Section II: Philosophy of Nature

Problem (a): *Do Scientific Laws Give a True Image of Reality?*

Let us ask in the first place whether all scientific knowledge can be expressed in formal laws. In a sense, the question calls for a categorical denial. Besides laws, other elements belong to the body of science, such as simple number-measures or explanations. If the question was formulated, it was not because of an ignorance of the other elements of science, but because of the role which laws play in science. They are the central element of the structure of the exact sciences. Laws unite and synthesize singular facts and allow formulation of universal propositions. These propositions and not singular facts are the truly scientific statements, because only they are verifiable, and thus satisfy the condition of objectivity on which science is based and which distinguishes the scientific mode of knowledge from other forms of cognition. To illustrate this affirmation the following example may be used.

The proposition: This particular amount of water, in this place, at this moment of time, has solidified at the temperature of 0° C under the pressure of 1 atmosphere, is not strictly speaking verifiable, because the phenomenon as it is described cannot be fully reproduced. Consequently, this proposition is of limited value for science. Instead the following universal proposition: water solidifies at the temperature of 0° C under the pressure of 1 atmosphere is a fully verifiable assertion, and therefore satisfies the conditions of objectivity. It is a scientific statement, and a law. In order that an object become subject-matter for the physical sciences, it must be of such a nature as to allow formulation about itself of a true universal proposition. Thus there are laws at the point of departure of scientific reasonings. Moreover laws are at each consecutive stage of explanations inasmuch as the purpose of theories is to synthesize laws and to explain them. The explanations terminate in statements which are laws.

In the light of what has just been said the meaning of the question under discussion becomes more intelligible. The question, in other words, is not whether scientific propositions can be universal because universality is the very condition which a proposition must satisfy in order to be scientific. The question is whether all universal propositions formed in the scientific study are sufficiently precise, i.e., formal, to be called laws. An answer can be given by taking into account the means by which science establishes these propositions. The method of measurement enables formulation of precise propositions. If the proposition is universal it is a law. At the same time the use of measurement excludes all imprecise knowledge which could not be expressed in the form of laws. The above explanation appears as a satisfactory answer to the question under discussion. There is however another and more difficult problem left unsolved, namely, whether it is really true that knowledge obtained through measurement and expressed in laws is really knowledge of only the formal element in nature.

If this question is answered in the affirmative it would mean that scientific laws are adequate representations not only of what they are explicitly meant to express, i.e., the constant relations between number-measures, but also that equally they completely express the nature of material phenomena. In this case, it would be necessary to conclude that in nature there is nothing more or nothing other than the formal element allegedly represented by laws. If this were so there would never be any danger much less a concrete instance of over-formalization of knowledge. We know that there exists not only the danger but there are obvious cases of this situation outside the field of physical sciences. However we are discussing laws in these latter sciences. It would not be methodologically correct to argue from situations formed in other branches of knowledge. Moreover, any analysis of the question whether there is anything in nature besides the formal element represented by laws (in order to be adequate), has to get to the very basis of the whole problem. What has to be explained is the nature of the formal element in scientific laws, namely the various species of quantity.

The question to be dealt with concerns in the first place the noëtic status of quantity, namely whether quantity can be adequately understood by means of the notion of determination only or whether besides the concept of the formal element, it is necessary to take into account its opposite. Direct, positive knowledge is that of determination, and quantity we know is a formal element. However divisibility is a condition of quantity. Now consequences must be drawn from these affirmations. In the first place let us analyze the meaning the last statement.

To say that divisibility is a condition of quantity amounts to stating that the formal element of quantity is not a self-sufficient principle. In order to produce quantity we need both determination and indetermination, or potentiality. In other words determination must be the determination of an indetermined something which may be called a subject. The determining element and its counterpart appear therefore as co-principles. Out of their interaction actual multiplicity results which can be counted and expressed by numbers. Consequently numbers, formal elements of knowledge that they are, stand in fact for a complex entity and not just for a pure form. They represent a truly material reality even if in an abstract manner. In the process of abstraction necessary for the formation of the concepts of numbers, the potential co-principle of things numbered is left out, so that only the formal element is taken into account. It is this element that is expressly signified by numbers. The explanation conforms to the principle stating that direct, positive knowledge is knowledge of the formal element. Separated by the intellect as the source of intelligibility, this formal element is a constituent part of material reality which material reality may be said to be more complex and less perfect than this element in itself.

What is, in the light of the above explanation, the status of quantitative laws? Do they express merely the formal element and nothing more? Inasmuch as quantity presupposes the complex reality of two opposite co-principles, quantitative laws must imply this complex reality as well. Should it therefore be concluded that these laws are an adequate representation of material phenomena? A distinction must be made between the written symbols and the understanding of them. The set of symbols may be taken to mean the outcome of a series of measurements made known through number-measures, and be considered only in its formal aspect with the insistence on determination, on the precision of numbers. In this case the mental image of the relation represented by the law is certainly a one-sided and incomplete picture of reality. If however the same symbols are understood in a more realistic way as standing for a complex reality whose materiality involves determination as well as indetermination, then they will convey a more complete image of material phenomena. In other words, the noëtic value of laws depends to a certain extent on the interpretation of their meaning. The interpretation will be made in the final analysis in the light of philosophical theories and principles. The set of symbols remains the same whatever the interpretation one is inclined to formulate or to accept.

It must be borne in mind that any attempt to exclude a broader interpretation of laws by limiting the signification of symbols used to the set of operations which produced them begs the question. Operationalism too is a philosophical interpretation. Of course the scientist does not have to turn philosopher each time he sees a set of symbols. Their explicit meaning is well known to him and he does not need to bother about their implicit signification. The fact is however that no serious scientist can in the long run avoid asking a question which will require an interpretation going beyond this or that law and its explicit meaning. Bridgman's heroic attempts to find what he considered a scientifically satisfactory way out of the morass of philosophical interpretations is the best proof of the need for a deeper and more general understanding of scientific formulas.

Whether taken at its surface value or viewed in a broader context, algebraic relations cannot simply be equated with physical reality as it is known to us. The abstract, formalized, immobilized structure can never be a complete image of things subject to change even if we forget about other difficulties such as quality, specific differences, intrinsic unity and so on. Nevertheless one must not overlook the fact that quantitative knowledge is the most powerful cognition of the material world available to us and also the most efficient. Its efficiency seems to prove that what it represents, it represents well. This merely invites us to ponder over the nature of things material in which change and quantity, determination and indetermination, similarity and dissimilarity coexist in a symphony of oppositions.

The classical interpretation of physical laws as absolute, one would be inclined to say, ideal rules which govern material phenomena in a deterministic manner proved inadequate and had to be replaced by an indeterministic and statistical interpretation. This understanding of laws seems to be philosophically more adequate inasmuch as it explicitly recognizes the factor of indetermination coexisting side by side with that of determination. Of course the only way to express indetermination is in relation to, and by means of some determined elements as is done in probability calculus.

Even if the statistical understanding of laws is obviously more justified the classical approach was more psychologically satisfying. Man desires certitude. A knowledge which gives him this feeling will be accepted as satisfying, as worth having and worth striving for. Such was, or seemed to be, the classical, deterministic understanding of physics. Although present day science is much more powerful than nineteenth century physics, it is in a sense less gratifying because less deterministic. Instead of affirming "it is certainly so," or "it is always so," it merely states "it is probably so" or "it is so in the majority of cases." Whether human intelligence will revolt against this state of affairs remains to be seen.

The existence of indetermination in material reality gives rise to another interesting problem with regard to laws. Laws are always universal. Their universality is the expression of the fact that a determination is found in more than one instance, either as a specific or generic identity of one or more aspects of things, or as a similarity of recurrent phenomena. In the first case we will have for instance laws of chemistry or of general physics. In the second group will be astronomical laws pertaining to such singular phenomena as solar or lunar eclipses. Keeping in mind the intrinsic relation between the universality of laws and the principle of determination one may wonder what effect the factor of indetermination may have on the universality of laws and on the validity of laws as representations of material reality.

If indetermination is the opposite of determination, then indetermination may be an obstacle to generalization resulting from form. Indetermination considered as the principle of limitation, as the root of particularization makes the image of reality constructed by means of laws appear as essentially one-sided. Laws represent what is common to many particular beings or occurrences, what transcends the singularity of things. To the extent that they go beyond the singular they serve as principle of explanation of the singular, and thus they are a condition of intelligibility, a means of understanding physical reality. Consequently the meaning of events such as experimental science can discover depends on laws. This meaning is proportional to the universality of the law or laws which the scientist is able to introduce into his explanation. In view of what was said about indetermination it is possible to conclude that explanations and understanding based on laws cannot be wholly adequate; they are unavoidably incomplete in a very special way.

The incompleteness in question must not be understood in too simple a way. The understanding through laws is one-sided, not because it leaves out something positive, a determination which could be grasped and represented by quantitative laws. Nor is it so because scientific laws do not apply to qualities. The incompleteness results from the fact that limitation, indetermination, that which is fundamentally opposed to universality, cannot be contained in laws, cannot be made known through them. But all this, which cannot be known through laws, is precisely unintelligible in itself. It can only be known indirectly, in relation to determination.

When we look at the moon we see one side of it, but we know that the other side is equally real, concrete and perceptible. The one-sidedness of our image of the moon is therefore merely the result of our position with regard to it, of our inability to go to the other side of the moon. The situation is quite different in the case of the one-sidedness of scientific knowledge expressed in laws.

If physical reality could be symbolized by the moon, it would be a moon with only one side that is concrete, determined, measurable and in general directly and meaningfully knowable. The knowledge of this side would be contained in a set of laws and of explanations of these laws. This knowledge would be one-sided not because there is an other, equally concrete side of the moon but because there is no such other concrete side. The knowledge would therefore be misleading to the extent that it would seem to suggest that there is the other side of the moon more or less identical with that exposed to our view. Curiously enough the inadequacy of knowledge expressed in formalized laws consists not in this, that it tells us too little about reality, but because it paints an image which is too perfect and thus suggests more than really is.

One may, of course, wonder whether this situation can be changed so as to make scientific knowledge give us a more adequate image of reality. The answer to this question is by no means a simple or an easy one. The very nature of knowledge in general is involved in this problem. Indetermination cannot be known in itself apart from determination. Nor can it be symbolized by anything else than a determined symbol. In the system of equations forming the skeleton of scientific theories there is therefore no place for indetermination as such. But scientific theories are not exclusively a mathematical structure. They include a set of rules according to which physical meaning is given to mathematical symbols and consequently also an interpretation in terms of sense-images. Without this interpretation mathematical formalism would be physically meaningless and the whole structure unintelligible. Moreover, besides the direct physical interpretation, the more fundamental theories and concepts imply a broader philosophical understanding. The image of reality formed by science involves precisely this direct physical explanation as well as the more philosophical one. It is to the realm of interpretation that the problem of indetermination belongs and it is there that the existence of indetermination in nature should be accounted for.

One may well wonder whether this accounting for, within the realm of science, can be much more than a very elementary statement of facts. The adequate treatment of the problem of indetermination in nature calls for a philosophical analysis. From the philosophical point of view the major question underlying the whole discussion is the relation between the particularising role of potency and the universality of laws. This question is, in other words, the age old puzzle of the justification of universals.

The efficiency of scientific laws in the order of knowledge and the power to master nature resulting from the possession of these laws clearly shows that they are not purely subjective creations of man's intellect in the

Humean or Kantian sense. They must have a foundation in nature. There must be a community of determinations in things material which justifies the universality of laws. But one is entitled to wonder how far or how deep does this community go and how is it to be found out. On the answer to these questions depends the knowledge of the absolute frontiers of science. But is this answer even theoretically possible?

To make things more confusing, all universal propositions formulated by science presuppose the principle of uniformity of nature. If things material are composed of an element of determination as well as of its opposite, then the supposedly universal principle of uniformity of nature must in the first place express this fundamental composition. Consequently this principle expresses, at least implicitly, the universal limitation and imperfection of form and therefore the limitation of laws. Seen in this light the principle of uniformity of nature far from being the justification for a deterministic interpretation of laws calls on the contrary for a much more cautious, statistical interpretation of their applicability. Nature is partially determined and partially indetermined, always to some, though differing, extent representable by formalized laws and to some extent non-representable. The situation cannot be changed. This is not the fault of science, because it is not nature that is subordinated to science but science to nature.

In the final analysis two different and in a way conflicting elements have to be considered in the discussion of the relation of scientific laws and indetermination of matter. On the one side the material world with its confusing mixture of form and indetermination, on the other, the intellect with its overwhelming desire for perfect, absolutely certain and determined knowledge. In view of this ideal of knowledge it is understandable that there is a natural tendency to equate science in general and its central element-laws, in particular, with this ideal. But it is also understandable why this endeavour will always remain the work of Sisyphus.

JERZY A. WOJCIECHOWSKI

University of Ottawa
Ottawa, Canada

Problem (b): *The Philosophical Stages of Man's Self-Discovery*

> "What is man that thou shouldst think of him,
> And the son of man that thou shouldst care for him?
> Yet thou hast made him little lower than God,
> And dost crown him with glory and honor.
> Thou makest him ruler over the works of thy hands,
> Thou hast put all things under his feet."
>
> (Psalm 8)

Throughout history man has constantly been occupied by the problem of who he is and where he stands in the world. He seems to feel an urgent desire to define himself and to clarify his own situation in the light of all reality. He need not be reflective or educated to arrive at a