allotted to our study, however, does not permit us to make these further investigations. The texts afforded should give sufficient evidence of the logical relation between *some* current American philosophy and late Medieval and Renaissance philosophy, as well as of the reaction in *some* current American philosophy against the basic fault involved in the previous relation. We have been obliged to make at least a summary examination of the logic between the Renaissance and the twentieth century in order to be able to recognize the common logical relation between the philosophy of the late Middle Ages and the Renaissance on the one hand, and contemporary American philosophy on the other.

Our study has enabled us, moreover, to see the remedy for the basic ill in much contemporary thought. Since the problem concerns the use of one or many methods in the study of reality, a basic requirement for secure investigation of various subject matters lies in the careful study of Aristotle's logical tracts, especially the *Topics*, as well as the first parts of his scientific treatises, wherein he establishes method as proportionate to this or that scientific subject. If this is done, the rather fruitless procedure of opposing conclusion to conclusion in discussion among scholars will gradually come to an end, and, in its place, there will be the methodic investigation of all important conclusions proposed by scholars.

CHRISTOPHER M. LEHNER, O.P.

Aquinas College
Grand Rapids, Michigan

DIVISION B: PHILOSOPHY OF NATURE: RAYMOND A. KOCOUREK, *Chairman*

Problem (a): *The Epistemological Problems of De-Anthropomorphization of Modern Science*

The mechanization of scientific observation and the ever growing mathematization of physical and natural sciences has led some scientists to the notion of de-anthropomorphization of science. This awkward expression for whose invention, by the way, I the present writer take no responsibility, could be regarded as a mere linguistic oddity, had it not been pregnant with philosophical meaning and far-reaching implications.

The presumed de-anthropomorphization of science revives old hopes of the possibility of achieving a perfect objective, i.e. ideal, infallible knowledge of the universe. We are thus near Plato's timeless dream of perfect intuition of immaterial IDEAS and not far from Hegel's belief in the dialectics of the Absolute. The methods and external aspects of the new science are obviously different from those of its venerable predecessors, but the true nature of the underlying belief or yearning for absolute knowledge is basically the same.

Since the old drama is played in interestingly new settings, it is worthwhile to examine it more closely.

It is logical to begin our inquiry with the discussion of the very notion of de-anthropomorphization. What in fact leads philosophizing scientists like von Bertalanffy to speak about de-anthropomorphization of modern science? [1] The obvious reason seems to be found in the ever growing distinction between the mode of common sense knowledge of the man in the street and that of physico-mathematical sciences. The former is a largely non-formalized, man-centred knowledge mainly of those aspects of the immediate environment which form the object of sense perception, i.e. the phenomenal world.

Until relatively recent times, this mode of knowledge was unchallenged and thus considered as the valid and adequate means of knowing physical reality identified with perceivable phenomena. The immediate knowledge found an overwhelming competitor in science. Ordinary expression of direct sense perception had to make place for more complicated but much more precise observation carried out through the medium of measurement. The resulting development of quantitative knowledge of measurable aspects of spatio-temporal exteriority, revealed such an astounding richness in variety of detail that the sheer number of new facts convinced scientists and non-scientists alike of the excellence of experimental knowledge.

To cope with the wealth of information, a very precise and highly specialized language and symbolism had to be invented. Moreover, the expanding theoretical structure demanded constantly more and more subtle and complex methods of mathematical analysis. Since the language used by the scientist had to suit their purpose, it was inevitable that it became isomorphic with scientific data and with the mode of knowledge which led to their discovery. Contrary to every day parlance, the scientific vocabulary became specialized to the extreme, de-anthropomorphized, and well suited for its purpose. Notions expressing direct sense perceptions and personal reactions to the humanly important facts of the environment are replaced by concepts denoting primarily number measures and their mathematical relations.

The concrete human being with his feelings, desires, personal opinions, has all but disappeared from the universe of scientific language. The depersonalization of science resulted in great objectivity, precision, verifiability and specific communicability of propositions, laws and theories. There is an indubitable advantage for the scientist to substitute number measures for non-formalized expressions of perceptions such as "big", "fast", "hard", etc. Small wonder that the claim of de-anthropomorphization was made.

Having used this word several times already, we may now try to define what de-anthropomorphization is or consists in. I take it really means mathematization of knowledge resulting from the use of the unit of measurement as the means through which and in which the knowledge of the external world is gained and expressed. The following example may illustrate this point. A stone is for us say big, hard and heavy; to the physi-

[1] L. von Bertalanffy, "An Essay on The Relativity of Categories," in Philosophy of Science, Vol. 22, N° 4, Oct. 1955, p. 243-263.

cist it has such and such a geometrical shape and size and weighs so many kilograms, but weight is relative to the force of gravity, so in turn weight is replaced by a more abstract and independent notion of mass.

Quite obviously, the concepts of size and mass are quantitative, not qualitative, as those formed in direct sense perception. Besides, being more abstract, they are more purely ideas, and thus more intelligible in themselves. In other words, the use of measure resulted in a transposition of simple sense knowledge to knowledge on a more intellectual level, i.e. in an intellectualization of knowledge. This process was accompanied by an increase of understanding. Thus far thus good. A progress in understanding, greater intelligibility, are welcome and expected results of every organized interrogation of nature. But we are allowed to wonder whether this phenomenon is to be taken for a sign of de-anthropomorphization of science. If de-anthropomorphization is identical with quantification of knowledge as well as with the insistence on precision and objectivity, then no doubt science is depersonalized to a great extent. Advantageous as it may be, so understood, de-anthropomorphization does not transform science into some sort of absolute, supra-human cognition. Objective and communicable or not, science shares in perfections and imperfections proper to intellectual knowledge as such.

The logical question to ask is whether this depersonalization of science may go on indefinitely or, if there are some inherent limits to it. It seems safe to assume that such limits must exist for at least two different reasons. First, not all sensible aspects of physical reality are equally well expressed in number measures. Intensive properties cannot be mathematized in the same way as extensive dimensions. Second, perfect depersonalization would transform a science of the material world, such as physics for instance, into an abstract and a-prioristic calculus. It is difficult to imagine what would be in this case the physical significance of laws and theories.

Although perfect de-anthropomorphization does not seem possible or even desirable, at least not from the point of view of moderate realism, one should not come to the conclusion that any fixed limit to this process may be set in an a-prioristic way.

We have mentioned before that de-anthropomorphization offers some advantages. Indeed, many scientists consider them the main reason for the claim of the supremacy of scientific knowledge over other modes of cognition. Let's briefly discuss these advantages so as to gain a better understanding of the whole phenomenon.

The desire of establishing a precise and detailed knowledge of the material universe forced scientists to devise ways and means of investigation satisfying the basic principle of objectivity. Objectivity, in turn, results from submission to the object. The observer or the experimenter must conform his methods to the kind of determination and to the mode of behaviour proper to the object. The use of the number-measures for recording the results assures the required precision, objectivity, at least on the macroscopic level, communicability and verifiability of those results. What is more, the ensuing mathematization offers the advantages of mathemat-

ical reasoning, namely logical coherence, clarity, freedom from contradiction and greater intelligibility.

The scientist discovers stable relations between number measures. Clad in algebraic forms they become laws, the central element of science. The very precision, determination and generality of laws expresses the element of constancy in nature, thus making possible construction of theories, mathematical evaluation of various events and mastery over physical reality. Even if Auguste Comte's contention that the aim of science is "savoir pour prévoir, afin de pouvoir" is not fully borne out by science, yet it well describes the all-too-natural human desire for certitude and mastery through knowledge.

The progress brought about by mathematization was achieved at a cost. No discussion of our topic would be complete without mentioning at least the price which science had to pay for becoming what it is today. The first and most obvious disadvantage of de-anthropomorphization is the departure from concrete images and notions which resulted in a complete rupture between the familiar and humanly important picture of the world of every day experience and the scientific world picture. Whatever science tells us about the nature of material reality, we live and we will continue to live in a world revealed to us through direct sense experience. Our psychological reactions are adapted to a macroscopic, non-relativistic world of qualitatively differentiated phenomena. Even inventions made possible through the departure from the familiar world image, such as X-rays, radio, atomic power are for us meaningful if and when they form part of our world.

The structure of our sense organs and the process of sensation remain unchanged and unaffected by the discovery of sub-atomic reality. Yet there is something disquieting in the disparity between the sense image of things around us and their picture emerging from micro-physics. The commonly invoked argument that our mode of perception is an instance of biological adaptation to life remains sound and satisfactory as long as we do not realize that from the epistemological point of view it is rather useless besides involving a vicious circle. We perceive things as they are, but they appear to us in such a way and not another, because our perceiving organs are what they are. If, for instance, the cones and rods in my retina were receptive to ultra-violet or infra-red radiation or to X-rays, the world would look quite different to me from what it looks now, but it would be just as real. To claim with the resources of our present day knowledge that I am better off limited in my vision to the colours of the rainbow than I would be if I were receptive to radiations of other wave lengths would take more courage and industry than I am able to master.

Scientific discoveries of this century based on precise measure and quantitative knowledge made us realize that our familiar world picture is neither complete nor the only one possible. We have thus learned that the problem of knowledge, of its nature and value, is more complex than we had thought previously. I am not prepared, in the short time at my disposal, to make a thorough analysis of the whole question, but I do want to point out that epistemological issues have a direct and decisive bearing on metaphysics.

The whole problem of knowledge, of the material world and of the nature of this world, is obscured and complicated by the fact that science rejects the Aristotelian notion of causality and transforms causal laws into statistical relations between number measures. Thus, for instance, the law of Boyle and Mariotte, i.e. $P \times V = \text{constant}$, is not interpreted by the physicist as meaning that the pressure is the cause of the change of volume of the gas. All that this formula explicitly expresses is a mean algebraic relation between consecutive readings of a manometer and a volumeter. To say that the change in the readings of measuring devices was produced by a cause is to use concepts not included in the immaculately pure and coherent scientific vocabulary. The notion of cause, the scientist will point out, is a typically anthropomorphic idea to be kept as far away from science as possible. It is therefore interesting and instructive to observe how these staunch adversaries of causality are willing to accept the ideas of heredity and of psychological determinism.

Independently of whether scientists accept or reject the very notion of causality, they in fact reduce all relations to quantitative ones. In this situation, necessarily, causal relations, except a species of formal causality, are excluded from the picture. Thus a new noetic situation is created One is allowed to ask what then is the meaning and the value of scientific explanation. Is this an explanation at all or something else and, if so, what precisely? Of course, our question assumes that to explain means to give the causes. But the very success of theoretical and practical sciences invites us to take a good second look on our conception of explanation. If we say that scientific explanations are not really explanations, then to be logical we would have to conclude that science is not an intellectual knowledge. We may, of course, introduce distinctions and point out that there are at least two kinds of explanations: substantial and accidental. There is, no doubt, always room for these distinctions, yet it is not quite certain, at least not for the writer, if they will do the job of clarifying sufficiently the situation. In the absence of a better distinction, we may settle for a temporary solution, stating that scientific explanations are explanations of the accidental kind.

A scientist who has heard about the distinction substance-accident could object that his study of measurable properties of nature is the most adequate possible, besides being the most efficient. If, he may say, it is true I know merely accidents I do know them adequately. My ability to transform chemical elements and to change material particles into energy and vice versa amply proves my contention.

Without intending to abandon the theory of substantial structure of things, we may try to explain the importance and the efficiency of the scientific mode of knowledge in a more adequate way than it was done until now. The obvious progress achieved through the reduction of the study of the material world to the quantitative approach and a consecutive rejection of the Aristotelian notion of causality, seems to indicate the predominant role played by quantity in the realm of inanimate matter. One should not believe that a statement of this sort solves satisfactorily the whole problem. The question awaiting a thorough study is that of the

various aspects of quantity, of quantity's role in the relations of order and the relation of quantity to other accidents.

The disparity between the scientific and the common sense pictures of the world and the rejection of causality are not, from our point of view, the only disadvantages of mathematization of modern science.

The discovery of new realms of physical reality was concurrent with the levelling and shallowing of the view of this reality. Whoever decides in favour of measurement and of the quantitative approach unavoidably takes up with homogeneous exteriority. Things appear to him as having only surface. Thus the famous statement of the Manifesto of the Vienna Circle that "in science there is no depth, everything is surface" becomes understandable.

The levelling applies not only to the subject matter but also to knowledge itself. The requirements of coherence and of uniformity of method leads to the adoption of a horizontal instead of a vertical organization of branches of knowledge. The effect of quantity contrary to that of substance is exteriorization and multiplication, not unity and integration. Even if mathematics is adopted as the most perfect and the highest science, it has not the unifying and ordering capacity necessary for the bringing together of particular sciences in the coherent hierarchy of knowledge. Besides mathematics and science in general exclude themselves from a higher unity of knowledge, centred on wisdom.

Another problem which we have to consider is the nature of the object of physical science and the relation between this object and the knower.

The goal of science is objective knowledge. The use of measurement and the exclusion, to the limits of possibility, of direct sense data as expression of the knowledge of the object, seems to assure the achievement of this goal. Ironically enough, the refinement of the methods of measurement brought about the least expected results on the form of the theory of relativity, the principle of incertitude, and the general abandonment of determinism for a more flexible statistical approach. In microphysics, the utmost in measuring precision has revealed to us a wealth of number-measures which result from the interaction between the object and the medium of measurement.[2] The object is deformed and it is impossible to find out from available information how it is in itself. It is unclear to the scientist himself in what sense he can use in this case the very concept of object.

Science presupposes the distinction between the subject and the object and the independent existence of the latter. Until recent times scientists assumed in conformity with common sense that they studied objective reality and nothing else. What they did not realize was the fact that the distinction between subject and object can be maintained and be meaningful only within the complex framework of common sense knowledge. But common sense knowledge is based on direct personal sense perception, largely qualitative and implies the awareness of the subject of his being a

[2] Vide for a broader discussion of this problem: my article "La relation sujet-objet et la physique quantique", in La Revue de l'Université d'Ottawa, issue of April 1959.

person, a unit within, but distinct from, the environment. If all this is brushed aside, as it is in science, then in the de-anthropomorphized, quantitative knowledge, there is no more place nor justification for the distinction between subject and object. These terms simply become unintelligible. Astounding as it may be, the new situation is a standing invitation for philosopher and scientist alike to ponder over it and try to answer the unexpected questions arising from unexpected facts.

We have seen that de-anthropomorphization of science is a mixed blessing. Whenever we shall try to make the final assessment of the epistemological value of this complex phenomenon, we should keep in mind that every truly fruitful effort of thought must be a creative one. If knowledge is to progress, new questions have to be asked and answered. The mathematization of science has led to a situation in which new questions have literally forced themselves on us and, in consequence, the horizons of knowledge have been vastly increased. Thus in overall conclusion, we must affirm that de-anthropomorphization of science has been distinctly beneficial. If we philosophers feel unhappy about it, it is our business and our duty to rethink the whole problem and try to incorporate the universe of science, in a positive manner, into the general hierarchy of knowledge.

The question which I propose for discussion concerns our ability to perform this task. More precisely, are we able to cope adequately with the problems of the philosophy of modern science within the framework of traditional philosophy?

JERZY A. WOJCIECHOWSKI

University of Ottawa
Ottawa, Canada

Problem (b): *The Truth Value of the Aristotelian Philosophy of Science*

In a conversation with Lucien Price on September 11, 1945, Alfred North Whitehead, the eminent British-American philosopher, had the following to say:

> . . . When I went up to Cambridge early in the 1880's my mathematical training was continued under good teachers. Now nearly everything was supposed to be known about physics that could be known—except for a few spots, such as electromagnetic phenomena, which remained (or so it was thought) to be co-ordinated with the Newtonian principles. But, for the rest, physics was supposed to be nearly a closed subject. Those investigations to co-ordinate went on through the next dozen years. By the middle of the 1890's there were a few tremors, a slight shiver as of all not being quite secure, but no one sensed what was coming. By 1900 the Newtonian physics were demolished, done for! . . . There is no more reason to suppose that Einstein's relativity is anything final, then Newton's *Principia* . . .[1]

Professor Whitehead died before he saw further verification of his convictions. We have seen some of these during the recent International Geo-

[1] Whitehead, Alfred North, taken from *The Dialogues of Alfred North Whitehead,* A Mentor Book, 1956, p. 297.