthropocentric. The world is what men can experience. But the couple of this concept, and from a realist meta-perspective necessary to sustain it, is the absence of the concept of the antecedent social activity necessary to make experience significant in science. And this has the objectionable ideological consequence (from the point of view of the practice of science) that whatever men currently experience is unquestionably the world. Experiences are a part, and when set in the context of the social activity of science an epistemically important part, of the world. But just because they are a part of the world they cannot be used to define it. An experience to be significant in science must normally be the result of a social process of production. But only transcendental realism can explain why scientists are correct in regarding experience as in the last instance the test of theory. For it is by means of it that, under conditions which are artificially produced and controlled, skilled men can come to have access to those enduring and active structures, normally hidden or present to men only in distorted form, that generate the actual phenomena of the world.

The anthropocentric and epistemic biases of classical and subsequent philosophy have resulted in the dominance, in philosophy, of what might be called 'idols' of a Baconian kind. These are false conceptions which cause men to see everything in relation to themselves. If we are to do justice to science, in philosophy, there must be two Copernican Revolutions. The first, establishing a transitive discussion, in which our knowledge is seen to be socially produced, and as such neither an epiphenomenon of nature nor a convention of man. The second, establishing an intransitive dimension, based on the reconstitution of a philosophical ontology, in which the world of which, in the social activity of science, knowledge is obtained is seen to be quite independent of man.

5. Conclusion.

The results of our three transcendental arguments can now be summarised in the following table :

Premiss	*Analysis : Intransitive Dimension*	*Analysis : Transitive Dimension*
1. Experimental Activity	Differentiation and Stratification of the World	
2. Scientific Development		Knowledge as a Produced Means of Production
3. Empirical Realism	Closed System of Atomistic Events	Spontaneity of Facts and Conjunctions

I said at the outset of this paper that I believed a more adequate philosophy of science was itself a precondition for the resolution of pressing meta-theoretical problems in the various sciences, and particularly in the social sciences. Let me just, by way of conclusion, indicate, along the two dimensions or axes of philosophy of science, the way in which our transcendental analysis of natural science may be of some help here.

First, if we reject the idea that scientists seek constant conjunctions of events or variables and understand them instead as searching for underlying causal structures that operate in open and closed systems alike and add the obvious that the world of man is open, we are ipso facto in a better position to explain the absurdity of orthodox philosophy of science when confronted with the social sciences where constant conjunctions are unobtainable, so that the philosophical theories and methodological strategies based on the notion of their ubiquity become patently inapplicable[35]. But, we are then equally in a better position to see that the central problem of the social (and psychological) sciences is that of devising (or reconstructing) a procedure of inquiry, and a mechanism of confirmation (and falsification), analogous to the establishment of closed systems in natural scientific laboratories[36]. Transcendental realism conceives the various sciences as unified in their method but specific to (or differentiated with respect to) their particular objects. Thus the goal of the human sciences is to discover the enduring and transfactually active 'mechanisms' of society and man. But only substantive social scientific theoretical labour, unhampered by empiricist shibboleths (such as the search for empirical invariances, or the desire for predictive success), can do so.

Secondly, if we appreciate that empirical realism not only functions with respect to the practice of science as a conservative ideology but does so in virtue of its underpinning by a conception of man, a study of which would itself form part of critical social science (and with which much existing social science is in resonance[37]), we will be in a better position to see how work in philosophy of science, the analysis of a particular social activity, may have implications not just for the definition of the method, but for that of the objects of the social sciences (e.g. through its capacity to illuminate the relationship between society and men); and in this way, through the connection between social science and social practice, come to inform social practice itself.

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NOTES

[1] Cf. J. Passmore, 'Philosophy', *Encyclopaedia of Philosophy Vol. 6*, ed. P. Edwards, Macmillan, New York, 1967, p. 221.

[2] Cf. P. Hacker, "Are Transcendental Arguments a Version of Verificationism ? ", *American Philosophical Quarterly*, Jan. 1972, p. 82.

[3] I. Kant, *Critique of Pure Reason*, trs. N. Kemp-Smith, A369, Macmillan, London, 1970, p. 346.

[4] A full analysis of their logic is contained in R. Bhaskar, *A Realist Theory of Science*, Books, Leeds 1975. See especially Chap. 2, Sect. 4.

[5] N. R. Hanson, *Patterns of Discovery*, Cambridge University Press, Cambridge 1963, Chap. 1.

[6] See e.g. G. H. Von Wright, *Explanation and Understanding*, Routledge and Kegan Paul, London, 1971, Chap. 2; and G. E. M. Anscombe, *Causality and Determination*, Cambridge University Press, Cambridge 1971.

[7] The reason for Von Wright's failure to see this stems from his assumption of a 'Tractatus-world', i.e. a world of logically independent atomistic states-of-affairs (*ibid.*, pp. 43-5), which precludes him from seeing laws as anything other than conditional statements about atomistic states-of-affairs.

[8] Cf. G. E. M. Anscombe, *op. cit.*, p. 21.

[9] Cf. J. R. Ravetz, *Scientific Knowledge and its Social Problems*, Clarendon Press, Oxford 1971, p. 76.

[10] Cf. I. Lakatos' Criticism and the Methodology of Scientific Research Programmes', *Criticism and the Growth of Knowledge*, eds. I. Lakatos and A. Musgrave, Cambridge University Press, Cambridge 1970, pp. 138-40.

[11] It was not the human mind, as Laplace thought (P.S. de Laplace, *A Philosophical Essay on Probabilities*, New York 1951, p. 4), but the peculiar conditions of the planets — and in particular the constancy of their intrinsic states and the extrinsic forces on them — that gave its 'special perfection' to astronomy.

[12] It is difficult to over-estimate the importance for modern science of the development of instruments such as clocks and telescopes, which may be seen as attempts to decipher the vocabulary of nature. See e.g. A. Koyré, *Metaphysics and Measurement*, Chapman and Hall, London 1968, Chap. 4.

[13] See e.g. R. Harré, *Principles of Scientific Thinking*, Macmillan, London 1970, especially Chap. 4.

[14] See R. Bhaskar, *op. cit.*, esp. Chap. 1, Section 5.

[15] A recent precursor of this view is contained in P. T. Geach, 'Aquinas', *Three Philosophers*, P. T. Geach and G. E. M. Anscombe, Blackwell, Oxford 1961.

[16] Formally we could say that in experimental production by doing ϕ we change α to a so altering the state that would otherwise have prevailed; and in experimental control by doing or being prepared to do ψ we exclude the intervention of elements $\beta_1 \ldots . \beta_n$ so allowing the mechanism M set in motion by a to generate b. The sequence a, b thus appears as a consequence of the results of our actions. It is in this sense that a closure is normally a human product.

[17] K. R. Popper, *The Logic of Scientific Discovery*, Hutchinson, London 1959 and T. S. Kuhn, *The Structure of Scientific Revolutions*, 2nd ed., University of Chicago Press, Chicago 1970 must take the primary credit for this recent awareness.

[18] It has been pointed out that cases of both 'inconsistency' and 'meaning-change' can be drawn from the history of the sciences. For example, Newtonian physics corrected Kepler's and Galileo's laws (see, e.g. P. Duhem, *The Aim and Structure of Physical Theory*, trs. P. Weiner, Atheneum, New York 1962, Chaps 9-10), and the concepts of 'mass' used in classical dynamics and the theory of relativity are radically different (see e.g. P. K. Feyerabend, 'Problems of Empiricism', *Beyond the Edge of Certainty*, ed. R. G. Colodny, Prentice Hall, Englewood Cliffs, N. J. 1965, pp. 168-71).

[19] For a critique of this tradition see R. Bhaskar, *op. cit.*, Chap. 3, Sect. 2.

[20] C f. R. Harré, 'Surrogates for Necessity', *Mind 1973*, p. 366.

[21] For example, geometrical optics is explained in terms of Young and Fresnel's wave optics; which is explained in terms of the electromagnetic theory of light; which can be explained in terms of the quantum theory of radiation. Cf. M. Bunge, *The Myth of Simplicity*, Prentice Hall, Englewood Cliffs N.J. 1963, p. 38.

[22] See R. Bhaskar, *op. cit.*, Chap. 3, Sects. 5-6.

[23] Cf. S. Toulmin, *Human Understanding Vol. I*, Clarendon Press, Oxford 1973, p. 158.

[24] J. S. Mill, *A System of Logic*, 8th Ed., London 1961, Bk III, Chap. 3, Sect. 1.

[25] L. Wittgenstein, *Tractatus Logico-Philosophicus*, trans. D. Pears and B. McGuiness, Routledge and Kegan Paul, London 1961, 6.35.

[26] I. Kant, *op. cit.*,B724. For us, on the other hand, if the Kantian categories were adequate to the objects of scientific thought, then they would continue to apply in a world without sense, and possess a meaning in relation to that possibility.

[27] See e.g. A. J. Ayer, *Language, Truth and Logic*, 2nd Ed., Victor Gollancz, London 1962, pp. 31-41.

[28] See e.g. W. V. O. Quine, 'Designation and Existence', *Readings in Philosophical Analysis*, eds. H. Feigl and W. Sellars, New York 1949, p. 224.

[29] D. Hume, *Treatise on Hume Nature*, ed., L. A. Selby-Biggs, Clarendon Press, Oxford 1967, p. 632.

[30] D. Hume, *op. cit.*, p. 132.

[31] D. Hume, *op. cit.*, p. 231.

[32] T. S. Kuhn, *op. cit.*, Chaps. II-IV.

[33] See e.g. M. Hesse, *In Defence of Objectivity*, Oxford University Press 1973, p. 14.

[34] See e.g. G. Buchdahl, *Metaphysics and the Philosophy of Science*, Blackwell, Oxford, 1969, p. 31.

[35] R. Bhaskar, *op. cit.*, Chap. 2.

[36] *ibid.* p. 245.

[37] *ibid.* pp. 243-4.