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SCIENCE AND METAPHYSICS

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The idea that there is a difference in principle between science and metaphysics, and not only a difference but an opposition, is about as old as science itself (and by 'science' we mean modern science as it has existed for the last three or four hundred years). It became generally accepted by the men of science themselves in the seventeenth century, at least after the influence of the Cartesians had been broken. For Descartes could not, of course, accommodate such a delimitation as his whole philosophy was one great attempt to merge science and metaphysics into one. But he already had to reckon with contemporaries who thought differently. Gassendi, for example, was of opinion that science (and with it all other secular knowledge) can attain only to the appearances which things present to us, not to their 'inner truth'[1]. Later, when Newton's physics swept everything before it, this became the prevailing idea (while the further idea that metaphysics is an impossible enterprise anyhow was to develop more slowly). After all, had Newton himself not repeatedly insisted with great fervour that he did not make hypotheses, i.e., metaphysical assumptions, but deduced everything from experiments? And had he not also answered those who criticized gravitation as an unexplained force by saying that he was not concerned with metaphysical causes (although what the critics believed they had demanded of him was not so much a metaphysical as a mechanical explanation of gravitation)? By the beginning of the nineteenth century the belief that 'no created spirit penetrates to nature's core' and that 'he is already blessed to whom she only shows her outer shell' had become so common that a man like Goethe (for whom nature had neither shell nor core but was a whole) could speak of it as a philistines' litany he had been obliged to listen to all his life[2].

But while it was thus generally believed that science is

non-metaphysical in that it deals with appearances only, it was believed no less — and often by the same people — that the new science, as opposed to traditional common sense, penetrated through the appearances of things to their reality. What I am referring to is, of course, the distinction which since Locke's *Essay* has been known as that between primary and secondary qualities and that can be found in one form or other with Kepler, Galileo, Descartes, Hobbes, Boyle and Newton, to mention famous names only.

They believed that some properties (the so-called primary qualities) of physical objects were such that they could be said without qualification to inhere in, or belong to, the objects themselves, while others (the secondary qualities) did not 'really' belong to them but were only effects caused in the human or animal consciousness by the primary qualities. Primary qualities were said to be number, figure, extension and motion or rest (sometimes also solidity, texture, size and weight), whereas secondary qualities comprised the remainder, but especially all colours, sounds, tastes and smells. To ascribe redness to a rose, heat to a fire, sound to a falling tree, is strictly speaking as mistaken as saying that the tickle caused by a feather is in the feather (Galileo)[3] , the pain caused by a sword-cut in the sword's motion (Descartes, Locke)[3,4], or the pain caused by a fire in the fire (Hobbes)[6]. And in a world uninhabited by man or animal the figures, the numbers, and the motions would indeed remain, but not the colours nor the tastes nor the sounds (Galileo)[7]. In fact, if only a metal or a stone existed, it would be 'hard to shew that there is physically anything more in it than matter, and the accidents we have already named', i.e., primary qualities (Boyle)[8]. The ordinary man, therefore, who believes in the objective existence of sounds, colours, etc., is constantly misled by 'apparitions' (Hobbes)[9] or 'phantasms' (Newton)[10]; and in the end it turns out that we all have been weaned on error, for 'we have been from our infancy apt to imagine that these sensible qualities are real beings in the objects they denominate... whereas indeed... there is in the body, to which these sensible qualities are attributed, nothing of real and physical, but the size, shape, and motion or rest of its component particles' (Boyle)[11].

Whether the ideas here expressed, and the distinction between primary and secondary qualities generally, are tenable is very doubtful indeed, but this question need not concern us here. The point rather is whether the whole view can be reconciled with the other view that science is concerned only with appearances, not with the natures of things. It seems that there is an ambiguity involved here in the word 'appearance' (or one of its equivalents), perhaps in a

way which permits one to say that, as regards the metaphysical reality of objects, science cannot say anything about it but is restricted to talking about appearances, while in regard of their physical reality matters are different — this can be known by science, and here science is not limited to appearances. But whatever construction one may put on it, I do not believe that the inconsistency can in the end be resolved. For speaking about primary qualities in isolation from secondary qualities makes sense only (if it makes sense at all) if they are associated with entities that are, in principle, unobservable, such as atoms or micro-particles; and there are no criteria which would allow us to distinguish between unobservable features of physical objects which are of a physical character and unobservable features of such objects which are of a metaphysical character.

The common view that the former are inferred from experience, while the latter are not so inferred, is now largely discredited, and it is not necessary (nor would it here be possible) to go into the details, apart perhaps from mentioning that supporting a scientific theory by empirical evidence seems to be equivalent to interpreting certain observed phenomena in one way rather than another and that in this sense traditional metaphysical theories or systems can be supported too. (And if the emphasis is put on falsification instead of support, it has to be said that scientific theories, just as metaphysical ones, can always be saved, whatever the observations, if one is only determined enough to save them). There is still justification for distinguishing between the two types of theory, but it is not constituted by this but by other reasons, in particular by the reason that in one case acceptance or rejection depend on practical success (success as regards control and production), if not in practice (in the laboratory and factory), then at least in principle, whereas in the other case success is irrelevant. Or to express the matter differently, it seems that some properties or alleged properties of physical objects are called metaphysical because their names from part of a metaphysical system, and others are called physical because their names form part of a scientific theory. But when the question is asked how we distinguish a metaphysical system from a scientific theory, then (forgetting about differences in scope or 'coverage') the answer cannot be in terms of empirical evidence but will have to be in other terms, for instance, in terms of practice : we can manipulate nature by means of science; we cannot manipulate it by means of metaphysics. That the point of empirical evidence cannot play the role of a criterion is also shown by history. Thus in the seventeenth century the difference between the physical and the metaphysical

was not clear at all, and gravitation, for example, was regarded as a physical concept by the Newtonians and as a metaphysical concept by their opponents.

It was the great merit of people like Mach, Poincaré and Duhem at the beginning of this century to have directed attention to the inconsistency of the traditional position and to have included in metaphysics what had not been included before, namely the belief in the physical existence of unobservable entities. When they said that science cannot tell anything about the 'nature of things', they meant by this also that it cannot tell anything about hidden structures underlying the appearances. The idea that there literally are such things in the world as electrons or protons was for them as metaphysical as the idea that there are entelechies or vital forces. For the reasons already stated, theirs is indeed the only consistent position that can here be taken.

The trouble is that they did not stop at this point but immediately went on to say that metaphysics even in this new and more appropriate sense was here quite alien and superfluous. Science, they said, has two aims, integrating and unifying sense-experience and furnishing predictions and recipes, and these aims can be achieved just as well or better without any metaphysical ballast; all that is needed is making precise empirical observations and introducing formal, 'uninterpreted' magnitudes to connect and integrate them; to ascribe to these magnitudes any ontological status — by saying that they represent an unobservable force like gravitation, unobservable particles like electrons — this is mere ornamentation which serves no scientific purpose, even if it might serve a psychological one.

This was their further thesis, but it is not a tenable one. For whether one shares it or not, the belief that there are realities behind the appearances and that scientific investigation can uncover them is not disposable but essential to science. To show this, let us start by considering a more specific case, the historical interpretation given by Duhem, a man who was quite fond of metaphysics but wanted it to be kept separate. The major schools of science in the seventeenth century, he tried to show, were all at one in condemning the Aristotelians for populating the world with occult entities and forces. For the Aristotelians regarded the qualities — sensible or insensible — of bodily substance as unlimited in number; and (it was alleged) a new occult property was introduced by them whenever a new phenomenon had to be explained (a procedure often illustrated by Molière's little joke that opium induces sleep because it has a dormitive power).

But while thus united against the Aristotelians, the men of science

were also at loggerheads amongst themselves, and for the same reasons. Each group accused the other of introducing occult entities, even if only a few, and each thought that its own entities were not occult. Thus when Newton had endowed matter with attraction and repulsion, i.e., with forces acting at a distance, this was to his critics a reversion to Scholasticism. Explaining why a body falls by reference to gravitation seemed to them no better than explaining why opium induces sleep by reference to dormitivity. Huygens, for example, who inclined towards atomism, wrote to Leibniz in 1690 that 'so far as concerns the cause of the tides given by Mr. Newton, I am far from satisfied, nor do I feel happy about any of his other theories built on his principle of attraction, which to me appears absurd'[12]. The Cartesians were no less hostile, and long before Newton entered the stage Descartes himself had attacked the idea of a gravitational force as absurd : in 1646 he had said of it in a letter to Mersenne that 'in order to understand this, we must not only assume that each material particle is animated... but also that these souls of material particles are endowed with knowledge of a truly divine sort, so that they may know without any medium what takes place at very great distances and act accordingly'[13]. On the other hand, those who on this point were united against Newton, were in other respects critical of each other. Denis Papin, for instance, a Cartesian, wrote to Huygens in 1690 : 'you believe that perfect hardness is of the essence of body [i.e., of atoms, the constituents of bodies]... you are there assuming an inherent quality which takes us beyond mathematical or mechanical principles'[14]. And Huygens was not slow to pay back in similar coin when he made his reply[15].

In short, each group accused the other of using explanatory categories that are themselves unexplained; each took its stand on certain metaphysical principles while attacking the principles of others as metaphysical. 'The Aristotelians, like the Cartesians, deny the possibility of empty space; the Newtonians reject any quality which is not reducible to a force acting among material points; the atomists and Cartesians deny any action at a distance; the Cartesians do not recognise among the diverse parts of matter any distinction other than shape and motion'[16].

This is the historical picture as Duhem represented it. Although it may perhaps be criticized here and there (for example, as regards the rather rigid distinction of Aristotelians, Cartesians, atomists and Newtonians), by and large it is acceptable. But because of his thesis that metaphysics is a superfluous appendage, he did not wish to draw the conclusion that there must be something in science which obliges its practitioners to use metaphysical categories. He had to show,

therefore, in some way or other that the great innovators would have achieved what they did even without such ideas, that — in his own words — 'the descriptive part of a theory has developed on its own by the proper and autonomous methods of theoretical physics; the explanatory part has come to this fully formed organism and attached itself to it like a parasite'[17].

But as for historical illustration in support of this claim, Duhem could manage only by shifting his criteria as to what counts as explanatory and as descriptive, as already metaphysical and as still scientific. This is well shown in the case of Huygens' optical theory of which he wrote that 'the consideration of the void, and of atoms and their hardness and motions played no role' in its formation, even though Huygens was an atomist, but that an analogy between light and sound, an experimental fact and 'a felicitous and bold hypothesis about the form of the surface of the optical wave in media of crystals' were sufficient for the purpose[18]. But this passage makes sense only under the assumption that statements such as 'all bodies consist of invisible particles called atoms' or 'all atoms are hard' are metaphysical or (in Duhem's sense) explanatory, whereas statements such as 'all light consists of invisible waves' or 'all light waves are propagated in such and such ways' are not metaphysical but descriptive. However, there is no justification for this distinction (and since Duhem himself referred to Huygens' new idea on waves as a 'bold hypothesis' he could not have used inference from experience as a criterion). In both cases an explanation of visible phenomena is furnished in terms of invisible entities, be they atoms or be they waves. That is, in both cases there is the belief in the existence of something forever hidden from view, something 'occult'. And if the term 'metaphysical' is to be used in this context at all, it will have to be used in such a way that *all* beliefs of this kind are included under this heading. If, on the other hand, one wishes to avoid the term and use 'explanatory' instead (Duhem himself clearly associated the two), it is no less obvious that in both cases there is an endeavour to explain observed phenomena instead of merely describing them.

Other historical points introduced by Duhem do not support his case either. Thus he tried to show that scientific discoveries often retained their value and validity long after the associated metaphysics had been discarded. The Cartesian laws of the refraction of light, for example, survived the Cartesian philosophical system. Science, he concluded therefore once more, is detachable from metaphysics. But what such examples prove at most is that a certain discovery can be detached from a certain specific metaphysical view, while in order to make his point Duhem would have to show (*a*) that it could have

been reached in the first place without this or any other metaphysics, and (*b*) that, having been detached from the original metaphysics, it could have continued to be acknowledged as a valid result of science without becoming attached to another metaphysical view. As far as I can see, Duhem showed neither.

All this, of course, is not to deny that in some sense of the word the men of science in the seventeenth century were more 'metaphysically minded' than they are today. After all, they thought they practised natural philosophy, many were in fact active as philosophers, and all were influenced by the views of philosophers of their own and past times. (And it has to be remembered also that philosophy then meant for a large if not for the most part metaphysics). But saying that in contrast to those days science is now quite independent from philosophy is not to say that it does not involve metaphysical beliefs, still less that it has foregone the claim to explain by reference to 'occult' entities. These are not hangovers from Aristotelianism and Scholasticism confined to the infancy of science. No doubt, the terminology has changed a great deal and increased in size; and the picture one makes oneself of the alleged underlying realities has changed too (atoms, for example, are no longer conceived as hard little particles). But the conviction of the existence of hidden forces and 'deep structures' is as strong as ever.

Views on science like that of Duhem have had the greatest influence on the thinking of later generations, and it is only recently that the spell seems to have been broken. The view that goes by the name of 'operationalism' (or 'operationism') would have been hardly possible without them, and the same holds for the conception of scientific explanation as deduction from premises amongst which no so-called 'model' occurs. In their most general aspect, however, they encouraged an instrumentalist conception of science, that is, the idea that scientific theory is merely a tool or instrument for calculation and prediction and that, therefore, the predicates 'true' and 'false' cannot be applied to it.

But it is again a historical fact that the practitioners of science, with rare exceptions, have never taken kindly to this interpretation. At the beginning of modern science, instrumentalism (in the garb of the ancient doctrine of 'saving the phenomena') was implicitly, and often explicitly, rejected by all the great founder figures. The opinion expressed in the preface to Copernicus *De revolutionibus* of 1543 by its editor Osiander (that there was no need for these hypotheses to be true but that it was sufficient for them to yield calculations in agreement with the observations) was certainly not shared by the author (who was than dying). Five decades later Kepler dismissed it

with contempt;[19] and that Galileo declined to follow the advice of Cardinal Bellarmine and others to speak *ex suppositione* and declare his astronomy to be a mere assumption, without claim to truth, is by now generally known. As for Francis Bacon, he — most unjustly — attacked Copernicus as a man who thought nothing of introducing fictions provided his calculations turned out right; and Descartes declared, though not publicly, that he knew nothing of physics if he could only say how things may be, without demonstrating that they cannot be otherwise[20].

One could say that this insistence on the truth of their theories only shows the fervour and naïveté of the pioneers, were it not for the fact that in the three or four centuries which have elapsed since then the position has not much changed. The practitioners of science today still regard their theories as systems of statements and hence as being true or false, even if they try to protect themselves by words and phrases such as 'probably' or 'as far as is known at present', and even if they view some theories as better than others simply because they are more easily handled.

To take an instrumentalist stance in the face of this situation amounts, in effect, to asserting what is always improper to assert, namely that a large number of people cannot mean what they say and have deceived themselves for centuries in that their alleged theoretical statements are not statements at all but concealed recommendations, rules, instructions, and such like : if they could only be persuaded to abandon the claim to the truth of their theories, or even better, if they only were to confine themselves to the manipulation of mathematical magnitudes, without saying that they mean anything 'real', all would be well; why use the word 'electron', for example, when one can do all the things one wants to do just as well by using a formula or symbol instead, thus making it impossible (for oneself as well as for others) to give way to the temptation of regarding these things as real inhabitants of the world ?

Advice of this kind is not only presumptuous, it is also based on a misjudgement of science. It may well be true (and I myself am convinced it is true) that the men of science are mistaken in their belief that they come to know hidden, underlying structures and entities. But even if it is true, it does not follow that they cannot mean what they say, or that there is justification in the demand that they should change their ways. Even if they are the victims of an illusion, it is an illusion that is constitutive of science and the elimination of which cannot be recommended without recommending the elimination of science itself. No doubt, in some

cases today the mathematical formalism is being pushed in the foreground as never before, and there are theoreticians who say that it is the only thing that matters : as long as the calculations are all right, everything is all right, and any 'interpretation' is an unnecessary luxury. But this is the view of a minority even amongst physicists. If it became general science could, no doubt, go on for a while, carried by its own momentum and living on its accumulated capital of ideas. But it would then gradually come to a halt. This may not be a bad thing, and those who advocate the purge may be doing a great service to mankind. But this is not the way they see it themselves. They believe that it would do no harm to science, that, in fact, it would do it a lot of good. And in this belief they are not justified.

That they are not justified, that in science one has to assume counterparts in reality to one's theoretical concepts, in short, that one has to believe in the existence of entities which are metaphysical in that they are in principle unobservable, this is a thesis — not uncommon today though usually discussed in different terms — which cannot be proved in the exact sense of the word, but for which there is very good support. The argument from the historical facts, which I have tried to indicate above, is by no means the only argument. There is at least also the following consideration. If we conceive science as it is usually conceived, i.e., as a progressive enterprise, and see in the formation of new theories, with new theoretical concepts, one of its constitutive features, it is hard to maintain that this condition could be satisfied in the absence of metaphysical belief of the kind here at issue. No one will hit on a new theory and come out with a new fundamental concept (as fundamental, say, as the concept of the gene) unless he believes that he is discovering something of the world's structure, some item with ontological status. All that is known about the way in which such concepts are formed points to the fact that it is by way of analogy with structures and situations of whose reality the discoverer is convinced already, and if the analogue is realistically conceived so will be that of which it is an analogue. What holds for the discoverer also holds for those who accept his discovery; that is, it is very unlikely that the new concept would enter the mainstream of scientific development if others did not share the realist position but merely regarded it as a conceptual tool and computational device. It is, therefore, a very safe bet that if instrumentalism were to become general, the progress of science would come to an end.

The standard response nowadays to a question such as whether metaphysics is necessary to science would consist in saying that it all

depends on what is meant by metaphysics and what is meant by science. No doubt, this is quite true, but it tends to obscure the fact that there are better and worse conceptions. As for science, no one has an adequate conception who ignores the historical dimension and forgets or denies that science is a human enterprise which, as other human enterprises, had its beginning and will have its end in time. If this is acknowledged, and if proper attention is paid to the historical facts as far as they are known, including those of the present, there is justification for saying that science is characterized by (amongst others) the assumptions (*a*) that there are underlying physical structures, more fundamental than the 'surface', (*b*) that these are hidden from view but can be discovered by inference, and (*c*) that the knowledge so acquired is profound as against 'mere' common-sense knowledge. It is these assumptions which account for the importance of theory in science. But they amount to a belief in an unperceivable, though knowable reality behind the appearances, and in at least one sense of the word 'metaphysical' such a belief is metaphysical in character. This is not to say that science is not metaphysical also in other respects, that there are no other metaphysical beliefs which are of equal or even greater importance to it. But these, we may safely assume, are not beliefs specific to science but shared with other, non-metaphysical fields, especially with common-sense or everyday experience. They have to be discussed, therefore, in a different context.

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NOTES

[1] See, for instance, Gassendi's letter to Lord Herbert of Cherbury of 1634, quoted in O.R. Bloch, *La Philosophie de Gassendi*, The Hague, 1971, p. 82.

[2] See his poem of 1819/20 'Allerdings — Dem Physiker'.

[3] Galileo Galilei, *Opera Complete*, Florence 1842 ff., vol. IV, p. 333 f. (here taken from E.A. Burtt, *The Metaphysical Foundations of Modern Physical Science*, Garden City, N.Y., 1954, p. 86).

[4] Descartes, *Principles of Philosophy*, IV, cxcvii.

[5] Locke, *Essay Concerning Human Understanding*, II, viii, 13.

[6] Hobbes, *Elements of Philosophy : Concerning Body*, IV, xxvii, 3

(Hobbes, *The English Works*, ed. Sir W. Molesworth, London 1839-45, Vol. I, p. 449).

[7] Galileo, *ibid.*

[8] R. Boyle, *The Origin of Forms and Qualities* (Boyle, *The Works*, London 1744, vol. II, p. 466).

[9] Hobbes, *Human Nature or the Fundamental Elements of Policy*, II, 10 (Hobbes, *English Works*, vol. IV, p. 8).

[10] Newton, "Letter to Oldenburg, February 1971/2", Newton, *Opera*, ed. S. Horsley, London, 1779-85 (repr. Stuttgart 1964), vol. IV, p. 305.

[11] Boyle, *ibid.*

[12] P. Duhem, *The Aim and Structure of Physical Theory*, New York, 1962, p. 15.

[13] *op. cit.*, p. 15/16.

[14] *op. cit.*, p. 16.

[15] *ibid.*

[16] *op. cit.*, p. 17.

[17] *op. cit.*, p. 32.

[18] *op. cit.*, p. 35.

[19] Kepler, *Prodomus dissertationum cosmographicarum*, 1591 (here quoted after Duhem, *op. cit.*, p. 42).

[20] Descartes' letter to Mersenne of March 16th, 1640 (here quoted after Duhem, *op. cit.*, p. 46). — It is true, there is a passage in his *Principles of Philosophy* (IV, cciv) to the effect that for mechanics, medicine, etc., it does not matter whether the causes ascribed by his theory are the true ones, as long as there is agreement with the observed phenomena. But even there he went on to say that where there was so much agreement there could hardly be falsehood. In any case, the private letter is more likely to represent Descartes' real views on the matter than any remark he saw fit to see published just ten years or so after Galileo's trial.