

MARITAIN'S EPISTEMOLOGY OF MODERN SCIENCE
A SUMMARY PRESENTATION

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Within the sphere of theoretical or speculative knowledge, Maritain distinguishes two great areas: the realm of wisdom in which man knows things through their first causes (namely, in metaphysics and philosophy of nature); and the realm of science, in the modern sense of the word, in which things are known through second or proximate causes. This second realm designates principally mathematics, the physico-mathematical sciences and the experimental or natural sciences.¹

In The Degrees of Knowledge, which is not "a didactic treatise, but rather a meditation on certain themes linked together in a continuous movement,"² Maritain treats of these modern sciences, for the most part, in Chapters II and IV. In Chapter II he cautions the reader that a whole treatise would be required for these questions of which only a general sketch is presented: "We are not unaware of the gaps in our outline: it is subject to many retouchings and many additions."³

Already, in Réflexions sur l'intelligence et sur sa vie propre, first published in 1924, two chapters were devoted to the modern sciences: Chapter VI on "La physique de la quantité et la révolution cartésienne" (written in 1918), in which the substance of his epistemology on the degrees of abstraction, on physico-physical science and on

physico-mathematical science is presented in condense; and Chapter VII which deals with simultaneity according to Einstein.

In 1935, three years after the publication of The Degrees of Knowledge, Maritain published La philosophie de la nature,⁴ which explains "with more precision and depth" matters already presented in The Degrees. The contents of La philosophie de la nature are presented in condensed form in Chapter II, "Science et sagesse."⁵ Three other texts deserve to be mentioned: Chapter IV of Quatre essais sur l'esprit dans sa condition charnelle, entitled "Science et philosophie,"⁶ which "completes Chapters II and IV" of The Degrees of Knowledge⁷; Chapter I of The Range of Reason⁸; and finally a text on Philosophy and the Unity of the Sciences, read at the A.C.P.A. of 1953.⁹

In this paper, my intention is to present the major articulations of Maritain's Epistemology of the modern sciences as contained in these texts. In order to achieve this complex and difficult task, I will first describe the context in which Maritain has offered his reflections on modern science. Secondly, I will delineate the main components of Maritain's epistemology of mathematics and of empirical sciences, i.e., the physico-mathematical sciences and the experimental sciences.

I. The Context: Maritain's Critical Realism

Maritain's epistemology is a "critical realism," in which "realism is lived by the intellect before being recog-

nized by it."¹⁰

We hope to show in this book that Thomistic realism, in preserving, according to a truly critical method, the value of the knowledge of things, opens the way to an exploration of the world of reflection in its very inwardness and to the establishment of its metaphysical topology, so to speak; thus, 'philosophy of being' is at once, and par excellence, 'philosophy of mind.'¹¹

Such a noetic

recognizes the existence of things outside the mind and the possibility of the mind's attaining these things and constructing within itself and by its own activity, beginning with the senses, a knowledge which is true or in conformity with what is.¹²

Contrary to critical philosophy, which begins with epistemology and which, as a consequence, is led to idealism, Maritain recognizes the primacy of being and gives priority to the many approaches to being by a mind which receives its first object through sense experience, which also has a knowledge of being in its own right in diversified and progressive ways. Maritain is averse to any kind of idealist interpretation of human knowledge and of science: "A knowledge that despises what is, is itself nothing; a cherry between the teeth holds within it more mystery than the whole idealist metaphysics."¹³

Epistemology, therefore, presupposes the lived expressions of the polymorphism of human knowledge in its movement and élan from sense experience to the knowledge of the infinite. More precisely, a knowledge of being qua being enables the mind to establish a critique of human knowledge which can understand and respect the manifold noetic exper-

ience of the human mind in a truly realist and metaphysical spirit and which can avoid the risk, inherent to idealism, of constructing a univocal theory of knowing from a particular type of knowledge.¹⁴ Maritain's "violent" criticism leveled against the epistemological reductions of Descartes and Kant is well known.

A realist epistemology of the modern sciences does not presuppose only metaphysics, of which it is a function as a wisdom; it presupposes also a recognition of and a certain acquaintance with the facts under scrutiny, namely, the modern achievements in these sciences. How could any epistemology of the sciences be established unless the epistemologist listened first to the sciences themselves?

It is perfectly clear that only by reflective abstraction can such a specific form (of knowledge and science) be disengaged from the various sciences already constituted among men.¹⁵

A close scrutiny of Maritain's intellectual life would provide us with sufficient evidence that he had more than a minimal acquaintance both with modern sciences and with modern philosophies of science. He studied biology and German neo-vitalism during two years (1906-1908) in Heidelberg where he met Hans Driesch; he certainly knew something of the achievements of modern physics (Einstein, Planck, etc.) and of modern mathematics (Reiman, Lobatchevsky, Russell, etc.). The historical sketch of the development of the relationship between philosophy and science in The Philosophy of Nature manifests a knowledge of the progress of science and of the philosophies of science during ancient and more recent

centuries. Here, Maritain's purpose is not purely historical, but history provides him with the facts to be scrutinized in a reflective manner in his epistemology of the sciences.

Our concern has been to consider the new physics only in relation to our critical researches concerning the proper noetic structure of the physico-mathematical knowledge of nature, and the relations and distinctions that need to be pointed out between that knowledge and the philosophy of nature.¹⁶

Maritain has given due credit to the scientific achievements of modern minds. "The full and effective recognition of their autonomy," he says, "is a precious gain made by the efforts of recent centuries."¹⁷ It would be very instructive, indeed, to study Maritain's understanding of the scientists and of the mathematicians whose contributions he praises:

The magnificent contributions for which physics is indebted to Lorentz, Poincare and Einstein on the one hand, and to Planck, Louis de Broglie, Bohr, Dirac and Heisenberg on the other, have also renewed and stimulated in this science the sense of the ontological mystery of the material world. The major disputes and discoveries in modern mathematics concerning axiomatic method, the transfinite and the theory of number, the the continuous and transcendent geometries, are in need of philosophical clarification towards which the works of Russell, Whitehead or Brunschwig constitute only a rather uncertain beginning.¹⁸

Moreover, a scrutiny of Maritain's reactions to Duhem, Meyerson, Bachelard, the School of Vienna, would certainly contribute to a better understanding of Maritain's epistemology of the modern sciences.

In short, Maritain's intellectual life style illustrates his basic conviction that a philosophy of being - like a living organism - has the capacity to grow and develop from the contribution of different intellectual achievements.

Furthermore, he is convinced - and his work gives evidence to this conviction - that Thomistic philosophy, because it is realistic, can recognize and guarantee the autonomy and the specific character of the modern sciences and can understand the process of specialization "which will normally continue."¹⁹ It can also - and it must - recognize in the progress of modern science the sign "of an improvement within the organic structure and differentiation of thought."²⁰

In the kingdom of being, the different approaches to being do not have to be reconciled; they are in natural harmony, provided each approach is recognized in its own identity.²¹ "Hypotheses non fingo," Maritain could have said.

According to Maritain, this primacy of reality over theories receives a fundamental expression in the Thomistic philosophy of the degrees of abstraction (or of visualization). This philosophy should help the epistemology of science in securing "l'esprit de finesse," or the capacity to distinguish the different orders of knowledge according, first, to the different aspects (or inspects) of the real which the human mind tries to understand and, secondly, according to the basic ways it can define them in view of

its bipolar noetic structure.

Let us recall briefly some of the essential elements of this philosophy of knowledge which expresses, in Maritain's view, the fundamental realism of our minds in its endless efforts to understand better and better the mystery of being.

The least intelligible in itself is more intelligible for us and becomes the way to reach the more intelligible in itself. This conviction of Aristotle expresses in a splendid manner the basic optimism of critical realism. To be sure, the individual mobile beings of the material world are not intelligible in their individuality qua individuality, but the intellect, by a process of abstraction from individual matter²² or by a process of visualization, but extensive (abstractio totalis) and intensive (abstractio formalis), can disengage the intelligible reality of mobile beings from their unintelligible individuality. Thus, the understanding can know "the universal and necessary reasons of contingent things."²³

Because of the ontological richness of beings and also because of the noetic bipolar structure of the knower, three spheres of intelligibility are made present to the human speculative mind.²⁴

1. The sensible real, or Physics, which abstracts from individualized matter (from the singular as such) and in which the mind considers bodies in their mobile and sensible reality, in their empirically ascertainable qualities and properties;

its object therefore cannot exist and cannot be thought without "sensible matter." This is the universe and the laws of sensible and mobile nature.

2. The preater-real, or Mathematics, which abstracts from matter as a basis of sensible qualities and in which the mind considers a real property of bodies: quantity (both continuous and discreet); its object, therefore, cannot exist without sensible matter but it can be conceived without it.
3. The trans-sensible, or Metaphysical, which abstracts from all matter and in which the mind considers analogical beings (including material beings) qua beings; its object, therefore, can exist and can be conceived without matter. This is the universe of being as such.

In each of these intelligible spheres, specific types of "sciences" can be constituted, depending upon the proper mode of defining the proper subject of which the mind seeks a knowledge "per causas," by demonstration and explanatory knowledge which could be necessarily true and in conformity with "what is." Such a demonstrative knowledge is not always attained, but the mind, as a faculty of understanding, tends towards such "perfect knowledge."

When the mind deals with universal essences as known (not exhaustively, though) or as revealed in their immanent necessities, it can attain, however imperfectly, a knowledge

of things in their principles or causes, a propter quid deductive science, as exemplified by philosophical or mathematical sciences. These are, in the full sense of the words, sciences of explanation in which dianoetic intellection takes place.

On the other hand, because of their specific way of defining, the sciences of observation unveil the necessities in things by the means of sensible experience, and not by assigning reasons through intelligible means. These sciences are not "propter quid" sciences, but "quia est" sciences in which "a well established constancy is a sign of some essential connection."²⁵ Hence, the inductive laws of modern science deal with the essence as hidden; they unfold it without revealing it. This is called by Maritain perinoetic intellection. These sciences are less perfectly sciences and they tend to multiply. But they tend also to become explanatory and, therefore, to be attracted by sciences of the first category (the deductive sciences); thus, the experimental sciences, for instance, tend to become deductive in subjecting themselves to the regulation of mathematics.

It is within this general epistemology of critical realism that Maritain will present his reflections on modern science, namely on mathematics as dianoetic intellection and perfect science, on the experimental sciences as perinoetic intellection and inductive sciences, and on the physico-mathematical sciences as "mixed sciences."

II. The Epistemology of Mathematics

Maritain's interpretation of mathematical knowledge can be considered, it seems to me, one of the most revealing examples of his critical realism. This does not mean that he has elaborated a complete and systematic philosophy of mathematics. No special chapter of The Degrees of Knowledge has been written on "this degree of knowing of major importance."

The achievements of modern mathematics certainly pose to the philosopher a number of difficult questions, and much intellectual effort is required before these can be elucidated.

The great disputes and discoveries of the modern mathematicians concerning the axiomatic method, the transfinite, the theory of numbers and space and transcendental geometry require a philosophical determination whose still uncertain beginning can perhaps be seen in the works of Russell, Whitehead and Brunschvig.²⁶

Hence appears the need of many preliminary studies before Thomistic philosophy "is in a position to propose a systematic interpretation in which all the critical problems raised by modern developments of the mathematical sciences may find solution."²⁷

Despite this state of affairs, in Chapter II, IV and V of The Degrees of Knowledge, Maritain has given certain precisions on important points "which indicate quite definitely in what spirit a philosophy of mathematics should be elaborated."

One of the first remarks made by Maritain on this matter

concerns a point of agreement relative to mathematics as a perfect expression of human knowledge:

However, for both the ancients and the moderns - and in this sense they are in agreement - the clearest, the most perfect type of science, the one most perfectly within our grasp is provided by mathematics.²⁸

Another point of agreement would certainly be the affirmation that mathematics deals with an object which is of the "ideal order," which abstracts from the order of existence.²⁹ This explains, says Maritain, why a philosophy which would develop from mathematics - Cartesian philosophy for instance - would tend to become idealist. This ideal character of mathematical objects explains also "the close relationship there is between mathematics and logic."³⁰

At this point, however, Maritain departs from other epistemologies. While recognizing a close relationship between mathematics and logic, as a realist philosopher, he cannot accept the identification of mathematics with logic. On the one hand, he regards mathematics as a science quite apart from physics and metaphysics, which deal with real and existing beings. The object of mathematics is not necessarily real; it is "an object whose intelligibility no longer implies an intrinsic reference to the sensible, but to the imaginable. This is the domain of the mathematical praeter-real."³¹ In a sense, therefore, mathematics, while being on the second level of intelligibility, is poorer in real value than philosophy of nature and the empirical sciences.

On the other hand, Maritain attributes to mathematics an object which is not a pure logical relation of reason. Maritain recognizes two lines of interpretation of mathematics: first, the intuitionist, according to which mathematics has a proper object, quantity; second, the pure postulationist, which attributes to mathematics the value of a coherent organization of symbols arbitrarily defined and from which other symbols are deduced logically. The former interpretation, Maritain feels, is the correct one. He cannot agree with the way Russell defines mathematics as "a study in which one does not know what he is talking about or whether or not what he says is true," as a discipline without content.³² On this question, therefore, Maritain finds himself in the company of René Descartes ("le grand péché français").

In truth, mathematics is not bound by the limits of sense intuition, because it abstracts from sensible qualities; in a way, it enjoys the freedom of the imagination ("la folle du logis"). That is why there are the Euclidian and non-Euclidian geometries; that is also why "mathematics constantly forms beings of reason such as irrational number, imaginary number, transfinite number, the species of configurations, etc."³³

What then, is the proper object of mathematics? It is quantity, disengaged by abstraction from its natural subject, and considered, not ontologically as a property of material beings, but "from the various relations of order

and measurement." Here, experience plays only a pre-scientific role in delivering to the mind quantity, the sensible commune, and in providing certain figures, numbers, etc. ..., and the mathematical objects are thought independently from the actual experience which first revealed them to the mind. They form their own universe of intelligibility, constituted by essences which

are recognized and deciphered, so to speak, by means of construction beginning with primary elements abstractively disengaged from experience. This very construction of the intelligible constitutive requires a construction in imaginative intuition in some way or other.³⁴

In mathematics, therefore, objects are either quantitative constructs of possible real beings or beings of reason founded on these essences. It is necessary that the constructibility of objects in imaginative intuition manifest ad sensum the intrinsic possibility of the entities considered by the mind. These objects constitute a universe of knowledge which has its own consistency, its own intelligibility.

Thus, the object of mathematics, while being of the ideal order, is not a pure logical relation. Quantity is originally a property of bodies, but, in mathematics, the mind deals with it as if it were a subsistent "being" of which it can have, through the mental construction of ideal essences, a dianoetic knowledge. These constructions have a meaning, radically, because they are rooted in quantity or intelligible matter and have the status of either possible real beings or of beings of reason founded on these possible real beings.

Two specifically distinct sciences can be developed in this generic level of intelligibility: the science of the continuum (geometry) and the science of number (arithmetic) with all their ramifications and their inter-relations, the science of number being higher in abstraction and immateriality. The effort of modern mathematics to overcome the difference between geometry and arithmetic have surely led to fruitful discoveries, says Maritain, but it "has only succeeded in making its difference more marked and precise."³⁵ From these entities of the praeter-real, mathematics proceeds to truths

established entirely by axiomatic and deductive means, beginning with an imaginative intuition and with notions that abstraction simply forms and reconstructs on the basis of experience.³⁶

Thus, we have a science of a pure type which delivers to the mind eternal truths reached in virtue of intelligible connections intuitively or deductively perceived. "Even though no triangle existed, it would always be true that the sum of the angles of the Euclidian triangle is equal to two right angles."³⁷ Such conclusions are of a dianoetic kind and are verified directly or indirectly in imaginative intuition, either because they can be constructed in such intuition or because they belong to a system of symbols stemming from a notion or object which may be constructed in intuition.³⁸ Mathematics, therefore, is a science of explanation in which we might say, contrary to Russell, that we know perfectly what we are talking about. At least, this is

what Descartes thought.

Two corollaries will be presented that illustrate Maritain's philosophy of mathematics.

First, Maritain affirms that mathematics deals not only with "possible beings" but also with beings of reason founded in reality. Applied to the problem of the different geometries, this means that Euclidian space is an ens geometricum reale but that non-Euclidian spaces are beings of reason which presuppose, for their intelligibility, notions of Euclidian geometry, because

among the systems of geometrical entities that are called Euclidian, Reimannian, etc. spaces, only tri-dimensional Euclidian space is directly constructible in intuition.³⁹

This means that non Euclidian geometries presuppose notions of Euclidian geometry.

The second corollary to be presented is important for the understanding of the development of the physico-mathematical sciences. Since every higher discipline is regulative with respect to its inferiors, mathematics as a science prop-ter quid will tend to be rectrix⁴⁰ in relation to the empirical sciences in order to constitute with them the scientiae mediae.

III. The Empirical Sciences

Even though Maritain's philosophy of mathematics is a revealing example of his critical realism, his more detailed explanations concerning the empirical sciences bear witness to his deep understanding of the human noetic condition.

Contrary to mathematics, the empirical sciences deal with existing reality, with actual real beings. In their effort to scrutinize the reality of the material or sensible world, they are similar to philosophy of nature and to metaphysics. This explains, at least in part, the attraction they have undergone, on the one hand, by philosophy of nature and metaphysics among the ancients, and a tendency towards positivism among the moderns, on the other hand.⁴¹

In fact, according to Maritain, the sciences of nature are bound to ontology in an "implicit, obscure, ungracious and unavowed fashion": they presuppose a rudimentary "realist" philosophy in the very admission of the existence of things distinct from thought and of the possibility of knowing them; thus, "science itself refers obliquely to the being of things as the foundation for the explicative representations it elaborates."⁴²

In their endless efforts to scrutinize the details of material things, however, these sciences have to be satisfied with "the proximate or apparent causes."⁴³ Such perinoetic knowledge, whether expressed in the empiriometric analysis or in the empirio-schematic analysis of observable reality, is a necessary consequence of the fact that "differentiae substantiales, quia sunt ignotae, per differentias accidentales manifestantur."⁴⁴

Mineral, vegetable, or animal, the immense variety of corporeal natures inferior to human nature refuse to deliver to us openly their specific determinations.⁴⁵

It is a fact that Descartes could not understand, but which accounts for the tendency of the empirical sciences to fragmentation and multiplication quasi ad infinitum.⁴⁶

This marvelous development and proliferation of the modern sciences, both in the physico-mathematical realm and in the experimental realm, is an outstanding expression of the progress of the human mind, says Maritain. It

... corresponds to a necessary law of growth of speculative thought. It constitutes one of the most authentic advances, in the order of the morphology of knowledge, that thought has accomplished in the course of modern times and of which reflexive and critical philosophy has become aware.⁴⁷

Such progress in science has been made possible, on the part of the scientist, through the necessary renunciation of the search for the real or ontological causes of this abundant and diversified richness of the phenomenal world.⁴⁸

Maritain observes, with a certain sadness, that, as a corollary of this state of affairs, "timeless metaphysics no longer suits the modern intellect"; three centuries of empirio-mathematicism

... have so warped the intellect that it is no longer interested in anything but the invention of apparatus to capture phenomena-conceptual nets that give the mind a certain practical dominion over nature, coupled with a descriptive understanding of it; descriptive, indeed, because its thought is resolved, not in being, but in the sensible itself.⁴⁹

How does Maritain account for this resolution "in the sensible itself" which seems to be the essential condition of modern science and the source of its richness as well as its poverty? This fundamental characteristic of modern

science and the source of its richness as well as its poverty? This fundamental characteristic of modern science stems from its modus definiendi which is given the name of empiriological analysis.

The empiriological resolution of concepts is a descending resolution of concepts towards the sensible, in the observable determinations of things in virtue of the evidence of sense experience: "Science resolves its concepts and its definitions in the observable and the measurable as such."⁵⁰

This means that science does not reveal the very being of things, a truth that Kant has so clearly explained and which is a basic tenet of the School of Vienna:

Cette vérité, c'est que la science - la science au sens moderne du mot - n'est nullement une philosophie, et demande par suite, si j'ose employer ce barbarisme, à déontologiser complètement son lexique notionnel.⁵¹

This modus definiendi by verification has its source in the bipolar character of human knowing. The conceptual analysis of the first degree of intensive visualization, i.e., of mobile being which cannot exist and cannot be thought independently from sensible matter, is at the junction of sense knowledge and intellectual knowledge and requires the exercise of both faculties. If the resolution of concepts is made in an ascending manner towards the intelligible in the sensible - which implies that the mind perceives aspects of sensible reality which the senses do not perceive - such resolution is ontological and gives way to philosophy of nature. If, on the contrary, the resolution of concepts by the intellect is refer-

red to the sensible, then an empiriological analysis takes place and makes science possible. That is why, as has been so well expressed by Yves Simon, "every concept is meaningless for the positive scientist which cannot be, either directly or indirectly, explained in terms of sensations."⁵²

Definitions are sought "by means of the possibilities of observation and measurement, by effectuable physical operations."⁵³ This seems to correspond to Ayer's principle of verification. Scientific conceptualization, therefore, is determined by the observability of the objects, and the derivative notions are symbolic condensations of the observable or the measurable.

This mode of defining, in fact, has developed in two directions through two different types of empiriological resolutions:

1. The resolution proper to the physico-mathematical sciences where the sensible being is defined in terms of "measurability" sub ratione quantitatis. It is the empiriometric resolution of those sciences which have subordinated their analysis to mathematics in order to become deductive, and, thus, which became scientiae mediae.
2. The resolution of scientific concepts in physico-physical sciences where the sensible being is defined in terms of its observability "per operationem sensus, sub ratione phenomalitatis." It is the emp-

irioschematic resolution of the non-mathematized sciences of observation, a resolution in the chiaroscuro of empirio-logical conceptualization of purely experimental sciences. These sciences are predominantly descriptive and inductive sciences; they are scientiae quia.

Physico-mathematical Science

For Maritain, physico-mathematical science is "the queen and goddess of the experimental sciences;"⁵⁴ it is the flowering of the scientiae mediae. With the mathematical reading of the sensible reality a new epistemological type of knowing emerges.

This type of scientific knowledge was not totally unknown to the ancients who cultivated astronomy, harmony, geometric optics, etc. Aristotle and Thomas Aquinas named these sciences scientiae mediae and considered them as formally mathematical because of their rule of interpretation, and materially physical because "the terminus in which judgment is completed and verified is sensible nature;"⁵⁵ thus, they are more physical than mathematical.⁵⁶

With the moderns, this mode of knowing tends to invade the whole domain of the empirical sciences and constitutes a science completely autonomous from philosophy and realizing perfectly the type of scientia media; this is the scientific revolution of da Vinci, Galileo, Descartes; this is the achievements of scientists like Einstien, Planck, etc. "Few spec-

tacles are as beautiful and moving as that of physics thus advancing towards its destiny like a throbbing ship."⁵⁷ The other empirical sciences are following the example of physics more or less completely.

How can we define this progressive mathematization of science? "It is an empiriological analysis of nature, mathematical in form and control (an empiriometric analysis)."⁵⁸ Mathematics provides a system of explanatory reasons of the sensible real by means of mathematical "beings of reason," which become, so to speak, a psuedo-ontology, a methodological substitute for the unknown essence. This substitute serves as a synthesis of the measurable phenomena and as a principle for their deduction, "a science or knowledge of the physical real at once experimental and mytho-poetical."⁵⁹

These sciences have given up the direct search for real causes in themselves and aim at translating their measurements of things into a coherent system of equations. But they still remain radically and preponderantly physical, "because they have their terminus in sensible nature."⁶⁰ The deductive synthesis, for instance, is verified by the coincidence of its results with effectively discovered measurements, so that there is a correspondence between a system of signs and experimentally known measurable events. That is why the scientist, while making extensive use of mathematics, of the praeter-real, is so attached to the physical real.

Such development of the physico-mathematical science is made possible by the very fact that the object of mathematics -

quantity - is a property of bodies underlying the sensible qualities. As a consequence, these qualities are intrinsically subjected to quantitative determinations and are measurable.

The empiriometric analysis, therefore, has its starting point in measured facts which are represented in a mathematized theory, which in its turn serves as a basis for scientific deduction. In the concrete movement of highly mathematized branches of knowledges it is very difficult to distinguish clearly between scientific fact and scientific theory, because these two orders constantly overlap.

... since science in order to build itself up is going back and forth from facts to the new theories they serve to construct, and from theory to the new facts it serves to discern.⁶¹

From these general considerations, it is quite easy to understand that metaphysics is of no real intrinsic utility for the development of science,⁶² since scientific theories express the synthesis of phenomenal data in symbolic substitutes of the "unknown essence." On the other hand, this does not mean that mathematized science has given up its radical realism, for no real progress in science is considered as acquired unless it has been verified in experience. Furthermore, this mathematization does not and cannot exhaust the richness of the "measurable and observable" data.

The Experimental Sciences

Thus, the ideal of modern science to be experimental relative to its matter and deductive in its form, as found in phys-

ico-mathematical science, cannot be fully realized. The experimental sciences provide ample illustration of the sensible real to complete mathematization, especially biology and experimental psychology.

These sciences do not exclude any mathematical treatment of data, but they are less reducible to mathematical interpretation and deduction than pure physics:

We do not believe that the use of mathematics in biology, for example, or psychology will ever succeed in subordinating this discipline in this typical fashion to the rules of mathematical explanation.⁶³

Insofar as the experimental sciences escape mathematization and resist the attraction of the second level of intelligibility, they have to be established on the foundation of empirio-schematic analysis in which the very possibility of observation replaces the essence.⁶⁴ These sciences are called sciences of observation and not sciences of explanation. They remain at the level of the quia est. "Experience is essential to the science itself and completely controls it."⁶⁵ This is why the mode of defining and conceiving their proper object is essentially empirio-schematic; it schematizes in concepts whose meaning is essentially dependent upon their empirical source. Consequently, they create an autonomous empirical vocabulary, according to this mode of defining per operationem sensus.

The experimental sciences, or the physico-physical sciences, or the empirio-schematic sciences, are, above all, inductive, and in them, knowledge

...grasps the essence in a substitute which is scientific law - the judgment wherein knowledge is perfected thus opens upon experience itself, or, to state it otherwise, every newly acquired conclusion must be verified in scientific fact.⁶⁶

Since science, by an internal dynamism tends to become explicative by deduction and since the empirio-schematic sciences resolve their concept in sensible and observable being, "The type of deductive explanation whose attraction they undergo should be of a philosophical type and not of a mathematical type."⁶⁷ That is why they propose solutions that resemble philosophical solutions. The vitalism of Hans Driesch provides a very good illustration of this affinity. Yet Maritain warns his reader not to attribute a philosophical meaning to empirio-schematic concepts which correspond to a different modus definiendi than that of philosophy of nature.

In physico-mathematical science, the mathematical concepts become part of the empiriometric conceptualization and their object comes within the rule of explanation of mathematics, the subalternant science. In the empirio-schematic sciences, the subalternation to philosophy of nature remains extrinsic and improper; it is a regulative, not a constitutive, subordination, a subordination as to the principles only, and giving orientation to thought and research.⁶⁸

In concluding this general exposition of Maritain's epistemology of modern science, it seems important to emphasize the fact that this epistemology, while being faithful

to the basic principles of Thomistic philosophy, has a great capacity, because of its realism, for understanding the marvelous development of modern science.

In fact, Maritain classifies the modern sciences in three categories, each of them having a legitimate place in the Thomistic division of the theoretical sciences:

1. The mathematical sciences, constituted by the dianoetic knowledge of quantity (both continuous and discrete), as a propter quid science of the praeter-real. They are apart from the other sciences because of their ideal character and because of their perfection as deductive sciences. Their object, nevertheless, constitutes an objective universe of intelligibility of the real (a possible real).
2. The physico-physical sciences or the experimental sciences, constituted by the perinoetic knowledge of the sensible real; their mode of defining is empirio-schematic and their process mainly inductive.
3. The physico-mathematical science constituted as hybrid science (scientiae mediae), physical by its proper object and its mode of verification, becoming deductive by its formal subordination to mathematics.

Maritain recognizes both the independence of modern science and philosophy and their essential harmony. Science and philosophy are mutually independent because they have

essentially different modes of defining their object. "They do not fish in the same waters."⁶⁹ On the other hand, a sound understanding of the presuppositions of modern science shows that science and philosophy are in fundamental harmony. "Les vertus intellectuelles sont des vertus-soeurs sous le ciel des universaux."

Nothing is more obvious than Maritain's optimism regarding the tremendous developments of modern sciences which are at home in the degrees of knowledge among which each science is recognized in its own place, its proper value and its dignity as a noble fruit of the human mind.

At the same time, however, Maritain expresses a great regret regarding the fact that our civilization witnesses a struggle between science and wisdom:

La tragédie de la civilisation moderne ne vient pas de ce qu'elle a cultivé et aimé la science à un degré très élevé et avec des réussites admirables, mais bien de ce que cette civilisation a aimé la science contra la sagesse.⁷⁰

NOTES

1. Jacques Maritain, The Degrees of Knowledge, trans. Gerald B. Phelan, (New York: Charles Scribner's Sons, 1959), p. 46. Cf. Quatre essais sur l'esprit dans sa condition charnelle, (Paris: Alsatia, 1956), p. 169. "En traitant du débat de la science et de la philosophie, nous entendons ces deux mots au sens qu'ils ont prise dans les temps modernes, et selon lequel la science désigne avant tout les sciences mathématique, physico-mathématiques et naturelles, ou, comme on dit encore, les sciences positives et les sciences des phénomènes; tandis que la philosophie désigne avant tout la métaphysique et la philosophie de la nature."
2. Degrees, p. xii.
3. Degrees, p. 21.
4. Jacques Maritain, Philosophy of Nature, (New York: Philosophical Library, 1951), including an important text of Yves Simon in an Appendix, "Maritain's Philosophy of the Sciences", pp. 157-82, reprinted from The Thomist, 1943. (First French edition, 1935.)
5. Jacques Maritain, Science et sagesse, Chapter II. English version: Science and wisdom, (New York: Charles Scribner's Sons, 1954). (First French edition, 1935.)
6. Jacques Maritain, Quatre essais sur l'esprit dans sa condition charnelle, (Paris: Alsatia, 1956), pp. 169-226.
7. Degrees, postscript to the third edition, p. xvi.
8. Jacques Maritain, The Range of Reason, (New York: Charles Scribner's Sons, 1952), pp. 3-18.
9. Jacques Maritain, "Philosophy and the Unity of the Sciences," Proceedings of the American Catholic Philosophical Association, 27th Annual Meeting, April 7-8, 1953, pp. 34-54.
10. Degrees, p. 79.
11. Degrees, p. ix.
12. Degrees, p. 22.
13. Degrees, p. 335.

14. Degrees, p. ix.
15. Degrees, p. 22. "On apprend beaucoup sur la science, en entendant parler les savants, comme sur l'art en écoutant les artists." (Quatre essais, pp. 173-4).
16. Degrees, p. xv.
17. Science and Wisdom, p. 33.
18. Philosophy of Nature, pp. 151-2.
19. "It is an obvious fact that the sciences, in proportion as they have achieved the admirable developments which characterize them in modern times, have tended toward greater and greater multiplicity. Great scientific disciplines have divided and are dividing into parts, each of which is enough to absorb the whole competence of a given scientist. And this process of specialization will normally continue. Of themselves, the sciences tend to divide and multiply, so to speak ad infinitum." (Philosophy and the Unity of the Sciences, p. 34.)
20. Degrees, p. 201.
21. "La philosophie thomiste et la science moderne n'ont pas besoin d'être réconciliées, elles sont en accord naturel, à condition que nous ne rêvions pas de mettre le physicien au service de notre philosophie ou notre philosophie au service du physicien" (Quatre essais pp. 231-2.) (See also: Philosophy and the Unity of the Sciences, p. 37.)
22. "If we reflect that what philosophers call matter (Plato's existing non-being) is in the final analysis nothing but the ontological principle of relative unintelligibility (or irrationality to use modern parlance) which affects the very substance of things in nature and signifies, so to speak, the distance separating them from the intelligibility in pure act proper to uncreated Being, then the fundamental thesis that intelligibility goes with immateriality, so forcibly propounded by St. Thomas Aquinas, is immediately understood." (Degrees, p. 34.)
23. Degrees, p. 28.
24. Cf. Degrees, pp. 32-6; 125-9; 136-8.
25. Degrees, p. 33.
26. Science and Wisdom, p. 65.
27. Degrees, p. xii.
28. Degrees, pp. 22-3.

29. "Here the mind escapes into a world of entities which were first grasped in the bodies of nature but immediately purified and reconstructed, and on which other entities, which are indifferently real or "of reason," will be endlessly constructed. This world frees us from the sensible real but only because in it we sacrifice any order of existence." (Degrees, p. 209.)
30. Philosophy of Nature, p. 30.
31. Science and Wisdom, p. 38.
32. Degrees, p. 143.
33. Degrees, pp. 140-141.
34. Degrees, p. 204.
35. Degrees, p. 36.
36. Degrees, p. 52.
37. Degrees, p. 33.
38. Cf. Degrees, pp. 53-5.
39. Degrees, p. 168.
40. Degrees, p. 41.
41. See also, on the same question, Degrees, pp. 39-40; 140-1; 165-7.
42. Degrees, p. 154.
43. Science and Wisdom, p. 5.
44. St. Thomas Aquinas, De generatione, I, lect. 8.
45. Degrees, p. 205.
46. Quatre essais, p. 227.
47. Degrees, p. 199.
48. "Ainsi donc c'est en abandonnant ce qu'il serait essentiel de connaître, que nous parvenons à connaître scientifiquement le monde matériel dans son détail indéfini; c'est en renonçant à le conquérir dans ses causes réelles que nous parvenons à le conquérir scientifiquement fibre à fibre." (Jacques Maritain, Reflexions sur l'intelligence et sur sa vie propre, /Paris: Desclee de Brouwer, 3me édition, 1930/, p. 184.)
49. Degrees, p. 3.

50. Philosophy and the Unity of the Sciences, p. 35. See also Quatre essais, pp. 179-82.
51. Quatre essais, p. 178.
52. Yves Simon, "Maritain's Philosophy of the Sciences," in Philosophy of Nature, p. 166. "For the zoologist, man is a mammal of the order of Primates. How could he define such a term as mammal? A vertebrate characterized by the presence of special glands secreting a liquid called milk. How is milk defined? In terms of color, taste, average density, biological function, chemical components, etc." (pp. 165-6).
53. "...un énoncé pourvu d'un sens scientifique exprime une relation stable entre les signalements ramenables en définitive à telle ou telle classe d'experiences sensorielles." (Quatre essais, p. 175.)
54. Degrees, p. 138.
55. Philosophy of Nature, p. 38.
56. Science and Wisdom, p. 43; Philosophy of Nature, p. 39.
57. Degrees, pp. 154-5.
58. Degrees, p. 184.
59. Degrees, p. 162.
60. Degrees, p. 42.
61. Degrees, p. 58.
62. Degrees, p. 3.
63. Degrees, p. 146.
64. Science and Wisdom, p. 52.
65. Degrees, p. 55
66. Ibid.
67. Degrees, p. 65.
68. On this important question which is beyond the scope of this essay, see Philosophy and Nature, pp. 102-14.
69. Philosophy and the Unity of the Sciences, p. 38.
70. Quatre essais, p. 170.

COMMENTARY ON
"Maritain's Epistemology of Modern Science"
by Jean-Louis Allard

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Professor Allard has given us an excellent summary of the general epistemology of modern science as analyzed and understood by Jacques Maritain. He has outlined with admirable clarity the basic orientation of Jacques Maritain and the main conclusions at which Maritain arrives, without going into the details of Maritain's understanding of the so-called "three degrees of abstraction" and his proposed subdivision of them, and without giving us his own evaluation of Maritain's position. Yet it is in the details and in the evaluation that many of the difficulties and uncertainties lie.

Maritain was a true pioneer in the Thomistic analysis of the vast field of modern science, which has been developing with enormous rapidity over the past four centuries, thanks, indeed, to its technological and practical orientation. It is perhaps safe to say that no Thomist of modern times has devoted more serious attention to the status of modern science - or more precisely, the modern sciences - than Jacques Maritain. Prior to him, Thomists of the nineteenth century were content to cling to selected principles and conclusions of a philosophia perennis, thought to belong

to metaphysics, rational psychology, and a natural theology. Even moral philosophy was nothing but a watered-down moral theology, championed against all odds as a Christian necessity. The philosophia perennis of nineteenth century Thomists was generally thought to be a single body of doctrine based on eternal metaphysical principles known since the time of Aristotle and synthesized in the schoolmen of the thirteenth century. This philosophia perennis was thought to be the metaphysics of St. Thomas, capable of refuting the prevalent errors of idealism, rationalism, empiricism, and materialism. Apart from men like Salvatore Roselli and Zeferino Gonzales, the vast areas of modern science were ignored, at best as an embarrassment, or at worst an error. Of course, the confining and restricting of all Thomistic philosophy to metaphysics inadequately understood could not continue. The predominance of the empiriological sciences in modern thinking eventually had to be recognized. At the beginning of this century, men versed in Thomistic thought gradually began to face problems and discoveries of modern science sympathetically, particularly in psychology. Men like Edward Pace, Joseph Gredt, Peter Hoenen, and Jacques Maritain immersed themselves in scientific thought and emerged with a plurality in the modes of human thought, a multiplicity even in scientific ways of thinking. No one was better qualified than Jacques Maritain to face the array of sciences, versed as he was in neo-vitalist biology and relativity physics, as well as in the Thomism of Cajetan and John of St. Thomas. In writings extending over 35 years, Maritain expounded his critique of

the modern sciences and proposed his pluralist modes of human knowledge. No Thomist can afford to ignore his contributions to modern Thomistic thought or his challenge to authentic Thomism.

In this brief comment I would like to point out three areas of Maritain's critique which I think may be permanent contributions, acceptable to most Thomists, and three areas where dispute has arisen and may open to further consideration or refinement.

Under the first heading of permanent contributions, one should, perhaps, note his realist orientation and his refutation of idealism. In a head-on critique of Kantian and neo-Kantian idealism, he points out that all the modern sciences, even the mathematical sciences, cry out for a realist justification, not only in their starting point, but also for their orientation to the real, even when it is through symbols, constructs, and substitutes. Far from demanding that reality be as it is conceived by the human mind, all scientific thought requires for justification an ontological realism readily perceptible to the human mind in a different kind of knowledge. Maritain's epistemology of the modern sciences is a

noetic that recognizes the existence of things outside the mind and the possibility of the mind's attaining these things and constructing within itself and by its own activity, beginning with the senses, a knowledge which is true or in conformity with what is.¹

At least Maritain shows that idealism is not a necessary consequence of the new modes of scientific thought. Rather, all the modern sciences in the last analysis require a

realist philosophy to justify their starting point and epistemological evaluation. Maritain's critique of idealism within the context of the modern sciences is a valuable contribution to Thomism, one that is of permanent value.

Secondly, Maritain has strongly argued for a realist natural philosophy distinct from metaphysics. He argues for a philosophy of nature whose object is the sensible world, ens sensible seu mobile, the proper object of the human intellect. This philosophy of nature, for Maritain, is not only distinct from metaphysics, but presupposed to it as its psychological foundation. Such a recognition of natural philosophy as a distinct and autonomous science antecedent to metaphysics is a tremendous advance over his Wolfian predecessors and a restoration of the authentic thought of St. Thomas. Although this is a valid and permanent contribution to modern thought, it still is not universally accepted among modern proponents of Thomism.

Thirdly, and perhaps most important of all, Maritain has shown that the expression "modern science" can be misleading, for it does not represent a single, homogeneous body of knowledge. Within the vast area of what he calls "empiriological science," he analyzes at least two essentially different kinds of knowledge: one which is formally mathematical in content and structure, which he calls "empirio-metrical"; the other which is formally sensible in content and structure, which he calls "empirioschematic."

Maritain might also have gone on to analyze the many other kinds of knowledge necessarily connected with every

human science, such as hypothetical, probable, opinionative, historical, statistical, as well as the great diversity of demonstrative and dialectical reasoning. Nevertheless, the recognition of the mathematical-physical sciences as essentially and formally distinct from physico-physical or empirio-schematic sciences is of utmost importance to a modern critique of the sciences.

The extension of mathematical principles to the totality of matter and motion, even while abstracting from matter and motion, was the great innovation of the 17th century. Maritain has rightly recognized this innovation as a revolutionary expansion of the ancient scientia media, an analysis of physical problems subalternated to mathematics. Only in our own century has the new physics developed sufficiently for us to see its true structure as formally mathematical, with all the inevitable consequences of mathematical abstraction, such as an infinite number of constructs, symbols, equations, and entities small and large based on the measurable. While these sciences mathematically demonstrate propter quid within their own area, compared to the physical qua natural, they beget, for St. Thomas, only quia demonstrations per causam remotam, namely, through quantity abstracted from sensible matter. Of these two different sciences, Maritain has rightly said, "They do not fish in the same waters." An insufficient recognition of at least these two different kinds of knowledge in the vast area of modern sciences can only lead to confusion and equivocation.

There are at least three areas of Maritain's critique of

the modern sciences, however, that still need to be investigated further. I raise these only to indicate that work still remains to be done by modern Thomists who intend to take the modern sciences seriously.

The first problem is the very terminology used to designate different kinds of knowledge, and Maritain's subdivisions of the so-called "three degrees of abstraction." Perhaps it is unfortunate that Maritain was too firmly attached to the terminology of Cajetan and John of St. Thomas to appreciate the authentic teaching of St. Thomas revealed by Thomists in the past thirty years.

The very concept of "three degrees of abstraction" is most misleading and not at all what St. Thomas had in mind. The only kind of "abstraction" proper to the world of sensible reality is the abstraction of a sensible whole from its particulars. This is the very condition of knowledge being intellectual at all, and is called abstractio totius, not "total abstraction," which is meaningless. While all intellectual knowledge necessarily sloughs off individualizing matter as such, nothing is belied, for the sensible whole is perceived with all of its observable characteristics, and it is difficult to see how its modus definiendi can be resolved into two different sciences, the ontological and the observable.

Antanomastically speaking, only mathematics "abstracts," for it alone concentrates on a part of the whole, abstractio formae, a quantitative form, separating it from the whole of sensible reality which it disregards. For St. Thomas,

mathematical abstraction is unique in that it includes two distinct sciences, geometry and arithmetic, since the continuous and discrete are two different and irreducible kinds of quantity. Metaphysics, for St. Thomas, is not constituted by an abstraction at all, but by a judgment of separation that not all beings are material. At that point, the analogy of being 'as being begins and covers the whole range of real being; while nothing is left out, it is not the difference that constitutes the point of the analogy. It is unfortunate that John of St. Thomas chose to subdivide the so-called "third degree of abstraction" into metaphysical, logical, and theological. This is unnecessary and distorts the whole picture. In a highly original manner Maritain has reshaped the language of Thomism and his insights need to be compared to the original insight of St. Thomas.

Be that as it may, the terminology used to differentiate philosophy and science is even more misleading. Philosophy is said to be knowledge through first and ultimate causes, propter quid, deductive, causal and explanatory, ontological and dianoetic. Science, on the other hand, is said to be knowledge through second and proximate causes, quia knowledge, inductive, experimental, observable, non-explanatory, schematic and perinoetic. Every science worthy of the name, however, is made up of all kinds of perception, probable as well as demonstrative, quia as well as propter quid, and quia demonstrations through a whole range of remote causes as well as through effects. One does not have a propter quid demonstration unless one has grasped, not the first and ultimate cause,

but the immediate, proper, commensurate cause whether material, formal, efficient, or final.

The whole of Harvey's De motu cordis is a detailed build-up to one propter quid demonstration through material cause. It would be ridiculous to extract that one syllogism and say it alone belongs to the science of biology, or worse, to say that it is non-causal, non-explanatory or merely inductive. All human knowledge from history and economics to metaphysics and ethics has got to be both inductive and deductive. This is also true of the more general parts of natural philosophy dealing with 'nature' and 'cause,' the proper principles of this science, which includes man and the soul.

Thus the dialectic and induction which Aristotle required to define the soul fills the whole of his History of Animals, Parts of Animals, and two books of De anima, as Festugière demonstrated in 1931. Even after Aristotle arrived at the definition accepted by all his successors as the true and essential one, he calls it "schematic."² St. Thomas comments that this is because the description is quasi-extrinsic, superficial, and incomplete, needing the further determination of all its parts.³ If such definitions are not further determined in detail, they remain incomplete and imperfect. This is exactly the problem with the simplistic definition of man as a "rational animal." It is only a schematic definition, needing to be filled out in detail by study, research and experience.

The second area needing further elaboration is the

precise distinction between natural philosophy and what Maritain calls the empirio-schematic sciences, among which he mentions only biology and psychology. Maritain starts with the de facto development of the empiriological science and insists that there is still room for a natural philosophy distinct from metaphysics. Yet he obliges this philosophy to be "poor and humble" in its quest for the more ontological aspects of nature and man.⁴ These aspects are limited to the elements of Aristotle's Physics and Thomistic rational psychology, obliquely connected with Aristotle's De anima.

These parts, however, admittedly deal only with the most generic and universal facts of sensible beings, namely that they move and that they move in very different ways. The first generic problem is to explain how this is possible. It does not seem reasonable to say that the generic consideration, which requires only common experience, belongs to one science, and the specific consideration, requiring detailed experience, belongs to an essentially different science. Nor is it adequate to say that one tends toward the ontological and explanatory, while the other tends toward the observable, experimental, and schematic. If the empirio-schematic sciences, at least of biology and psychology do not offer any causal explanation whatever, not even through material cause and structure, then, as some Thomists have said, they cannot be called sciences at all, but are purely dialectical preparations for science. This, however, would be to underestimate the real, probative value of the so-called experimental sciences. The more specific any investigation becomes, the more

detailed and experimental its method must become; this, I think, is true of all human knowlege.

The third and most recent area to merit the attention of Thomists is the contention of Maritain and many others who do not follow him that "as regards physical realities, we succeed in attaining quidditative definitions only of ourselves and of things belonging to man."⁵ It is not surprising that we know man better than animals or inanimate things, but it is a serious challenge to Thomistic realism to say that we cannot know the essential and quidditative nature of anything but man and the things of man. As one recent Thomist has expressed it, this is to sell St. Thomas short. More important, however, it betrays an ignorance of the whole way of arriving at definitions, even the definition of man. We have forgotten that the so-called "essence" of every natural thing is no more than a principle (principium) of observed characteristics. We do not have an immediate intuition even of man as a rational animal; we must arrive at such a definition through the observed characteristics of animality and rationality. That this is no easy matter is obvious from the number of those who deny that rationality is essentially different from animality.

The method of division or dichotomy is only one of two methods discussed by Plato and Aristotle for arriving at definitions. Indeed, this method is severely limited and not very fruitful in the world of nature (including man) where essences are only principles of observed behavior. The other method is that of comparison and similarity, which is far more

important and fundamental. Faced with the difficulty of classifying and defining animals, Aristotle realized that even groups of birds and fishes must be marked off by many differentiae, and not by means of dichotomy.⁶ These numerous differentiae are more than mere substitutes or signs for a definition, for they are the sole means of understanding the essential natures as an ontological principle of those observed differentiae.

Much work still remains to be done on how the human mind arrives at an understanding of essential natures as a principle of observed manifestations. Thomists have tended to neglect the whole area of how we arrive at essential definition, whether they are of ens mobile, motion, time, the soul, man, or locusts. I only hope that Thomists of the stature of Jacques Maritain will be forthcoming to devote serious attention to the remaining problems of science and knowledge.

NOTES

1. Jacques Maritain, The Degrees of Knowledge, trans. under the supervision of Gerald B. Phelan, (New York: Charles Scribner's Sons, 1959), p. 22.
2. Aristotle, De Anima, 413a10.
3. St. Thomas Aquinas, Summa Theologiae, II, Lect. 2, n. 244.
4. Jacques Maritain, Philosophy of Nature, (New York: Philosophical Library, 1951), p. 76.
5. Degrees, p. 31; Philosophy of Nature, p. 196.
6. Aristotle, De partibus animalium, I, 2-4, 643b10-25.