The distinction between philosophy and the experimental sciences.

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THE DISTINCTION

BETWEEN PHILOSOPHY

AND

THE EXPERIMENTAL SCIENCES

Submitted to the Committee on Graduate Studies of Assumption College in Partial Fulfillment of the Requirements for the Degree of Master of Arts

by

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1955
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The subject of this thesis is the distinction between philosophy and the experimental sciences. The part of the problem studied, is chiefly centred on the confusion which exists between the legitimate field of research of the philosophy of nature, and the legitimate orbit of the experimental sciences. The separation of these two intellectual disciplines engenders an examination of the approach of each to sensible reality, their methods of investigation, and the types of knowledge which they achieve.

The problem, in its major aspect, is primarily historical, since the majority of the scholars preceding Galileo directed their efforts toward the solving of the riddles of the universe mainly by philosophical speculation; whereas, with the complete enunciation of the experimental method, the moderns sought to discover the truth contained in reality by the scientific method. Since they were unaware that the new method was limited to the observable and measurable, they firmly believed that they had discovered a new means for philosophical speculation. As was inevitable, the limits of scientific knowledge were defined by scientists such as Mach and Poincaré. Unfortunately, they chose to reject the possibility of any knowledge which did not lie within the scope of the experimental method.
The cause of traditional philosophy was eclipsed, but not annihilated. The result has been a major division. On the one hand, the advocates of Thomism, together with such prominent men of science as Caldin, Conant, Owen, and Thompson have acknowledged the aim and validity of traditional philosophy. On the other hand, the materialists, pragmatists, and positivists rejected traditional philosophy and preferred to found their philosophies on the theories of science. It has been at this point, in order to salvage any possibility of a philosophy anchored to reality, that Maritain and his contemporaries have expanded and applied a study of the nature of philosophy and the natural sciences, so that it would be possible to separate them, and place each one in its particular position in a well ordered hierarchy of knowledge.
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I

INTRODUCTION

A HISTORICAL PERSPECTIVE

The failure to distinguish philosophy and the experimental sciences has been one of the major reasons for the intellectual chaos to be found in the contemporary world. Certain schools of thought, following in the tradition of Herbert Spenser and August Comte, have sought to resolve this controversial question by denying the validity of traditional philosophy and, therefore, rejecting it. For they assumed that, since the philosophical method of their Greek and Scholastic predecessors had failed to solve certain scientific problems to which it had been applied, it must necessarily be invalidated as a means of discovering any knowledge. So, for a long time, the experimental sciences and their method remained as the only recognized means for achieving a real and valid knowledge. Other schools of thought, following in the tradition of Aristotle and St. Thomas Aquinas, have recognized philosophy, the validity of its procedure, and its contributions to the growth of man's knowledge. Accordingly, they have tried to resolve this problem by placing philosophy and the experimental sciences in their proper positions within a well-defined hierarchy of knowledge, and affording to each the recognition to which it is due.
Since neither of these alternate solutions is universally accepted, the distinction between what is philosophical and what is scientific remains as one of the principal problems to confront contemporary thought.

If we turn to the historical aspects of the distinction between philosophy and the experimental sciences, we will discover that this problem did not arise with the Ancients because their whole effort was devoted to the organization of the philosophy of nature as a science distinct from metaphysics. This was achieved with admirable success. However, as M. Maritain has pointed out, the Ancients, Aristotle and the early scholastics paid for this capital truth by a serious intellectual error. They did not ignore the detail of phenomena but failed to perceive that this detail of phenomena needed its own specific science which would be distinct from philosophy. The Ancients, in their optimism, were often prone to arrive quickly at what were oftentimes very hypothetical or fallacious explanations for the details of sensible nature. Philosophy and the experimental sciences were one, and all the sciences concerned with the material world were sub-divisions of one unique specific science called the philosophy of nature. The philosophy of nature was a science to which it belonged at once to analyze corporeal substances and to explain rainbows, and therefore, it absorbed all the natural sciences. For the Ancients, the detail of phenomena was not the object of a specifically
distinct science. This does not imply that the epistemology of the philosophy of the ancients did not allow for a definite relationship of the material sciences with philosophy but simply states that the method peculiar to the experimental sciences was not elaborated.

The scholastics who followed the Ancients continued to direct their efforts toward the separation of the philosophy of nature from metaphysics. They were also aware of the methods of analysis of natural phenomena in certain fields such as optics and astronomy; but they did not, in a clear cut way, conceive of the possibility of a general science of the sensible specifically distinct from the philosophy of nature. They still continued to interpret natural phenomena from a point of view essentially ordered to an ontological

1 Jacques Maritain, La Philosophie de la Nature (Paris: Pierre Tequi, 1935), p. 31. "Toutefois, cette vérité capitale était payée chez les anciens chez Aristote lui-même, et chez les anciens scholastiques également au prix d'une grave faute de précipitation intellectuelle. On ne peut pas dire que les anciens étaient incurieux du détail des phénomènes, ils s'y intéressant autant que les modernes, mais ils n'avaient pas vu que ce détail des phénomènes exige sa science à lui sa science spécifique, distincte spécifiquement, (ye ne dis pas généralement) de la philosophie de la nature. Pour l'optimisme des anciens que se portait, très rapidement à des raisons d'être quelquefois très hypothétiques quand il s'agissait du détail des phénomènes, philosophie et sciences expérimentales étaient un seul et même savoir, et toutes les sciences du monde matériel étaient des subdivisions d'une seule et unique science spécifique qui s'appellerait 'philosophia naturalis', et à laquelle appartenaient à la fois l'explication de la substance des corps et l'explication de l'arc en ciel. On peut dire que pour les anciens la philosophie de la nature absorbait toutes les sciences de la nature. Le détail des phénomènes ne faisait pas pour eux l'objet d'une explication scientifique spécifiquement distincte."
knowledge. Thus questions which today are called scientific did not constitute a specifically distinct discipline but were a part of philosophy. This continued to be the case right down to the seventeenth century.

The emancipation of the experimental sciences was not sudden and abrupt, but gradually moved forward through the initial efforts of men such as Francis Bacon, Copernicus, and Kepler. Francis Bacon is credited by history\(^2\) as one of the first advocates of induction, as the principal means to a valid knowledge of the sensible. Although modern scientists value the contributions of Bacon and his contemporaries, they consider that their unique science had its inception with the seventeenth century scientist, Galileo. In Galileo, the new movement reached further than in any of his predecessors. With a solid foundation in the new principles, he combined the experimental methods of Gilbert with mathematical deduction and thus discovered and established the true method of the physical sciences.\(^3\)


\(^3\) W. C. Dampier - Whetham, *A History of Science* (London: Cambridge University Press, 1930), p. 141. "In Galileo the new spirit went further than in any of his predecessors. With a sound grasp of the new principles he learned the modern need of concentration and worked out his carefully delimited problems in a more completely and methodical way than the universal genius of Leonardo could stoop to accomplish... But above all he combined the experimental methods of Gilbert with mathematical deduction, and thus discovered and established the true method of physical science."
In general, the new procedure of the natural sciences is a combination of the experimental method and mathematical deduction. More specifically, Galileo's theory and practice of the scientific method can be expressed in three phases. The first is observation; the second is an explicative hypothesis in the form of a mathematical law; the third is the verification of the hypothesis. Galileo, because of this contribution, was the real initiator of scientific induction as the moderns themselves understand it. However, mathematics is not in Galileo what it becomes in Descartes, where it is the first principle of all natural philosophy.

The new approach to the explanation of natural phenomena, as instituted by Galileo, adopts the following analytical procedure. In a controlled system, certain observations concerning a specified natural process are recorded by means of instruments and measurements. This record of observations contains the relevant measured values of those variable magnitudes which characterize the process under investigation. These measured values are carefully examined to determine

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whether or not there is a relationship. If a relationship is discovered, it is enunciated by a function which describes the pertinent relationship. The resultant generalization of explanation is tested as to its validity by an application to a particular process within its jurisdiction. If successful, it is formally stated as a law.\(^5\)

With the explicit development of the experimental method, the progress of the natural sciences began. Foremost among the group of distinguished scholars of science who applied the analytical procedure to the investigation of the material world was Isaac Newton. Among his many contributions to the growth of the sciences was a functional analysis of the experimental method in order to show its range of application. Just as Galileo had previously, Newton also affirmed that the analytical method deals with experimentation, the observation of phenomena, and through these, the development of general conclusions arrived at through induction. Furthermore, the scientist does not admit any objections to his conclusions unless they arise from other experiments. If no objections arise to nullify the conclusion, it is affirmed as universal. Should further experimentation reveal something which in part contradicts

the conclusion, it is restated to include those changes
necessitated by the new discovery. Through the analytical
procedure, the scientist can determine the simpler consti­t­
tuents of composite bodies; he can determine the laws of
motion; and in the universe he can determine causes from
effects, the general causes from the particular causes, and
therefore finally arrive at the most general causes. In
accord with these principles of procedure, Newton and his
contemporaries continued their experimentation and instituted
many advances in the physical sciences.

At this point it is interesting to observe that New­
ton and his contemporaries did not clearly perceive the uni­
queness of this new scientific knowledge and so believed that
they were philosophizing; they were completely unaware that
they were pioneers within the realm of a new intellectual
discipline, distinct from philosophy. The confidence of
this new scientific age in its procedure is expressed by
Cotes, a friend of Newton. So certain were these men of
science that they were engaged in a new mode of philosophical speculation that they completely rejected the doctrine of Aristotle and the Peripatetics as barren and invalid. Furthermore, they believed that through this synthetic and analytical method the laws and forces of nature could be deduced from certain selected phenomena, and that this method, in its broadest extension, would provide the means through which the causes of all things could be derived from the simplest principles possible.7

At this point in history a reversal has arisen in the position of philosophy and the experimental sciences. On the one hand the Ancients had considered philosophy and the natural sciences as one intellectual discipline principally because they had failed to perceive that the detail of

7 A. Cotes, "Preface to the Second Edition," Isaac Newton, Mathematical Principles, trans. A. Motte, rev. F. Cajori (Berkley Cali University of California Press, 1946), p. xx. "The sum of the doctrine of the schools derived from Aristotle and the Peripatetics is herein contained. They affirm that the several effects of bodies arise from the particular natures of those bodies; but whence it is that bodies derive those natures, they do not tell us, and therefore tell us nothing. There is left then the third class which profess experimental philosophy. These indeed derive the causes of all things from the most simple principles possible, but then they assume nothing as a principle that is not proved by phenomena. They frame no hypothesis, nor receive them into philosophy otherwise than as questions whose truth may be disputed. They proceed therefore, in a twofold method synthetical and analytical. From some selected phenomena they deduce by analysis the forces of nature and the more complete laws of forces, and from thence by synthesis shew the constitution of the rest. This is the incomparably best way of philosophizing."
phenomena needed its own specific science distinct from philosophy and because the experimental method was yet to be completely enunciated. Thus all the sciences concerned with the material world were considered as subdivisions of the philosophy of nature. On the other hand, the scientists of the seventeenth century had discovered the principles and procedure essential to the study of the detail of phenomena, but believed this to be a new method of philosophizing. Galileo and Newton, together with their contemporaries had failed to recognize the unique nature of philosophy and consequently believed their efforts to be philosophical. As a consequence, although the method of the physical sciences had been enunciated, all the sciences were included together under what was termed experimental philosophy. In the one instance the Ancients had absorbed science into philosophy, and now philosophy was absorbed into the physical sciences by the scientists, and so the confusion between philosophy and the physical sciences remained.

With the continuous progress of the experimental sciences there was a growing awareness among many scientists such as Mach and Poincaré of the unique nature of scientific knowledge. Mach, in seeking to analyze scientific knowledge, began with sensible nature, which is the object studied in the natural sciences. From his investigations Mach concluded that the basic elements of nature are sensations. He believed that primitive man first picked out certain compounds
of these sensations which were relatively stable, so that
the first and oldest words are names of things. This sele-
ction was accomplished through the process of abstraction,
abstractions from the environment of things, and from their
continual minor fluctuations which pass unnoticed. Further-
more unalterable things, as such do not exist, but are ab-
stractions. The name is but a symbol for a compound of ele-
ments from whose changes we abstract. A single word is
assigned to a whole compound to suggest all constituent ele-
ments at once. Mach emphasizes that sensations are not the
signs of things, rather, a thing is a though symbol for a
compound sensation of relative fixedness. The world is not
composed of things but of flux and sensations such as colours,
tones, and pressure, and in view of this, it is impossible
to affirm either permanence of the thing-in-itself. Since

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8 Ernst Mach, The Science of Mechanics, trans., T.J. McCormack (La Salle, Illinois: Open Court Publishing Co., 1942), pp. 578-80. "Nature is composed of sensations as its elements. Primitive man, however first picks out certain compounds of these elements - those namely that are relatively permanent and of greater importance to him. The first and oldest words are names of things. Even here there is an ab-
stractive process, an abstraction from the surroundings of
things and from the continual minor fluctuations which these
compounds undergo, which being practically unimportant are
not noticed. No unalterable thing exists. The thing is an
abstraction, the name symbol for a compound of elements from
whose changes we abstract. The reason we assign a single
word to a whole compound is that we need to suggest all the
constituent sensations at once. When later we come to remark
about the changeableness we cannot at the same time hold fast
to the idea of the permanence of a thing unless we have re-
course to the conception of the thing itself or other such like
absurdity. Sensations are not the signs of things, but on
Mach was also in agreement with "Newton and Cotes in that he considered the experimental method as the only real and valid means of knowledge, his epistemology represented a real attempt to discover and analyze the nature of scientific knowledge. On this basis he concluded that sensations or the detail of phenomena and their connections formed the basis for scientific knowledge and that experience alone is the means of this knowledge. The natural sciences, according to Mach, could not reach any inner natures because they did not exist, rather, it discovered and described the connections of the not further analyzable elements of sensations.

Since Mach realized that the physical sciences are limited to a certain approach in their study of natural phenomena, he also sought to fit the terms of the experimental sciences to this approach. In trying to achieve this, he attempted to purify terms, such as causality, of their previous philosophical meanings. He considered the concept of cause significant only as a means of provisional knowledge or orientation. Thus, the scientist, in his investigation of an event, must regard phenomena as dependent on one another in the same manner as a geometrician regards the sides and angles of a triangle as dependent on one another.\(^9\)

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\(^9\) Ibid., p. 582. "The notion cause possesses signi-
Mach's description of causality expresses a concrete attempt to purify the content of the physical sciences of previous philosophical concepts. Because his epistemology expresses an awareness of the limits of scientific knowledge, he marks an advance over many of his predecessors.

Henri Poincaré, the French mathematician, also made a similar study of the physical sciences and formulated certain conclusions about the nature of the natural sciences. He considered the physical sciences to be a classification of facts which appearances separate. It is a union of these facts as though they were bound together by some natural and hidden kinship of force. Basically, the physical sciences are systems of relationships. Poincaré also concluded that the objectivity of the experimental sciences is in these relationships and these relationships alone have objective value.¹⁰

¹⁰ Henri Poincaré, *The Foundations of Science*, trans. George Bruce Halstead (Lancaster Pa.: The Science Press, 1946), p. 349. "How what is Science? . . . It is before all a classification, a manner of bringing together facts which appearances separate though they were bound together by some natural and hidden kinship. Science in other words is a system of relationships. Now we have just said, it is in the relations alone that objective value since it teaches us only relations, this is to reason backwards since it is precisely these relations alone which can be regarded as objective."
Thus, Poincaré also affirms the concept that the physical sciences are a study of relationships among phenomena and that these relationships are gained through experience. There is no thought of seeking the inner nature of things, but only the discovery and description of phenomena, and their relationships. These form the basis for a real and valid scientific knowledge.

The thought of Mach and Poincaré illustrates the growing awareness of the specific limits of the experimental method as an instrument of knowledge. In its fundamental approach, the method has remained the same in its three typical phases: observation, an explicative hypothesis, and the verification of the hypothesis. But, its limitation to the discovery and description of the relationships and the detail of phenomena has been clarified. The experimental sciences no longer persist in an attempt to solve every problem in the universe. Thus, the inner natures of things no longer form a problem in the physical sciences. This awareness of the unique nature of the natural sciences has seen the meanings of terms such as causality removed from their previous philosophical definitions and their restatement within the limits of the experimental sciences.

Although some of the limitations of the physical sciences had been clarified, the confusion between philosophy and the experimental sciences still remained: for many of the major scientists still considered scientific knowledge alone.
as real and valid, and recognized only the experimental method as an instrument of knowledge. They had failed to recognize the unique nature of philosophy and considered traditional philosophy as the product of an obsolete procedure. So strong was the faith of many philosophers in the progress of science that they constructed whole systems of philosophy on the tenets and interpretations of the physical sciences.

As Fulton Sheen has pointed out, many philosophers to-day take generally accepted results of the experimental sciences and weave them together to form a picture of reality. Furthermore, Sheen noted that all philosophers do not philosophize in the same way, and therefore, philosophy no longer seeks truth but forms points of view in line with the latest scientific trend. In Whitehead's philosophy there is a definite break with the mechanistic view, and the formation of an organismic concept of reality. Lloyd Morgan and S. Alexander express the view that there is a movement toward higher levels of being. In Santayanna there is a naturalism which is Platonic in spirit. These are examples of philosophers who are no longer conscious of their own intrinsic value. They have no higher mission except to apply the categories of the material to the spiritual, and the spatio-temporal to the eternal. In this current state philosophies

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11 Fulton J. Sheen, Philosophy of Science, (Milwaukee: Bruce Publishing Co., 1934), pp. 21-24. "To take the gradually
became an enumeration of personal points of view based on current scientific doctrines. The contention still remains that the experimental sciences are the only sound foundations for all knowledge. Traditional philosophy is still considered the product of an obsolete procedure.

The development of philosophy as a valid science distinct from the experimental sciences has been slow and faltering outside the realm of the Thomistic school of thought. But it has been materially aided by a definite realization of the incomplete picture of reality presented by the experimental sciences alone. The result has been a concerted effort by men such as Galdin, Owen, Thompson, and other prominent scientists to distinguish between philosophy and the natural sciences.

accepted results of the various sciences, . . . and to weave them together in a picture of reality seems the readiest and safest way of philosophizing. And this is precisely the method many philosophers follow today . . . But not all philosophers synthesize in the same manner and hence one must not look for truth but only for "points of view". This makes philosophy equivalent to the enumeration of personal points of view, and Professor Overstreet is not unwilling to embrace this confusion worse confounded. To-day on the contrary in one outstanding philosopher after another we find forceful expressions of points of view in line with newer trends. In Whitehead for example, we discover a definite break with the mechanistic views and the formation of an organismic concept of reality. In Lloyd Morgan and S. Alexander we are given as over against the entropic philosophy of materialism, the view of a world in which there is a nias toward higher levels of being. In Santayanna we find a naturalism that is nevertheless Platonic in spirit . . . . . . . . . . . . . . . . . .

These are but a few specimens of a philosophy which is no longer conscious of its own intrinsic worth, and which sees no higher mission in life for itself, than applying the categories of material to the spiritual, of the physical to the mental and the category of the spatio-temporal to the eternal."
Within the Thomistic tradition, the philosophy of nature has been revitalized and its formal and material objects reaffirmed to show that there can be a philosophical knowledge of natural phenomena. Thomistic philosophy does not seek to supersede the proper operations of the scientific method; but it does contend that traditional philosophy is a legitimate science which gains a knowledge of reality which is as real and valid as scientific knowledge.

In its historical aspects the distinction between philosophy and the physical sciences has, as a problem for contemporary thought, resolved itself into two broad opposing groups. The one group, because they have failed to recognize the unique nature of traditional philosophy, have rejected it as the invalid product of an obsolete method. They have maintained since the birth of the experimental method and scientific tradition that this procedure alone is capable of discovering real knowledge. More recently, the need for philosophical speculation has become more apparent. And so the philosophers within this group have sought to develop their systems by beginning with the most recent accepted scientific doctrine. Within their systems they have completely rejected any concepts of substance, nature or causality as founded in traditional philosophy. Some of the more prominent members of this group are the naturalists, the pragmatists, and the dialectical materialists.

The other group recognizes the value and purpose of
traditional philosophy and the value and the accomplishments of the experimental sciences. They recognize the incomplete picture of reality offered by either science or philosophy when alone. Therefore, they seek to form a more complete picture of reality by distinguishing between the proper field of operations for each; they seek to restore order by placing each in its proper position within the hierarchy of knowledge and affording to each the recognition to which it is due. Most prominent in this group are those philosophers such as Maritain, Caldin, Owen, Thompson, Renoirte and others who follow in the tradition of Aristotle and Thomas Aquinas. Since neither of these alternate solutions is universally accepted the distinction between what is philosophical and what is scientific has remained as one of the principal problems to confront contemporary thought.
II

THE APPROACH OF PHILOSOPHY AND SCIENCE TO SENSIBLE NATURE

With the development of the material sciences and their marked success in the solution of many of the problems of nature, there has been a deep and wide-spread influence to the point where it has been reflected in a new usage and meaning for many terms such as principle, causality, and substance. Confusion has resulted from the failure to distinguish the legitimate spheres of philosophy and the science. In actual fact, it is not, as some thinkers such as Comte and Spenser contend, a question of the new scientific meaning for a term superseding a philosophical meaning considered obsolete because it had been defined prior to the new approach. Rather, this problem revolves around the more basic issue of the distinction between philosophy and the natural sciences. In this instance, the distinction is concerned with the question of the basic approach of each intellectual discipline to the study of reality. Within philosophy itself there is one part, the philosophy of nature, which is specifically directed to the same object of study as the natural sciences. Both are concerned with mobile being but each seeks to penetrate it from a different point of view. The clarification of these points of view or formal objects is essential to the clear understanding.
of the line dividing philosophy and the experimental sciences.

In regard to these different approaches, M. Maritain has pointed out that in the philosophy of nature the mind searches for the inward nature and intelligible reasons of things. In following this approach, the mind comes to the statement of notions like corporeal substance, quality, operative potency, material and formal causes, and other similar concepts. Although all of these notions apply to the world of the observable, they do not describe objects which in themselves are representable by the senses, or expressible in an image or spatio-temporal scheme. These concepts are not defined by observations or measurements which can be performed in a particular determined way.

Furthermore, M. Maritain also indicated that philosophy is ever present in the emperical explanation. The scientist, like every other man, remains invincibly ontological, but in this case the ontology is oblique and indirect. For a scientist, being is never sought for itself; it is only there as a basis for empiric definition and of physico-mathematical entities. Thus, within the philosophy of

nature there is a definite interest in changing being, not in the detail of phenomena, but in intelligible being itself as mutable or changeable. The material object of the philosophy of nature is mobile being and its formal object is the intelligible aspects of mobile being.

As M. Maritain has indicated, the resolution of concepts is made in an infra-philosophic direction within the natural sciences. What things are in themselves is not the point of interest. What is important are the possibilities of empiric proof and mensuration which these things represent, and the connecting together, according to certain stable laws, of the data furnished by these means. Every definition must be made no longer 'by the nearest gender and specific difference' as in philosophy, but by observable and highly determined measurable properties. For the experimental sciences the possibility of observation and

en suivant cette route a des notions comme celle de substance corporelle de qualité, de puissance operative de cause matérielle ou formelle etc., qui tout en se rapportant au monde observable ne désignent pas des objets qui soient eux-mêmes représentables au sens et exprimables dans un image ou dans un schème spatio-temporel; ces objets ne sont pas définis par des observations au des mensurations a effectues de telle façon déterminée.

Dans l'explication 'empireologique d'autre part, il y a encore comme nous les notions à l'instant, de l'ontologique puisqu'il s'agit d'une connaissance intellectuelle, et que pour faire de la science experimentale nous ne devenons pas des animaux sans raison; en ce sens le savant comme toute homme reste rive à l'ontologie mais il n'y a la d'ontologie qu'indirectement et obliquement. L'ontologie n'est jamais la dégage pour lui même, il n'est là qu'à titre de fondemont de representations et definitions empiriques ou d'entités psychio-mathematiques.'
measurement replaces the essence of quiddity sought for in things by philosophy\textsuperscript{2}. Thus, observation and measurement underlie all the natural sciences either implicitly or explicitly; the natural sciences have for their material object mobile being, and for their formal object the observable and measurable aspects of mobile being.

Inasmuch as both the scientific and the philosophic adopt a different approach to the study of nature, the result has been a development of new meanings for terms which nominally appear alike in the technical lexikons of both philosophy and the experimental sciences. At this point it is necessary to guard against the erroneous assumption that the scholars prior to the formal statement of the scientific method were completely ignorant of the experimental sciences. This was not the case. On the other hand, with the complete enunciation of the new approach to nature, terms such as

\begin{quote}
\textsuperscript{2} Ibid., p. 292. "Ainsi donc d'une façon générale, dans tout ce registre empiriologique la résolution des concepts se fait dans une direction infra-philosophique. Ce n'est pas à ce que les choses sont en elles-même qu'on s'intéresse; ce qu'importe, ce sont les possibilités de constation empirique et de mensuration qu'elles représentent, c'est aussi la possibilité de relier entre elles, selon certaines lois stables, les données fournir par ces constatations et mensurations; toute définition deva se faire, non plus par le genre prochain et la différence spécifique, mais par des propriétés observables et mesurables bien déterminées dont on assignera dans chaque cas les moyens de recherche et de vérification pratique. La possibilité d'observation et de mensuration remplace ainsi pour un tel savoir l'essence ou quiddité cherchée dans les choses par la philosophie."
\end{quote}
matter, substance, and casualty did receive new scientific meanings, meanings which served to exemplify the characteristics of the scientific method and approach. In some instances, the philosophical and scientific meanings parallel each other, but their basic differences can be ascertained by a comparison of their usages within philosophy and the experimental sciences.

1. Substance

Within Thomistic philosophy, there is a division of the modes of being into ten predicaments. These predicaments themselves are divided into two major parts which are substance and accident. In respect to the predicament substance, St. Thomas affirmed that "it belongs to the quiddity of essence of a substance to exist or to be not in a subject."3 In a further clarification of this philosophical concept, Maritain stated that a substance is a thing or nature that can exist by itself or in virtue of itself and not in another thing, that is to say a previously existing subject. Substance signifies a thing existing in itself or subsisting, so that it is self-contained as an existent

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3 Thomas Aquinas, Summa Theologicae (Ottawa: Impensis Studii Generalis 0. Pr., 1946), III, q 77, a.1, ad2. "Non est ergo definitio substantiae: ens per se sine subiecto,... sed quidditati seu essentiae substantiae competit habere esse non in subiecto."
thing. It should be noted that the classifications of the predicaments is not arbitrary, but is fully grounded on the various kinds of beings which are found in the real order. Therefore, the idea of substance represents something that really exists.

In its scientific usage, substance is the term applied to homogeneous forms of matter— that is, those forms that are alike in all their parts. Iron, water, and carbon dioxide qualify as homogeneous forms of matter or substance because observation shows them to be alike in all their parts. Other common materials such as granite, and soil show differences in various parts even to superficial observation, whereas, other materials such as gun powder, or pieces of cast iron, while apparently of uniform composition, show similar differences of structure when viewed under a microscope. Such mixtures are not homogeneous and therefore are not substances.

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4 Jacques Maritain, "Introduction Generale A La Philosophie," Elements De Philosophie (Paris: Pierre Tequi, 1930), I,160. "Nous dirons donc que la substance est une chose ou une nature faite pour exister par soi ou a raison de soi (per se) - et non pas en autre chose, in alio, c'est-a-dire en sujet déja pose dans l'éter ... Ce que designe le terme substance c'est une chose faite pour exister en soi ou pour subsister, c'est à dire se tenir en elle même en existant."

5 L. Richardson and A. Scarlett, General College Chemistry (New York: Henry Holt and Co., 1947), p. 1. "Substance is the term applied by chemists to homogeneous forms of matter— that is, those that are alike in all their parts. Thus, iron, water and carbon dioxide are substances. On the other hand, such common materials as granite, soil, a mince
In conformity with the difference between the philosophical and the scientific approach to reality, the term substance has two different applications. The philosophical meaning of substance is indicative of a mode of being, and although it is derived from and is applicable to the world of the sensible, it does not describe something which is itself representable by the senses or expressible in an image or spatio-temporal scheme. The scientific usage of substance to denote homogeneous forms of matter is derived from the world of the observable, and it is both applied and verified by direct observations and measurements made within the sensible order.

2. Accident

In its philosophical application, the term accident includes certain diverse modes of being which have a common factor. According to St. Thomas an accident is "a thing to which it is due 'to be' in another", 6 Therefore its essence piae, even to superficial observation show differences in various parts, whereas other materials such as grains of gun powder or pieces of cast iron, while apparently of uniform composition, under the microscope show similar differences of structure. Such mixtures are not homogeneous, and thus, in the strict chemical sense are not substances."

6 Thomas Aquinas, Commentum In Quator Libros Sententiarum Magistri Petri Lombardi, IV, Dist. XIII, q1, 1. Opera Omnia, Parmae ed. (New York: Misurgia, 1949), VII-I - 632. "... res cui debetur esse in alio; et hoc numquam separatur ab aliquo accidente, nec separari potest: quia illi rei quae est accidens, secundum rationem suae quidditatis semper debetur esse in alio."
is to inhere in another as in a subject. These accidents are finite natures which exist or are able to exist and manifest reality proportionate to the manner of predication.

Within philosophy, the accident quantity is considered from the viewpoint of a mode of being; the quantity of a mobile being is its extension. Mobile being is not contracted in one point. It has parts spread out in three dimensions in space so that one part is in this part of space and another part is in another part of space. This quantity is defined by St. Thomas as: "that which is divisible into two or more constituent parts of which each is by nature a 'one' and 'a this'". Quantified being is therefore a being which has divisible parts; it is a whole being which is actually undivided but capable of being divided into parts; it is actually one, a unit, but potentially many.

Outside philosophy, the accident quantity is considered in two ways. The first, as M. Maritain has pointed out, is in mathematics. Here the mind considers the aspects of a body which remain when the sensibles are abstracted. Numbers and extension are objects of thought which cannot exist without sensible matter, but can be conceived without

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it. The knowledge of quantity in its relations of order and measurement forms the intellectual discipline of mathematics. The second, as J. Maritain has indicated, is in physico-mathematics. Physico-mathematics is a scientia media, an intermediary science half-way between mathematics and empirical natural science, of which the physically real forms the subject matter in regard to the measurements which it allows us to draw from it, but whose formal object and conceptual equipment remains mathematical. It is a science which is materially physical and formally mathematical.

In its philosophical aspect, quantity is considered in its relation to being as a mode of being. In mathematics it is considered in terms of its relations of order and measurement;

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8 J. Maritain, Les Degrés Du Savoir, p. 72. "Celle qui reste quand tout le sensible est tombe - la quantité, nombre ou étendu paris en soli: objet de pensée qui ne peut pas exister sans la matière sensible, mais qui peut être conçu sans elle car rien de sensible... C'est le grand domaine de la Mathematica, Connaissance de la Quantité commune telle, selon les relations d'ordre et de mesure qui lui sont propres."

9 Ibid., pp. 63-64. "C'est une scientia media ... une science intermédiaire, a cheval sur la mathematique et sur le science emperique de la nature, une science dont le réel physique fournit la matière par les mesures qu'il nous permet d'aller recueillir en lui, mais dont l'objet formel et la procédé de conceptualisation restent mathematiques; disons une science matériellement physique et formellement mathe-
matique." This explanation by M. Maritain is based on the following text from St. Thomas, In Boet de Trinit q'.5, a.3, ad. 6. "Quaedam vero sunt mediae, quae principia mathematica ad res naturales applicant, ut musica et astrologia quae tamen magis sunt affines mathematicis, quia en earum consideratione id quod est physici, est quasi materiale quod autem mathematici quasi formelle."
within the physico-mathematical sciences, quantity enters in as extension and deals with measurements in the terms of scalar and vector quantities. In each case the use of quantity is determined by the specific approach to nature employed by each intellectual discipline.

Within the realm of philosophy, quality is defined by St. Thomas, "as the disposition or modification of a substance", the qualities disposed the parts of a mobile being so that they are in some particular figure, have a given colour or manifest other characteristics. Qualities are also distinguished as those which are natural and deeply rooted in being, and those such as shape which are surface qualities. The natural qualities can also be divided into active and passive qualities. Here the proximate principle of determining an operation is called active, and the proximate principle of receiving activity is called passive. A quality is usually both active and passive. Figure, however, is only passive. It is determined by the termination of the extended mobile being in some definite manner.

Within the natural sciences, qualities or properties are distinguishing characteristics of the material in question. They are observable characteristics which may serve for the identification of materials. Under fixed external

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10 Aquinas, In IX Metaphys. lect. 1 (Cathala no. 1768) "Qualitas ex hoc quod est quaedem dispositio substantiae."
conditions, such as properties as odour, colour, density (weight per unit volume), freezing point and boiling point are identifying properties. On the other hand, those qualities which apply only to given samples of the material in question, such as size and weight, are not useful in the identification and determination of this material. They are properties confined to a particular specimen and are not properties of the substance as such. The scientific concept of property bears a relationship to the necessary accident which has a necessary connection with the substantial essence and emanates from that essence and bears no relationship to the contingent accident.

Since the natural sciences deal with the observable and the measurable, one of the key points to which their investigation is directed, are physical qualities or characteristics of the thing being investigated. In this instance the philosophical definition of the concept quality, as a modification or disposition of a thing, must underlie the operation of observation and measurement because the natural sciences do not define qualities or properties except in a description. Each quality of a body which is ascertained is defined in the terms of description and

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result; the description is of the instrument used, and the result is a mathematical determination made in reference to an arbitrary scale which has been developed to show the range and relationship of the property in question.

Other predicamental accidents, such as relation, when, and where, also are individually determined within the philosophical and the scientific spheres in accord with the different approach of each to reality. Within philosophy these accidents are determined as distinct and diverse modes of being, each with its own characteristics, which cannot exist by themselves but must inhere in another. They represent a division of being which really exists. Within the natural sciences, these accidents are determined in the same way as quality, which is in terms of observation and measurement, or description and result. This is usually accomplished in terms of functions which act within a prearranged frame of reference. The values assigned to each accident are both applied and verified by direct observations and measurements made within the sensible order. In some instances the values assigned may become very remote from the real order, but the application and verification still holds, although the connection to reality may be made through an elaborate instrument.
3. Principle

"Within philosophy a principle is that from which something else takes its rise. In a more specific definition, St. Thomas has stated that a principle "is that from which anything proceeds in any way whatsoever whether in being, on becoming, or in knowing." The first type of principles to be considered is the principle of knowledge. "A principle of knowledge (is) the basic idea for understanding any body of knowledge such as the premises of a proof." To come from something means to come out of a material and that in two ways either out of the most inclusive material or out of the least. This is an example of a real principle. In other cases a definition may be the point of initiation and this definition itself is a nominal principle.

In philosophy an important distinction is between principle and cause. It should be noted from the definition of principle that it implies only an order of origin and

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12 Aquinas, *In V Metaphys.* lect. 1 (Cathala no. 761). "Reducit omnes praedictos modos ad aliquid commune; et dicit quod in commune in omnibus dictis modis est, ut dicatur principium illud, quod est primum aut in esse rei, sicut prima pars rei dictur principium, aut in fieri rei, sicut primum movens dictur principium aut in rei cognitione.


does not include any notion of influence derived from the principle of those things which follow it. Even the common sense notion of cause differs from the notion of principle; first as implying a real and positive influence on the things of which it is the cause, whereas principle implies no such influence; secondly, and because of this, cause implies that the caused things are dependent on it, but principle implies no such dependence on the part of things which follow it; thirdly, cause implies some priority to the effect, if not in time, at least in nature. Such priority is not implied by the notion of principle, which signifies merely an order between things, which can be present without any priority\textsuperscript{15}. In effect causes are principles, but not all principles are causes.

Within the natural sciences, the term principle retains part of its philosophical meaning as an origin from which something proceeds. A scientific principle, in general, does not stand as absolute and universally accepted, but rather as relative and changing. For the continuous dialectic of the sciences functions in such a manner that a principle may be obsolete, may be revised in

\textsuperscript{15} Thomas Aquinas, \textit{De Prinzipiis Naturaee}, ed. E. Nauwelaarts (Louvain: Society of St. Paul, 1950), p. 91. The distinction established between principle and cause is based on the following text from Thomas: "Sed causa solum dicitur de illo-primo ex quo consequitur esse posterioris. Unde dictur quod causa est id ex cuius esse sequitur aluid."
part, or may be formulated in completely new terms. Except in a few cases there is no formal agreement as to what constitutes a principle. What may be denoted as a principle by one, may be termed a theory or law by another. In general, the most widely accepted definition of principle is a wide generalization somewhat similar to a law. The difference between these two types of generalizations, law and principle, is that the term law is used in science, is applied to a somewhat restricted and precise generalization. The statement that, bodies attract each other inversely as the square of their distances and directly as their masses, is commonly referred to as a law of gravitation. The concept, that the present diversity of plant and animal life is due to a common descent from primitive ancestors with modifications in succeeding generations, is usually referred to as the principle of evolution. It should be noted that no law or principle of science is regarded as absolutely proved.16 As a product of the sciences, a principle is an explanation drawn from empirical observation, subject to change because of the dialectic natural to the sciences.

In conformity with the difference between the philosophical and scientific approach to nature, the term principle has two applications. The philosophical meaning is indicative of being inasmuch as it is that from which something else takes its rise. It is primary and absolute. The scientific meaning retains a meaning which is reminiscent of its philosophical predecessor. It functions in a relative way within the dialectic of science after it has been formulated as an explanation derived from empirical observation. In this respect a theory or law may serve as a principle or a principle may serve as a theory or law. The philosopher used the term principle in its most primary sense where it refers to the thing itself. While the scientists employ principles in a secondary way where it deals with relationships between physical objects, situations and events in so far as they are observable and measurable.

4. Causality

Within philosophy cause usually comes under the heading of principle, but while a principle expresses priority, cause signifies a priority of a particular kind. There is an essential connection between the cause and that which follows it, namely the effect. Cause can be defined as a principle to which something else owes its existence.
According to St. Thomas, a "cause brings some influence on the 'to be' of a thing caused."\(^\text{17}\) Cause is further divided into material cause and formal cause, which are internal; and efficient cause and final cause which are external. The material cause is that from which a thing is made; the formal cause is that which determines the nature of the thing. The efficient cause is that by which the thing is produced; the final cause is that on account of which the thing is made.\(^\text{18}\) Each of these causes is a primary principle of a real being.

In a scientific application, the term cause does not have the range of its philosophical counterpart. For as the scientist\(^\text{19}\) has stated, the notion cause possesses importance only as a means of provisional knowledge or orientation. In any examination of an event, the scientist must regard phenomena as dependent on one another in the same way as the mathematician regards the sides and angles of a triangle as dependent on one another.\(^\text{19}\) Furthermore,

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\(^\text{17}\) Aquinas, \textit{In V Metaphys.} lect 1 (Cathala nos 751, 749) "nomen Causa importat influxam quamdam ad esse causati: Nam causa est ad quam de necessitate sequitur."


\(^\text{19}\) Ernst Mach, \textit{The Science of Mechanics}, p. 582. "The notion cause possesses significance only as a means of provisional knowledge or orientation. In any exact or profound investigation of an event, the inquirer must regard
in a more recent statement, Max Born concluded that causality postulates that there are laws by which the occurrence of entity B of a certain class depends on the occurrence of an entity A of another class. Causality as a concept, is synonymous with the term relationship where the relationship is timeless and spaceless.\(^{20}\)

In conformity with the different approaches to reality the philosopher uses the term cause in its most primary sense where it is a principle of the thing itself. While the scientist uses the term cause in a secondary sense where it deals with dependence or relationships between physical objects, phenomena, situations and events in so far as these relationships come within the scope of observation and measurement. The natural sciences in dealing with principles and causes are confined to the level of the secondary proximate principles and causes of classes of mobile being, while within philosophy the principle attention is focussed on the first principles and causes of mobile being.

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the phenomena as dependent on one another in the same way that the geometer regards the sides and angles of a triangle as dependent on one another.\(^{20}\)

Each of these terms which has been considered serves to emphasize the basic distinction between the approach of the natural sciences and the philosophy of nature. Each approach is primarily interested in reality and both arrive at a valid knowledge of nature to the degree which they penetrate it, and in harmony with the limitations imposed by their different formal objects. It should be noted that within the hierarchy of knowledge both the natural sciences and the philosophy of nature are restricted to the first degree of abstraction. The objects which they undertake to investigate cannot exist apart from matter nor be conceived apart from it. The very nature of this material object denies the possibility of ever completely penetrating to its inner nature or essence of corporeal substances.

Though it is true that the material object of philosophy and science can be the same, namely ens sensibile, the formal object which determines the specific nature of the intellectual disciplines, in the two instances, is essentially different. The scientist presents nature in terms of molecules, ions and other similar constructs within a framework of time and space. The philosopher, on the other hand, seeks for what, in fact, that matter is which is so figured; what, as a function of intelligible being, is the nature of corporeal substance. The approach of the philosophy of nature is a study of the intelligible aspects of corporeal substances. This is distinct from the scientific
approach which is a study of the observable and measurable aspects of corporeal substances.

The approach of the natural sciences is not completely unilateral because there are divisions within the sciences. Physico-mathematics provides a pertinent example of a scientia media or intermediary science which is halfway between mathematics and empirical natural science. The physically real forms the material object in regard to the measurement which it allows the scientist to draw from it and the formal object and conceptual procedure remains mathematical. It is a science which is materially physical since it has its end in sensible, and is formally mathematical.

Outside the realm of physics there are the biological sciences which study the spheres of life and organic wholes. Although this science resolves its concepts into sensible and observable being, it does not undertake the construction of a closed universe of the physico-mathematical type; and the form of deductive explication which it employs is not of the mathematical type. Biology also employs physico-chemical explications, which are geared to a mathematisation of the real, but it remains primarily a science without the universal mathematical explanatory deduction of physics.

There are two distinct and valid approaches to the study of sensible nature. The one, the philosophy of nature, approaches reality or ens mobile in an effort to seek out
its intelligible aspects, that is, it is emphasizes the ens of ens mobile. The other, the natural sciences, which are divided into the physical, the physico-mathematical, and the biological sciences, together with their inner sciences, approach reality or ens mobile in an effort to discover and correlate its observable and measurable aspects, that is, it emphasizes the mobile of ens mobile.
III

THE NATURE OF SCIENTIFIC KNOWLEDGE

The methods of science depend on basic postulates such as the principle of causality, and the law of the uniformity of nature. Science uses basic concepts in a way which is quite different from philosophy. In science causality does not function in its primary meaning as a principle of the thing itself, rather, it is considered in a secondary sense so that it deals with systems of relationships within the realm of the observable and the measurable. Accordingly, the physicist Max Born, in his evaluation of causality, concluded that causality, as a basic premise, postulates that there are laws by which the occurrence of an entity B of a certain class is dependent upon the occurrence of an entity A of another class. In this instance, an entity can be any physical object, situation, phenomenon, or event. A as the cause must be prior or at least simultaneous with the effect B. It is also postulated that cause A and effect B must be in spatial contact or connected by a chain of intermediate things in contact. The principle of the uniformity of nature as a

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1 Max Born, op. cit., p. 9.
primary premise of the natural sciences asserts that under certain conditions there is a uniformity in the activity of mobile beings. As a principle it does not infer that every action in nature is completely determined, but it does state that there is an order in nature to the degree that it can be successfully investigated, and the results tabulated either by statistics of functional relationships.

To obtain any given relationship the scientist employs a specific approach. Where necessary, the apparatus is assembled to reproduce a desired set of conditions and to measure the occurrences in a closed system. In those branches of the natural sciences where this is not possible, the initial part of the procedure is trained observation. In order to be successful, the observer must obtain a composite picture of the object under investigation; he must have an extensive knowledge of the previous research accomplished in this particular field. Only then can he be prepared to discover relationships between phenomena apparently quite remote from each other. These requirements

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2 For a further discussion of the principle of the uniformity of nature vide Dougherty, op. cit., pp. 162-166.

for trained observation also apply when direct observation is replaced by experimentation.

Wherever possible, experimentation is employed. The object of an experiment is to set up a controlled system where only one circumstance is allowed to vary at a time. The experimenter, if possible, also seeks to eliminate non-essential conditions of the phenomenon under investigation. If more than one circumstance is varied at the same time, it is impossible to determine which condition creates the effect, or when no effect ensues, if any of the participating circumstances is completely indifferent. Therefore, in the first part of the scientific procedure the investigator aims at the determination of certain relationships either through observation alone or experimentation. These relationships, if they are verified by a number of repeated experiments or observations of the same nature, provide the material for the next step, which is the interpretation of these relationships. They form the basis for a type of reasoning known as scientific induction.

\[4 \text{ Ibid.}\]
Scientific induction is but one division of induction. In its widest extension, as P. Coffey has pointed out, it also includes the attainment of necessary self-evident principles through abstraction, intuition, and generalization. Therefore, induction is any process of reasoning which moves from the plane of the concrete singular to the plane of ideas, the plane of the universal. When parts in question are the singular data of sense experience, as they usually are within the natural sciences, it is impossible to enumerate them completely since the human mind cannot pass in review all of individual cases. Therefore, induction, as employed within the natural sciences, is incomplete induction, induction by incomplete enumeration.

W.R. Thompson in his book, Science and Common Sense, has provided an illustration of the function and characteristics of scientific induction by applying it to a classi-

5 P. Coffey, The Science of Logic (London: Longmans Green and Co., 1912), 11, 25. Now this simple process of abstraction, intuition, and generalization by which we attain to a knowledge of self necessary principles, through the notions which we abstract from sense experience, is sometimes called induction. But this is using the word in such a wide sense as to make it embrace every mental process by which we ascend from or through the particular to the universal.
fication of the House-fly. Repeated observations disclosed that the House-fly possesses two wings and only two wings as a constant attribute, therefore, the House-fly belongs to a two-winged species. It also has a complex collection of anatomical features which characterize it as a member of the family of Muscid flies. Further observations of flies of this type reveals that, although they differ somewhat, they all have two wings. In general it can be concluded that Muscid have two wings, or that the Muscid is a two-winged type. Furthermore, Thompson indicated that this example is an ascending induction, the movement from the particular to the general, and that it is possible to reverse the process in a descending induction, the movement from the general to the particular. This is the example given for a descending induction. "The Muscid is a two-winged. Now the Blow-fly, the Green-bottle, and the House-fly are all Muscids. Therefore, the Green-bottle is a two-winged insect."

In the same discussion, Thompson also reached certain conclusions about the characteristics of the inductive


7 Ibid., p. 32.
process as an instrument within the natural sciences. It is an ascension from particular cases to the concept of a nature common to them, which expresses itself in every individual. Accordingly, the truth attained does not pertain merely to a collection of individuals but has a general value. As an argument or proof, the inductive conclusion, in most instances, cannot lead to complete certainty, since it depends on an insufficient enumeration of cases. Although the inductive process gains a knowledge about the nature of things, it does not gain absolute certainty because there is no guarantee that the constancy of the properties observed is an essential feature of material things. Inductive science, though often unconscious of its limitations, can only reach conclusions which are more or less probable. On occasion, the probability in favour of a generalization is

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3 Ibid., pp. 31-32. "In the inductive process we thus pass from the enumeration of particular cases to the idea of the nature common to them which will express itself in every individual; so that the truth reached applies not merely to the collection of individuals but has a general value. On the other hand, the value of the inductive conclusion depends on a sufficient enumeration of cases and thus, considered as an argument or proof, cannot, ordinarily at least, lead to complete certainty.

Thus, while the inductive process gives us definitely more than knowledge of a mere collectivity and really tells us something about the nature of a thing, it does not enable us to attain absolute certainty. We cannot always be sure that the constancy of properties we observe in the material which we can examine is an essential feature, and this is because the inductive process does not really lay the nature of things open to us, or enable us to discern their inherent necessities."
enormous, but absolute certainty is never reached.

The facts obtained through observation and experimentation, although of fundamental import, do not constitute a science until they have been classified and correlated through scientific induction. The function of a scientist rests upon the interpretation of results in order to discover a law. Within the natural sciences a law is sometimes defined as, "A common mode of action of material things". The laws which are formulated have as their test the capability of experimental verification within the limits of calculated error. If a law is verified within the limits of experimental error, it is an exact law; and if the deviation is somewhat greater than that inherent in the experiment, it is an approximate law.

The element of probability which is a characteristic of scientific induction also manifests itself in the scientific law. Scientific laws are such are not statements of absolute certitude, nor are they totally contingent. The reason for the element of stability in a scientific law is, as M. Maritain has indicated, the fact that it does nothing but explain or express in a more or less direct, or more or less distorted manner the properties or exigencies of a certain ontological indivisible. This ontological indivisible which is not within the observable remains an x an

9 Richardson and Scarlett, op. cit., p. 10.
indispensable x for the natural sciences. This x is none
other than what philosophy designates by the same essence,
or nature. Although scientific laws seek to express the
essences and natures of things, it must be clearly under­
stood, as M. Maritain has pointed out, that the natural
sciences do not penetrate to these essences in their in­
telligible constitution. Even the question of knowing
whether the provisional and unstable categories which the
scientists construct, and upon which they toil, correspond
exactly to these essences, remains in doubt. Nevertheless,
the raison d'être for the necessity of the stable relations
among the elements chosen by the scientists from phenomena,
formulated by the scientists, and upon which they build,
resides exactly in these presupposed ontological non-observ­
vables. The necessity of these laws is founded on the fact
that they are concerned with the observable manifestations
of the essences or natures, and that these essences or natures
are the foundation of intelligible necessities.

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10 Maritain, Les Degrés Du Savoir, p. 50. "Remar­
quons que la loi scientifique ne fait jamais qu'exprimer (de
façon plus ou moins directe ou plus moins détournée) la pro­
priété ou l'exigence d'un certain indivisible ontologique
qui par lui-même ne tombe sous les sens (n'est pas observable)
et reste pour les sciences de la nature un x (d'ailleurs in­
dispensable), et qui n'est autre que ce que les philosophes
designent sous le nom de nature ou essence."

11 Ibid., p. 51. "Les sciences expérimentales ne
pénètrent pas ces essences dans leur constitution intelli­
gible et même la question de savoir si les catégories plus
ou moins provisoires et instables qu'elles construisent et
A scientific law is a statement of the relationship discovered among certain phenomena through observation and experimentation. As a law it can reach a high degree of probability but never absolute certitude, since it is based on incomplete induction. The possibility always exists that the investigator may discover an exception which would require a modification of the law. This poses one of the major limits of a scientific law, and the material sciences. The stability and power of a scientific law lies in the fact that it is concerned with the observable manifestations of essences of things. In this respect the necessity of a scientific law is founded on the fact that it seeks to express and describe, however poorly, the properties of the natures of things as they manifest themselves within the realm of the observable and measurable. Therefore, a scientific law is a composite of the necessary and the contingent, where the contingent must always be prepared to submit to modifications introduced by new discoveries gained through the dialectic of science. In the course of this dialectic, the necessary factors of an old law, if its basic premises

sur lesquelles elles opèrent leur travail rationnel leur correspondent exactement, reste le plus souvent douteuse. C'est bien cependant dans ces non-observables ontologiques présupposées que reside la raison d'être de la nécessité des relations stable formulées par le science entre les éléments que l'esprit choisit dans les phénomènes, ou qu'il construit sur leur fondement. La nécessité des lois vient de ce que celles-ci concernent proprement et en fin de compte les essences ou natures, et de ce que les essences ou natures sont le lieu des nécessités intelligibles.
are correct, always find a place in the new law which
supersedes it.

The natural sciences are never content with the
knowledge of facts and laws alone. They seek a further
explanation which is a hypothesis, a definitely reasoned
explanation of the facts and laws which have been accumu­
lated by scientific research. The characteristics of a
scientific hypothesis are such, as Coffey has indicated,
that it must be based on accurate and unbiased observation
of facts; it must be constructed in order to explain them;
and therefore, must have for its object a real cause. It
must be self-consistent and must be free from conflict
with established truths and laws since truth cannot oppose
truth. In this instance, caution is needed to assure a
real conflict which cannot be eliminated by any possible
restatement of a proposed hypothesis. The hypothesis
must be based on some analogy with known causes; be capable
of exact deductive inference; and must be verifiable by
the submission of these inferences to the control of ob­
servation and experimentation. When a hypothesis presents
not only a sufficient explanation, but the only possible
explanation of the facts it purports to account for, it is
verified or established\(^\text{12}\).

\(^{12}\) Coffey, *op. cit.*, II, 121.
The conditions necessary for the proper development of a scientific hypothesis also apply to a scientific theory, inasmuch as a scientific theory is usually defined as "a hypothesis which has been applied to an extensive series of related facts and has been found satisfactory in its explanation of those facts"\(^{13}\). It is important to the complete understanding of the nature of a scientific theory to comprehend, as E.F. Caldin has indicated, that a scientific theory, as a working hypothesis, is not a strict deduction, but a construction based on empirical laws.

A scientific theory is not deducible by formal logic from the empirical laws that support it. The argument is not of the deductively correct type, 'p implies q' (in other words, 'q is deducible from p'), but p is likely on the evidence, therefore, q is likely - where p stands for an empirical law or set of laws, and q for a unifying theory. It is rather a sort of inverted form of this argument: "q (a unifying theory) implies p, r, s; but p, r, and s are empirical generalizations that are likely on the evidence; therefore, q is likely. The conclusion does not follow from the premise; the likelihood of the theory is therefore not a deduction from the empirical laws that are taken to support it. How then is a theory valid? The answer is parallel to that which we give for empirical generalization. Scientific theories

\(^{13}\) Richardson and Scarlett, op. cit., p. 11.
are not deductions but interpretations (as indeed they are commonly called in science); these interpretations claim validity in as much as we are justified in regarding empirical laws as signs pointing to the unified scheme or picture presented by a theory. The justification of the belief that empirical laws are signs of a more fundamental order requires at least the assumption that there is order in nature.

Therefore, a scientific theory, together with the other generalizations of the natural sciences, relies for its justification on the primary postulate that there is uniformity in nature.

Within the framework of the natural sciences it might appear that certain theories, such as the complex theories of physico-mathematics, are completely divorced from reality. However, this is not the case. As M. Maritain has carefully pointed out, physics is based on the ontologically real and is preoccupied with causes; but in the instance of physico-mathematics, it only envisages these physical causes from the angle of mathematics. It retains the real only in its measurable bearing as recorded by instruments; and it is through these measurements which are real, that the entities of this science have a foundation

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In reality; but it is in the measurable that mathematical physics resolves all its concepts, which alone have meaning for it. Once attained, these measurements are joined by mathematical relationships, deductive in form, which need to be completed by a certain hypothetical construction of the physically real, wherein it is only asked that their ultimate numerical results should coincide with the measurements of things gained by the instruments utilized. In this way mathematical theories co-ordinate the physical laws discovered by experimentation through the utilization of mathematics.

Just as in all science, mathematical physics and its theories seek the truth, but in the following sense. As M. Maritain has indicated, a physico-mathematical theory is considered "true" when the comprehensive and correlated system, and the arrangement of mathematical symbols and

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15 Maritain, Les Degrés Du Savoir, pp.121-122. "La physique s'appuie sur la réalité ontologique, elle est pré-occupée des causes... Mais cette réalité ontologique, ces causes physiques, elle les envisage exclusivement sous l'angle mathématique... Du réal, elle ne retient que son comportement mesurable, les mesures prises sur lui par nos instruments, - et ces mesures, c'est bien quelque chose de réal, c'est grâce à elles que les entités et les symbols de la physico-mathématique sont fondés dans la réalité. Mais c'est dans le measurable qu'elle résout tous ses concepts, le measurable seul a un sens pour elle. Et une fois en possession de ses mesures, elle vise essentiellement à tisser entre elles un reseau de relations mathématiques à forme deductive... Qui sans doute, devront, se compléter par une certaine reconstruction hypothétique du réal physique, mais aux-quelles il est seulement demandé que leurs ultimes resultats numeriques avec les mesures effectuées sur le choses par nos instruments."
explicative entities which it can organize, coincides in all its numerical conclusions with real measurements effected by an investigator. It is not in the least necessary that each of the symbols and the mathematical beings in question should precisely correspond with any physical reality, a certain nature or ontological law in the world of bodies. With certain modifications, the requirements for a physico-mathematical theory to be true, applies to all scientific theories.

Thus, a scientific theory is a definitely reasoned explanation of facts accumulated by investigation which has been applied to an extensive series of facts which are related and has been found satisfactory in its explanation of those facts. It is not deducible by formal logic from the empirical laws that underlie it; rather, it is an interpretation of the empirical laws which support it. A scientific theory is developed by a standard procedure and its validity is tested by experiments deduced from it. As a theory it can reach a high degree of probability but never absolute

16 Ibid., pp. 122-123. "Une théorie physico-mathématique sera dite "vraie" quand le système cohérent et le plus ample possible de symboles mathématiques et d'entités explicatives qu'elle aura organisé coïncidera par toutes ses conclusions numériques avec les mesures réellement effectuées par nous, sans qu'il soit nullement nécessaire qu'une réalité physique, une certaine nature ou loi ontologique dans le monde des corps, corresponde déterminément à chacun des symboles et des êtres mathématiques en question."
certitude since it is founded on empirical laws which themselves are based on incomplete induction. The possibility exists that further research may discover an exception which would require modification of the theory. This poses one of the major limitations of a scientific theory and consequently scientific knowledge. The stability and power of scientific theory is founded on the fact that it seeks to express and describe, however poorly and remotely, the properties of the nature of things as they manifest themselves within the realm of the observable and the measurable. Therefore, a scientific theory is a composite of the necessary and the contingent, where the contingent must be prepared to be submitted to the dialectic of science. In the course of this dialectic, the necessary factors of the old theory, if its basic premises are correct, always find a place in the new theory which supersedes it.

In the terms of a brief illustration, the earlier stages of the atomic theory provide an excellent example of the type of knowledge discovered by the application of the scientific method to the problem of change within the realm of the observable and the measurable. As Dr. Conant has pointed out, the idea that matter was composed of fundamental units, or ultimate particles goes back to the dawn of western thought. If expressed merely in general terms, the concept of fundamental units, as a speculative idea, can hardly be regarded as an integral part of the natural sciences until
it forms the basis of a working hypothesis from which deductions capable of experimental verification can be made. As a working hypothesis, the atomic theory became a new conceptual scheme only after Dalton had demonstrated how fruitful it was in connection with the quantitative chemical experimentation that had been developed by the chemical revolution.\(^{17}\)

In this instance, the rebirth of the atomic theory was no accident because certain experiments by Lavoisier and others cast grave doubts on the current theory of that time, the phlogiston theory. Historically, George Ernest Stahl (1660-1734) was the chief advocate of the phlogiston theory. A theory which considered that all metals were made up of calces — our metal oxides — and phlogiston, a combustible material. In the process of the combustion of metals it was assumed that phlogiston was expelled and that the calx remained. The smaller the residue of calx after combustion,

\[^{17}\text{James B. Conant, Science and Common Sense (New York: Yale University Press, 1951), p. 48. "The notion that there were fundamental units — ultimate particles — of which matter was composed goes back to ancient times. But expressed merely in general terms this is a speculative idea and can hardly be considered an integral part of the fabric of science until it becomes the basis of a working hypothesis on a grand scale from which deductions capable of experimental test can be made. This particular speculative idea or working hypothesis on a grand scale, became a new conceptual scheme only after Dalton had shown about 1800 how fruitful it was in connection with the quantitative chemical experimentation that had been initiated by the chemical revolution."} \]
the more phlogiston it contained. Consequently, in the light of this theory, carbon was considered as consisting entirely of phlogiston. If carbon was added to a metal calx, the calx would absorb phlogiston and become a metal again. The object of this theory was the systemization of the phenomena of oxidation and reduction which is so important in chemistry.

The basic premise upon which the phlogiston theory was constructed was the postulate that metals lose weight through combustion. Therefore with the enunciation and the experimental verification of the law of constant composition which stated that every chemical compound contains unvarying proportions of its constituents, and of the law of the conservation of mass which stated that in every chemical change the total mass of the reactants is exactly equal to the total mass of the products, the weakness of the phlogiston theory became apparent. More specifically, it was discovered that a metal gains weight in combustion and, therefore, the phlogiston theory was discarded because its basic premise had been disproven.

Subsequent to these developments, and after considerable experimental research, John Dalton developed the

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law of multiple proportions. This law stated that when any two elements A and B combine to form more than one compound, the weights of A that will combine with 1 g. of B are in the ratio of small whole numbers. For Dalton this justified a notion which he has always considered, and allowed him to elaborate his atomic theory. The basic premises of his thought becomes evident from these sections of his atomic theory.

There are three distinctions in the kinds of bodies, or three states which have more especially claimed the attention of philosophical chemists, namely, those which are marked by the terms elastic fluids, liquids, and solids. A very familiar instance is exhibited to us in water, of a body, which, in certain circumstances is capable of assuming all three states. In steam we recognize a perfectly elastic fluid, in water, a perfect liquid, and in ice a perfect solid. These observations have tacitly led to the conclusion which seems universally adopted, that all bodies of sensible magnitude, whether liquid or solid, are constituted of a vast number of extremely small particles or atoms of matter bound together by a force of attraction which is more or less powerful, according to the circumstances, and which as it endeavours to prevent their separation is very properly called in that view, attraction of cohesion; but as it collects them from a dispersed state (as from steam into water) it is called attraction of aggregation or more simply affinity. 19

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Dalton's outstanding achievement was the interpretation of the new chemical data and the new chemical laws through his atomic theory. He gave new impetus to the idea that change must be explained by means of small particles. His atoms did not have vague specifications but were endowed with those properties which the progress of chemistry demanded. In the light of this theory, the experimental sciences have progressed to determine other specific properties of the atom which has enabled them to enlarge upon and modify Dalton's atomic theory.

This brief outline of the development of Dalton's atomic theory serves to illustrate that the progress of the experimental sciences is bound up in a strict adherence to their principles. The first is the empirical principle which refers to the method of experimental sciences. It requires a strict adherence to the accepted methods and requires their proper application. The phlogiston theory serves as a real example of the consequences when the basic premises which underlie a theory are faulty. This principle also serves to limit scientific knowledge to the type gained through observation and experimentation; but in defining scientific knowledge as that gained and verified by the experimental method, it forms no conclusions about other methods employed by other intellectual disciplines.

The second basis for scientific knowledge is the quantitative principle which necessarily follows from the
first. The quantitative principle is a limiting principle which states that as long as science is true to its method, it must confine its studies to the observable and measurable aspects of reality, and, therefore, the knowledge gained is restricted to the observable and measurable within the realm of reality. The atomic theory, for example, illustrates that the scientific method begins and ends with the observable and measurable; the knowledge gained, therefore, is only concerned with the observable and measurable of reality. Again the quantitative principle does not speculate about the possibility of other aspects of reality which might be known in different ways since they fall outside the scope of scientific investigation.

The third principle, the mechanical principle, is concerned with the goal of every scientific inquiry. Science aims at gaining a knowledge of the general laws that govern the behaviour of events within the observable and measurable of reality. It is necessary to the stability of scientific knowledge that the laws which it enunciates happen in regular, repeated and invariable sequences. The atomic theory, in this instance, would be of no consequence were it not based on laws which reflected the uniformity of nature and causality. Therefore, the mechanical principle is a limiting principle which recognizes that scientific knowledge, because it is concerned with laws, is
restricted to the assimilation of that kind of behaviour which consists of natural cause and effect series. Again, just as its counterparts, the mechanical principle only acts within the lines of strict scientific investigation and does not reflect on any other acts such as chance which occur outside its sphere of application.

The fourth fundamental principle of science is the progressive principle, which deals with the natural dialectic of the experimental sciences. This principle affirms that scientific knowledge is constantly being revised. Every scientific theory is liable to constant modifications and revisions in the light of future experience. If any part of scientific knowledge is in error, it is rejected just as the phlogiston theory was rejected when it was found in error. Moreover, the knowledge of science is not only always expanding, but is normally available to all investigators so that every scientist stands on the shoulder of his predecessor. Again, this progressive principle contains no implications about progress on other levels of life; and in itself is no guarantee of human progress

These four principles present the characteristics and limitations of the natural sciences, and of scientific

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knowledge. Experimentation and the other steps of this procedure form the basic pattern for every scientific advance. This pattern is a constant in every scientific investigation, new or old; in one respect it forms the history of scientific knowledge because the unfolding of this method coupled with the ingenuity, the intuition, and the fallibility of the scientist marks the progress of the experimental sciences. The whole of scientific knowledge is constructed through its theories and laws upon the experimental, and so it also suffers from the incomplete enumeration of scientific induction. Therefore, scientific knowledge may reach a high degree of probability but never absolute certitude. The possibility always exists that new discoveries will require modifications within its structure. This poses one of the major limitations of scientific knowledge, and distinguishes it from the knowledge gained by other intellectual disciplines.

The stability and power of scientific knowledge is founded on the fact that it seeks to express the properties of the natures of things as they manifest themselves within the realm of the observable and measurable of reality. Scientific knowledge is a composite of the necessary and the contingent where the contingent must always be prepared to be submitted to the natural dialectic of the sciences. In the course of this dialectic, the necessary factors of scientific knowledge, if their basic premises are correct, always find a place in the new knowledge which modifies or supersedes it.
IV

ON THE NATURE OF THE PHILOSOPHY OF NATURE

Philosophy, since it is a study of reality, has in the course of the development of Western thought, sought the solution of many of the problems of sensible nature which have confronted it. Accordingly, the study of the problems of ens mobile has been prominent both in philosophy and in the sciences of phenomena. It is a fact of historical record that the many problems, which arose from the investigation of sensible reality, presented such a provoking challenge to thoughtful men, that the whole effort of the early Greek philosophers, such as Thales, Heraclitus, and Anaxagoras, was directed toward their solution. The investigations of these philosophers, their contemporaries, and their successors culminated in the major contributions of Aristotle and St. Thomas Aquinas.

With the decline of philosophical progress, and the discovery and immediate success of the experimental method, a new era was born. Philosophy, forgetful of its great heritage, also sought to continue its progress by adopting both the new experimental method, and the conclusions which the experimental sciences had discovered and formulated. The experimental method became for many the philosophical instrument for research and the scientific theories, its basic premises. Therefore, as a consequence, it would seem
that these philosophical systems which have scientific theories as their basic premises would face annihilation as complete systems as soon as the theories upon which they stand are superseded in the natural dialectic of scientific progress. In contrast to these systems, Thomism does not pretend to imitate the experimental method or to adopt any particular scientific theory as its foundation. In direct reference to the question of *ens mobile*, it cannot be over-emphasized that the principles and conclusions expressed by Thomism, through its philosophy of nature, are not the products of scientific experimentation.

Instead, Thomism tries to reach beyond phenomena, in order to grasp what the mind perceives to be most inward and fundamental in things. As M. Maritain has pointed out, the inmost core of things which philosophy seeks to discover is being, the being in sensible things which is first object attained by the intellect. And what is being? Being is what exists or can exist; it first and immediately presents to the intellect that it exists, or can exist outside the mind. It is sufficient to experience the absolute impossibility of the intellect's thinking of the principle of identity; what is, is, without positing (at least possible) extramental being, of which the principle of identity is the first of all axioms. This apprehension of being is absolutely primary and is implied in all other intellectual
Since philosophy has its foundation in being, rather than in the observable and measurable aspects of sensible phenomena, it is essentially distinct from the natural sciences. This difference is also reflected in the methods peculiar to each intellectual discipline. Just as the scientific method is directed to the discovery of the relationships among phenomena, so the philosophical approach is geared to the discovery and development of the laws and principles of being. The point of initiation for the philosophical method is being, as found in extramental reality. It is the real made known by the senses, and attained by physical contact with the universe. Philosophy rests upon facts which are well founded existential truths. These facts are not created by the human mind, but are given to the mind which discerns and judges them. Philosophy in its search for truth begins with experience.

Although philosophy begins with experience, it does

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1 Maritain, Les Degrés Du Savoir, pp. 183-184. "L'être, en effet (l'être enveloppé dans les choses sensibles) est le premier objet attaint par notre intelligence. Et qu'est-ce qui est signifié par ce nom d'être sinon ce qui existe ou peut exister; et qu'est-ce qui est d'abord et immédiatement présente par l'a l'intelligence sinon ce qui existe ou peut exister pour s'é... Il suffit a chacun de se consulter soi même et d'essayer d'exécuter en soi l'impossibilité absolue ou se trouve l'intelligence de penser le principe d'identité sans poser de l'être extramental (au moins possible) dont ce premier de tous les axioms exprime le comportement... Cette appréhension de l'être est absolument première et elle est impliquée dans toutes nos autres appréhensions intellectuelles."
not aim at a knowledge of the particular, but seeks to discover the necessary and universal principles which are contained in the inner core of reality. Therefore, the first major part of the philosophical method is the movement from the plane of the particular to the plane of the universal, and the formation of universal concepts. In his description of this initial step, M. Coffey has indicated that it is from sense observations of a few instances that these concepts are formed. These observations are necessary in order to get, for example, the notions of "whole" and "part" and "greater". Once these intellectual notions have been abstracted from sense experience and have been compared with one another, there is an immediate intellectual intuition of the necessary truth that "the whole is greater than its parts. It will be seen that this truth does apply to every whole, be it actual or possible, known or unknown. This truth is assented to, not because all the instances have been examined, but because the relation is perceived to universal because it is necessary. This process of abstraction, intuition, and generalization, by which a knowledge of self-evident necessary principles is attained through the notions which are abstracted from sense experience, is sometimes called induction. Here the term is used in its widest sense to denote every mental
process by which there is an ascension from or through the particular to the universal.

Thus, once the intellect grasps the notion of being, it perceives certain fundamental principles through abstraction, intuition, and generalisation. These principles are the principle of identity which states: what is, is; and the principle of non-contradiction which states: what is, cannot not be at the same time and in the same relation. These necessary and universal principles are the point of initiation for the next major part of the philosophical method which is the syllogism.

The syllogism is distinguished from other types of argumentation according to the manner in which it manifests the truth. M. Maritain has indicated that in a syllogism the mind begins with the first universal principles known immediately by the intelligence and joins these principles to a conclusion, or conversely, the mind can resolve a conclusion into these principles. Here the mind moves purely on the intelligible plane, and develops the truth of the propositions, in so far as it is contained

\[2\quad \text{Coffey, op. cit., II, 24.}\]
in the universal truth from which it has been drawn. In the terms of M. Maritain's example, the preceding is illustrated: "Everything that subsists immaterially is indestructible, but the human soul subsists immaterially; therefore the human soul is indestructible."

This is an example of a deductive argument or syllogism in which the S (human soul) and the Pr (indestructible) of the conclusion are united to each other by their common union to the middle term (that subsists immaterially). ³

More specifically, M. Maritain has defined a syllogism as, "an argumentation in which, from an antecedent that unites two terms to a third, a consequent is inferred uniting

³ Maritain, "L'Ordre Des Concepts", Elements De Philosophie, II, 196. "Notre esprit se peut a partir des premiers principes universels connus immediatement par l'intelligence, en reliant a ces principes une conclusion ou en la 'resolvant' en eux: il se peut alors purement sur le plan intelligible, et il manifeste la verite d'une proposition en tant qu'elle est continue dans une verite universelle dont elle derive.

Example: Tout ce qui subsiste immateriallement est indestructible; or l'ame humaine subsiste immateriellement donc l'ame humaine est indestructible.

C'est l'argumentation deductive ou le syllogisme dans lequel le S (l'ame humaine) et le Pr (indestructible) de la Conclusion sont unis entre eux de par leur union a troisieme terme appele moyen terme ("qui subsiste immatieriellement").
these two terms to each other. The two terms, as M. Maritain has indicated, that are united as S and Pr in the conclusion are called extremes. Since the Pr normally has a greater extension than the S, the Pr of the conclusion is called the Major Extreme or the Major Term (T), and the S of the conclusion, the Minor Extreme or the Minor Term (t). The term to which each of these two terms T and t is united in the antecedent, and which is the means or reason of their union in the conclusion, is called the Middle Term (M).

These three terms, T, t, and M, are remote matter of the syllogism. The two propositions composing the antecedent, each of which unites one of the extremes to the Middle Term, are called the Premises of the syllogism. The premise containing the Major Term (the term that becomes the Pr of the conclusion) is called the Major. The premise containing the Minor term (the term that becomes the S of the conclusion) is called the Minor. The Major, Minor, and Conclusion constitute the proximate matter of the syllogism.

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4 Ibid., p. 207. "Une argumentation dans laquelle d'un antécédent qui unit deux termes à un troisième, ou infére un conséquent qui unit ces deux termes entre eux."

5 Ibid., p. 208. "On appelle extrêmes les deux termes qui sont unis à titre de S et de Pr dans la Conclusion. Et comme le Pr a normalement une extension plus grande que le S, on est convenu d'appeler le Pr de la Conclusion Grande Extrême ou Grande Terme (T) et d'appeler le S de la Conclusion Petit Extrême ou Petit Terme (t). Le Terme auquel chacun de ces deux termes T et t est uni dans l'antécédent, et qui est moyen ou mison de leur union dans la Conclusion est appelé Moyen Terme (M). Ces trois termes T, t et M, sont la matière édifiée du Syllogism.
The syllogism, as a mode of reasoning, not only has its point of initiation with the principles of identity and non-contradiction, but also depends on these same principles for its strength and validity. For as M. Maritain has pointed out, the total force of the syllogism and the deductive art hinges upon this supreme self-evident principle which is: two things, identical with the same third thing are identical with each other; or, two things, one of which is identical, the other not identical with a same third thing, are different from each other. This principle, as the principle of triple identity in its positive form, and the principle of the separating third in its negative form, is but a particular expression of the principle of identity, or of the principle of contradiction. But the first principle of syllogism may be applied to those reasonings which have for their matter abstract and universal concepts only through two other equally basic principles, which deal with the relation of the universal concept with its subjective parts. Accordingly, this principle states: that which is universally affirmed of a subject, is affirmed of everything contained under that subject; or that which is universally denied of

Les deux Propositions qui composent l'antécédent, et dont chacune unit l'un des extrêmes au Moyen Termme sont appelées les Prémises du Syllogisme. Celle qui contient le Grande Terme (c'est-à-dire le terme qui sera le Pr de la Conclusion) est appelé Majeure. Celle qui contient le Petit Termme (c'est à dire la terme qui sera le S de la Conclusion) est appelé Mineure. Majeure, Mineure et Conclusion constituent le matiere prochaine de Syllogism.
a subject, is denied of everything contained under that subject. These principles are self-evident since it is the nature of the universal to be one and the same in all those things in respect of which it is universal\textsuperscript{6}. The syllogism, as a process of reasoning, is governed by certain definite limits which, if adhered to, allow the development and discovery of certain universal truths. These truths are derived from necessary principles gained from experience through abstraction, intuition, and generalization, and are as certain as the principles upon which they rest. Herein lies one of the major reasons for the power and range of philosophy.

\textsuperscript{6} \textit{Ibid.}, pp. 215-217. "Toute la vertu du Syllogisme et de l'art deduire depend de ce principe suprême évident par lui-même: Deux chose identiques a une meme troisième sont identiques entre elles; et deux choses dont l'une est identique et l'autre non identique a une meme troisième sont diverses entre elles.

Ce principe qu'on pourrait appeler "principe de la triple identité" dans sa forme positive, et "principe du tiers séparant" dans sa forme négative, n'est qu'une expression particulière du principe d'identité, ... ou de contradiction .... Mais le principe du Syllogisme ne peut s'appliquer à nos raisonnement - qui ont pour matière des concepts, abstraits et universels, - que moyennant deux autres principes également suprêmes, qui concernent le rapport du concept universel, avec ses parties subjectives et qu'on ne saurait meconnaître sans détruire le Syllogisme.

\textit{Tout ce qui est affirme d'un sujet universellement est affirme de tout ce qui est contenu sous ce sujet... ou tout ce qui est universellement nié d'un sujet, est nié aussi de tout ce qui est contenu sous ce sujet... Ces deux principes sont connus de soi ou évidents par eux-mêmes, puisque la nature de l'universel consiste précisément en ce qu'il se trouve un et le même en toutes les choses à l'égard desquelles il est universel.}"
Within the structure of philosophy, there are certain definite divisions which lend order to this science, and exercise certain limitations on each of its parts. This division is the three degrees of abstraction, which correspond to the degree of immateriality of the object under study, and permit the classification of the generic types of knowledge. Within the first degree, which is the recognized field of research for physics and the philosophy of nature, the mind abstracts from singular and individual matter only. The object which the mind presents to itself can neither exist, nor be conceived apart from or without sensible matter. The object studied is ens mobile, being as subject to change. Within the second degree, which is the field of mathematics, the mind abstracts from sensible matter, and the object considered is quantity, which cannot exist apart from matter, but can be conceived apart from it. Finally, within the third degree of abstraction, which is the field of metaphysics, the mind abstracts from all matter, and the object grasped is being as being, which cannot only exist without matter, but can also be conceived without it. In each instance, the means for philosophical research is governed by the range and limitations of the particular

7 This brief outline of the three degrees of abstraction is a summary of a more complete exegesis found in Maritain, La Philosophie De La Nature, pp. 12-14.
degree of abstraction within which it is employed, and results, in each case, in a type of knowledge with certain definite characteristics.

The degree of abstraction determines the characteristics of the type of knowledge gained from ens mobile. For as Maritain has indicated, the philosophy of nature resolves its concepts from intelligible being. This knowledge is the product of a type of ontological explication open to the speculative intellect. It is not connected with empiric conditions, but with reasons of being and primary causes; and tries to discover the nature of things. The philosophy of nature relies on experience much more closely than does metaphysics, and must be prepared and able to submit its judgments to the verification of the senses; but it is a deductive apprehension which assigns reasons and intelligible necessities in the degree to which it is assured of the intrinsic constituents or the essence of its object. The philosophy of nature is able to gain a knowledge

8 Maritain, Les Degres Du Savoir, p. 345. "C'est dans l'être intelligible lui-même, si obombre qu'il soit par la matière sensible, qu'un tel savoir resout ses concept, ils ressortit à un type d'explication ontologique ouvert au mouvement naturel de l'intelligence speculative. Ce n'est pas aux conditions empiriques, c'est aux raisons d'être et aux causes proprement dites qu'il s'attache; c'est les essence des choses qu'ilveur découvrir ... Il depend de l'experience d'une façon plus contraignante que la métaphysique et doit pouvoir amener ses jugements jusqu'à la verification du sens, mais c'est un savoir deductif, assignent les raisons et les nécessités intelligibles dans la mesure où il s'est assuré du constitutif intrinsèque ou de la quiddité de ses objets."
of the intelligible aspects of sensible reality which is specifically distinct from the knowledge gained by the natural sciences. The scientist seeks to investigate ens mobile from the point of view of its observational and measurable characteristics, and he arrives at descriptive knowledge such as the atomic theory. The philosopher seeks to investigate ens mobile from the point of view of its intelligible aspects and arrives at essential knowledge such as the hylomorphic theory.

When a philosopher begins a study of the problem of change, in corporeal beings, he is confronted with certain difficulties. The first is the problem of the primary constitutive principles of ens mobile, a problem arising chiefly from the difficulty of reconciling being as stable and determinate, with being as dynamic and indeterminate. From observation, it can be seen that corporeal beings have inertia and activity, extension and indivisibility; and permanence and flux. The question then arises as to what the intrinsic causes are, that can account for these opposite properties in ens mobile. The philosophical atomists state that corporeal beings are essentially inert, and they chose to ignore the intrinsic activity of corporeal beings. The philosophical dynamists on the other hand, choose to ignore the inherent passivity of mobile beings, and state that corporeal beings are essentially active. The integral position of the Aristotelian-Thomist explanation recognizes that corporeal beings
are both active and passive.

Accordingly, as M. Maritain has enumerated, Aristotelian philosophy recognizes two substantial principles in corporeal substances. The one is prime matter of which things are made, which in itself is nothing actual; it is a principle wholly indeterminate, incapable of separate existence, but capable of existing in conjunction with something else, which is the form. The form is an active principle of corporeal substance which determines the purely passive first matter\(^9\). This doctrine which regards a body as a compound of prime matter and substantial form is known as hylomorphism.

Furthermore, the hylomorphic theory states that a corporeal substance compounded of prime matter and substantial form is a real substantial unity endowed with active and passive powers, through which, by a tendency which is inherent, it seeks to develop its own perfection. It explains the opposite characteristics of \emph{ens mobile} by two principles

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\textit{Maritain, "Introduction Générale à La Philosophie", Elements De Philosophie, I - 117. "La philosophie d'Aristotle reconnait dans la substance corporelle deux principes substantiels: (1) la matière (matière première)...im pur "avec quoi" les choses sont faites et qui par soi-même n'est rien de fait, un principe absolument indéterminé, incapable d'exister par lui-même, mais capable d'exister par autre chose (par "la forme"). (2) un principe actif, qui est comme l'idée vivante de la chose, ou comme son âme et qui determinant cette matière première purement passive.}\end{flushright}
which are incomplete and cannot exist separately. It takes into account both the dynamic and static properties of ens mobile, and provides the means for the development of a philosophical solution for many of the problems of sensible reality. Such a problem is substantial change.

Before this problem can be resolved into the primary terms of hylomorphism, it is first necessary to distinguish the various kinds of change. Change is divided into four species; substantial change or mutation which is the transition from one being to another; qualitative change which is alteration; change in quantity which is either augmentation or diminution; and change in place which is latio or local motion. Substantial change or mutatio is divided into generatio and corruptio; "generatio est mutatio de mon subjecto in subjectum;" and, "corruptio est mutatio de subjecto in non subjectum." It is the 'coming-into-being' of what did not exist, and the reverse passage in non-being. Therefore, substantial change is the transition of one being into another.

Through the development and application of the primary principles of corporeal substance, which are prime matter and substantial form, and the accidental principle of mutation which is privation, the philosopher is able to give

10 Thomas Aquinas, Quaestiones Disputatae De Veritate, Q. 28, 1c (Taurini Italia: Marietti, 1931), IV-302.
an explanation for substantial change. Prime matter and substantial form are real and necessary principles of being in change, not ideal suppositions or mental constructs.

The first requirement for substantial change is a subject. The common subject is prime matter which is pure potency. As St. Thomas has stated, "omne quod generatur, generatur ex aliquo, ut intellegitur id ex quo est generatio non privatio sed materia."11 Prime matter is the common foundation that remains throughout the change. Substantial change is transmutation rather than creation and total annihilation.

The next requirement for substantial change is the term of generation which is the substantial form. It is the principle of determination and the first act of prime matter. Just as in the case of prime matter, when mutation occurs the substantial form does not suffer from generation or corruption. For, as St. Thomas has said, "formae enim proprie non fiunt, sed educuntur de potentia materiae".12 Thus, in substantial change, when a form is acquired, it is educed from the potency of the matter, and when a form is lost, it reverts to the potency of the matter to reappear anew whenever external conditions conspire to cause its

11 Aquinas, In VII Metaphys, lect. 1 (Cathala no. 761).
12 Ibid., lect. 7, (Cathala no. 1423).
reappearance.

Substantial change, presupposes in the subject which passes to a new substantial act a capacity to this rather than to another form, and also supposes in the subject a lack of such suitable form. The principle which signifies this lack is privation, which is an accidental principle of substantial change. As St. Thomas has said, "materia enim sub una forma existens habet in se privationem alterius formae", where "privato non significat aliquam naturam in subjecto sed praesupposit subjectum cum aptitudine." Privation indicates that prime matter is disposed to certain perfections when the perfection is acquired privation disappears. It is not the pure negation of form but the negation of substantial form in a suitable subject and so is a real principle. When generation is completed, privation ceases.

Therefore, every substantial change in the universe of mobile being requires something that remains through the change. This is prime matter. Otherwise there would be a constant annihilation and creation. It requires something new, substantially new, to which it tends while the old form disappears, or it would not be substantial change. It also requires the privation of a new form in a suitable

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13 Aquinas, *In XII Metaphys.* lect. 4 (Cathala no. 2470).
14 Aquinas, *In X Metaphys.* lect. 6 (Cathala no. 2051).
subject, otherwise there would not be sufficient reason for the appearance of a new form. The corruption of one form is the generation of another, and conversely the generation of one form is the corruption of another.

The preceding examination of substantial change serves to illustrate that the operational technique of philosophy, or in this instance the philosophy of nature, provides the means for the discovery of a real knowledge of the intelligible aspects of sensible reality. The philosopher begins his study with the facts of ordinary experience. Once he has grasped being, and apprehended certain necessary principles, he is able to expand his investigation through deductive argumentation. Then, if the laws of logic have been adhered to rigorously, the truths which he has discovered are as certain as the necessary and universal principles from which they have been derived, so that, as in the case of the hylomorphic theory, he arrives at a certain knowledge of things in their causes. Herein lies the power of philosophy.

The philosophy of nature cannot penetrate the diversities and specific particularities of the world of bodies. Within the first degree of abstraction, which is the legitimate orbit of the philosophy of nature, the essences of sensible things are hidden, and corporeal substances are rendered opaque, because of the element of resistance to intelligibility which belongs to matter. It is indeed
possible to reach certain essential and specific determi-
nations concerning man, but below man, the essences remain
hidden as to their specific natures. True philosophical
certitudes are reached only in the distinction between
very widely extended spheres such as matter and form, or
living and non-living beings.
CONCLUSION

Our study has revealed a clear-cut division between those who recognize a distinction between the philosophy of nature and the natural sciences, and those who do not. The one group, made up of the pragmatists, the naturalists, the dialectal materialists and their adherents, fail to recognize the unique nature of traditional philosophy, and reject it as an invalid product of an obsolete method. They maintain that real knowledge is achieved by the experimental method alone. Within this group the need for philosophical speculation is resolved through the construction of systems which have their foundations resting upon the most recent accepted scientific doctrines. The other group, made up of Maritain, Caldic, Owen, Thompson, and others, who follow in the tradition of Aristotle and Thomas Aquinas, recognizes the value and purpose of traditional philosophy, the value and accomplishments of the experimental sciences, and the incomplete picture of reality offered by either science or philosophy when alone. They seek to unify the picture of reality and to restore order to the field of knowledge.

One of the fundamental tenets to which the various materialistic positions are anchored, is the premise that it is impossible to probe reality to the point where the
nature of things can be laid open to the mind. Real knowledge is limited to phenomena and to the methods of the natural sciences. This limited concept of knowledge provides the major argument of this group against traditional philosophy. In contrast to this position, the advocates of Thomism maintain that it is indeed possible to gain a knowledge of reality by a means quite distinct from the experimental method. The crux of the Thomistic position is that there are two distinct and valid approaches to sensible reality, namely the approach of the philosophy of nature, and that of the natural sciences.

For Thomists, the philosophy of nature has its point of initiation in the terms of observable data, but the mind in its consideration of these, seeks for their inward nature and intelligible reasons; it seeks to know what things are in themselves. The natural sciences, on the other hand, never seek the ontological for itself, and so, the resolution of concepts is made in an infra-philosophic direction. What things are in themselves is not the point of interest; what is important are the possibilities of empiric proof and mensuration and the connecting together of the empirical data according to certain stable laws. Though the material object of the philosophy of nature and the natural sciences is the same, namely ens mobile, the formal object which determines the specific nature of these intellectual disciplines is different. The scientist studies the laws of
phenomena, linking one observed instance to another, and if he seeks the structure of matter, it is by representing it to himself in terms of molecules, ions, and other similar constructs, within a framework of time and space. The philosopher, on the other hand, seeks for what in fact matter is, what the nature of corporeal substance is as a function of intelligible being.

In his search for knowledge, the scientist moves from the visible to the visible, from the observable to the observable. The philosopher proceeds from the visible to the invisible; to what in itself is outside the bounds of all sensory observation. The principles which are the aim of the philosopher are pure objects of intellection, not of sensible apprehension, or imaginative representation. Therefore, there are two distinct valid approaches to the study of sensible nature. The one, the philosophy of nature, studies sensible reality in an effort to seek out its intelligible aspects, that is, it emphasizes the ens of ens mobile. The other, the natural sciences, approach reality in an effort to discover and correlate its observable and measurable aspects, that is, it emphasizes the mobile of ens mobile.

Although the materialists deny the validity of the philosophy of nature just as firmly as the Thomists affirm it, there is no open dispute between these groups when it is a question of the technique of the natural sciences.
When the focal point of the problem shifts from the purely technical aspects of the experimental sciences to the nature and limitations of scientific knowledge, the conflict arises again. On the one side, the major materialists are convinced that the experimental procedure provides the only means for analyzing all the problems which confront humanity; and that the knowledge gained in this manner, alone is accepted as valid and true. On the other side, the Thomists together with many major men of science, such as Conant, Caldin, Owen, and Thompson, stand convinced that the experimental method cannot come to basic conclusions in regard to reality.

Although the advocates of the diverse kinds of materialism have completely overruled traditional philosophy as defunct and obsolete, they have been unable to obliterate the pressing need for philosophical speculation. As a consequence, they have been forced to search in science for principles to serve as foundations for their various scientific constructs. In doing this they failed to recognize that the success of science is due to its careful observation of the limits expressed by its principles. In its legitimate operation, it confines itself to the quantitative and mechanical, and does not presume to speak about spiritual values and freedom; it understands that there are vast areas that are beyond its scope. Since this group was awed by the accomplishments and prestige of science and worshipped it.
as omniscient and omnipotent and the bearer of man’s salvation, they adopted an attitude toward science which was strictly unscientific. To distinguish it from science proper it has been termed scientolatry or scientism. Since the limitations of the natural sciences are ignored, this peculiarly modern form of idolatry claims the working principles of science can be used as universal principles in terms of which the whole of reality can be explained and controlled.

Since Thomistic philosophy recognizes the distinction between philosophy and the natural sciences, it seeks to restore order to human thought by applying each to its proper part of reality. The proper techniques of the experimental procedure are admitted and applied to the quantitative and mechanical aspects of reality. But philosophy, not science, is admitted as the proper means for the discovery of those principles which enable the intellect to transcend the sensory order, and to deduce truths which pertain to the basic principles of being. Philosophy provides the certitude required for discovery and understanding of those fundamentals of existence such as spirituality and freedom. For, if the laws of logic are adhered to rigorously, the truths discovered are as certain as the necessary and universal principles from which they have been derived. An acceptance of the philosophy of nature opens the way for the formation of a real knowledge of the material world beyond the scope of the experimental method.
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