

INTERNATIONAL ENCYCLOPEDIA of UNIFIED SCIENCE

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By

*Otto Neurath, Niels Bohr, John Dewey,
Bertrand Russell, Rudolf Carnap,
Charles Morris*

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pend more upon the education of children and youth than upon any other single force. On the other hand, the teaching of science can hardly take the place which belongs to it, as an attitude of universal application, unless those who are already animated by the scientific attitude and concerned for its expansion actively co-operate. The first condition to be satisfied is that such persons bestir themselves to become aware of what the scientific attitude is and what it is about so as to become diligently militant in demonstrating its rightful claims.

The import of what has been said is that the scientific attitude and method are at bottom but the the method of free and effective intelligence. The special sciences reveal what this method is and means, and what it is capable of. It is neither feasible nor desirable that all human beings should become practitioners of a special science. But is intensely desirable and under certain conditions practicable that all human beings become scientific in their attitudes: genuinely intelligent in their ways of thinking and acting. It is practicable because all normal persons have the potential germs which make this result possible. It is desirable because this attitude forms the sole ultimate alternative to prejudice, dogma, authority, and coercive force exercised in behalf of some special interest. Those who are concerned with science in its more technical meaning are obviously those who should take the lead by co-operation with one another in bringing home to all the inherent universality of scientific method.

On the Importance of Logical Form

Bertrand Russell

The instrument of mathematical logic, which has begun to be appreciated during the present century, possesses two rather different kinds of utility—one in pure mathematics, the other in the various empirical sciences. Of the former I shall say nothing, since the ground is familiar; but on the latter there are some things to be said that bear on the importance of a modern encyclopedia.

In the empirical sciences it is not so much in relation to inference that mathematical logic is useful as in relation to analysis and the apprehension of identity and difference of form. Where identity of form is of the traditional mathematical kind, its importance has long been realized. The kinetic theory of gases has been applied to the stellar universe, which, to the non-mathematical mind, appears very different from a gas. A British mathematical professor at Tokyo was led by his location to study earthquakes, and made useful applications of his results to the vibrations of the footplates of locomotives. But, where identity of form is not of the sort that can be expressed without logical symbols, men of science have been less quick to recognize it; while the general public, through logical incompetence, has been led into grave practical errors. During the Black Death the inhabitants of Siena attributed the calamity to their presumption in planning a much enlarged cathedral, oblivious of the fact that the mortality was just as great elsewhere. Similarly, in 1931, the population of every country attributed the depression to the sins of its own government; this caused a movement to the Left where there was a Right government, and to the Right where there was a Left government. Only a few impotent intellectuals observed that the phenomenon to be explained was world-wide, not local.

The distinction between macroscopic and microscopic physics, which has become important since the rise of quantum theory, suggests possibilities as regards scientific method in other fields. Although, as a mathematical ideal, macroscopic physics may be supposed deducible from the behavior of the individual atoms, it was in fact discovered first, and its laws remain valid, for most practical purposes, in spite of the discoveries of the quantum physicists. This suggests the possibility of a social science not deduced from the laws of individual behavior but based upon laws which are only valid for large numbers. The theory of evolution, in biology, is the most striking example. Economics, in so far as it is a science, is another. Vital statistics afford another field for the observation of statistical behavior; it might be thought, for instance, that there is an inverse correlation between increase and density of the population, but Australia, though confirming this as regards rabbits, negatives it as regards human beings.

Logical method has important applications to psychology. Suppose, for example, that, in order to deal with dual and multiple personality, we desire a definition of 'person' not derived from bodily continuity. We may observe that dual personality is connected with amnesia. We may define a relation M between two experiences, consisting in the fact that one is, in whole or part, a recollection of the other, or the other of the one. If N is the ancestral relation of M , all the experiences which have to a given experience the relation N may be defined as the person to whom the given experience belongs; for the student of dual and multiple personality this is probably the most convenient definition.

I said that mathematical logic has less importance in relation to scientific inference than in relation to analysis, but this statement needs qualification. Outside mathematics, the important inferences are not deductive, i.e., they are not such as mathematical logic makes. But logic can state their character with a precision which was formerly impossible. Much has been done, for example, by Carnap, in analyzing the kind of inference upon which scientific laws are based. Since all inferences of this kind

are probable, not demonstrative, the study of probability, as Reichenbach insists, is of fundamental importance in scientific method.

The importance of logical form may be illustrated by what may be called the principle of the dictionary: Given two sets of propositions such that, by a suitable dictionary, any proposition of either set can be translated into a proposition of the other set, there is no effective difference between the two sets. Suppose—to take a hypothesis that I neither affirm nor deny—that all scientific propositions can be tested in terms of physics, and can also be stated on Berkeleian principles, in terms of psychology; then the question as to which of these forms of statement is the more correct has no meaning, since both or neither must be correct. Such dictionaries, which can, as a rule, only be constructed by the help of modern logic, suffice to dispose of large numbers of metaphysical questions, and thus facilitate concentration upon genuine scientific problems.

Let us take another example of the principle of the dictionary. The general principle of relativity showed that, in expressing the laws of macroscopic physics, we can transform our co-ordinates in any way we choose, so long as topological relations in space-time are preserved as topological relations among co-ordinates. It follows that the laws of macroscopic physics are topological laws, and that the introduction of number through co-ordinates is only a practical convenience, the laws being such as can, in theory, be expressed without the use of number. The old view that measurement is of the essence of science would therefore seem to be erroneous.

The unity of science, which is sometimes lost to view through immersion in specialist problems, is essentially a unity of method, and the method is one upon which modern logic throws much new light. It may be hoped that the *Encyclopedia* will do much to bring about an awareness of this unity.