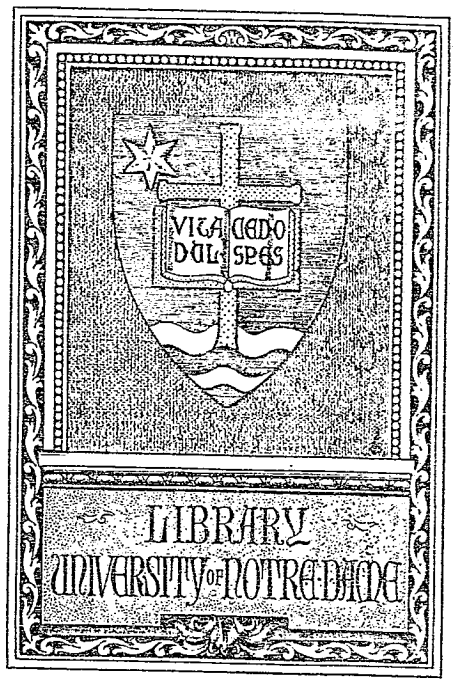

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NATURAL SCIENCE AS PHILOSOPHY

QUEBEC
1959

Omnium enim quae ratione cognosci possunt, necesse est aliquam doctrinam tradi ad perfectionem humanae sapientiae quae philosophia vocatur.

(In Pol., Proemium)

Nam et apud philosophos Prima Philosophia utitur omnium scientiarum documentis ad suum propositum ostendendum.

(Contra Gentiles, II, c. 4)

NATURAL SCIENCE AS PHILOSOPHY *

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Until I walked into this room, I did not know where I was being take
nor why. It is all Father Belleperche's doing. Now he challenges me t
come up and tell you what I think of Dr. Adler's televised talk which w
have just heard — I for the first time. I am therefore quite unprepared
but I suppose I will have to offer you some comments just the same
if only to comply with Father Belleperche's importunate request. While
watching this film from the back row, I imprudently voiced my occasiona
disagreement to my neighbour, and the expression of this disagreement
turns out to be the very object he had in view. I am now called upon to
unfold myself in public. There is no real need to take this second step,
but it happens to be the thing that Father Belleperche wants. I take no

* — These pages are the transcript of a tape-recording. The occasion was not merely informal, but unexpected, and the result, like most impromptu speaking, is disorderly and repetitious. The circumstances are as follows. Early in January I was visiting in Detroit, when the Reverend R.J. Belleperche, S.J., of the local university, induced me, after some argument, to join an intimate gathering of friends in Windsor, just across the river. The intimate group turned out to be the professors and student body of Holy Redeemer College, who were all quite unknown to me. In fact the whole thing had been planned. My companion was carrying with him the film of a televised talk by Dr. Mortimer Adler on *The Difference between Philosophy and Science*. Both the opinions of Dr. Adler on this subject and the fact that he had given a televised conference on them were as new to me as everything else in the affair. When the projection was over, my Jesuit friend called me to the podium. I did not know at the time that my rambling remarks were being recorded, which was all to the good. I neither speak nor write well, let alone do both at once.

pleasure in opposing my friend Mortimer — he is indeed an old friend— *sed magis amica veritas*, as he himself would agree.

* * *

To begin, I might call your attention to what has been stated here regarding the nature of science, philosophy, and theology. The things Dr. Adler has said differ widely and openly from what Aristotle held on the subject — not to mention St. Thomas. Whichever position you may prefer, it seems right to make plain the mind of these Masters on some of the points under discussion.

Take notice first of all of the initial paragraph on page one of the outline we have in hand. What about this difference between philosophy and science? Do they differ in the way we have just heard? The problem and its proposed solution are perhaps not that simple. Can we have a philosophy that is not science? Conversely, is every science philosophical? The common opinion among Thomists today is that philosophy and science are quite distinct. Dr. Adler asserts that 'philosophy and science are independent branches of knowledge, each with its own object and its own method.' He adds that 'No one complains that an engineer cannot build an airplane. Similarly, no scientist should complain that philosophers cannot solve scientific problems; nor should philosophers complain that scientists cannot solve philosophical problems.' I cannot go along with this parallel. Surely the philosopher wants to know about the elemental structures of nature, about the circulation of the blood, for instance. (And by elements I do not mean the principles of mobile being as such, which are called elements only by analogy.) The problem is in fact far more involved. It is the philosophical spirit that sends one in quest of physiochemical, botanical, physiological, anatomical knowledge. No one will contest that such knowledge helps to solve problems in medicine and agriculture. And to these practical sciences and arts, advanced engineering has become essential too.

Our Masters distinguished various kinds of science, but all as more or less parts of philosophy. A science was either practical or speculative; natural or rational, i.e. logical. If we take *philosophia naturalis* as St. Thomas does in his commentary on the *Ethics* (lect. 1), the expression applies

to mathematics, philosophy of nature, and metaphysics, all of which are radically distinct by their modes of defining. Mathematics are actually two separate and irreducible sciences: geometry and arithmetic. Besides, the ancients distinguished, apropos of mathematics, the sciences from the art of calculation — an art common to both geometry and number theory (a technique which later developed into algebra and calculus), providing them with that kind of unity, quite extrinsic in a way, that is made so much of nowadays, as one sees in the geometrizing of number and in the arithmetizing of continuity. As to the philosophy of nature, it was thought to move gradually from the generalities of the *Physics*, through cosmology (the *De Coelo*), psychology (the *De Anima*), right down to the generation and diverse movements of animals and their psychology. Aristotle even devised a theory to explain why dogs run slantwise.

Philosophy begins in wonder, as Aristotle states in Book I of the *Metaphysics*. Originally philosophers wondered 'at the obvious difficulties, then advanced little by little and stated difficulties about the greater matters, e.g. about the phenomena of the moon and those of the sun and of the stars, and about the genesis of the universe.' A man philosophizes in order to escape from ignorance; and so any knowledge that frees man from the bonds of ignorance and doubt will be philosophical in Aristotle's sense.

As I have said, the philosophy of nature has many ramifications; but these do not divide the science except materially, as St. Thomas explains in his exposition of the *Posteriora Analytica* (I, lect. 25). Even the application of mathematics in the study of nature does not divide the subject of this study. I mean that, while mathematical physics is formally mathematical, it remains 'principally' natural by reason of its term, namely the subject. For we apply mathematics to nature, not for the sake of mathematical knowledge but for the sake of learning more about nature (In *II Physicorum*, lect. 3). There can be different approaches to the same subject; but there is no reason to call the one philosophical and the other not at all so, even though one may deserve to be called 'more philosophical' than the other, according to the kind of ignorance from which it liberates. The 'more philosophical' could be described as related to the things which are of greater concern in learning the *why* of anything.

* * *

Notice, now, the first paragraph of Dr. Adler's outline:

> Any really thoroughgoing study of the difference between philosophy and science will have to consider the two fundamental differences between them. First, there is a difference in their object — i.e. what they are about. Second, there is the difference in how they go about giving us a knowledge of their object, — i.e. a difference in their methods. These would seem to be two significant ways in which one body of knowledge can differ from another, one having to do with *what* is known, and the other with *how* it is known.

Dr. Adler uses a terminology which is nowadays commonly used in our textbooks. He says that 'there is a difference in their object, i.e. what they are about.' Now, what did Aristotle and St. Thomas mean by *objectum scientiae*, and what did they intend by *subjectum scientiae*? They distinguished between the *subject* with which science deals and the *object* that the science aims at. By the object of a science — science being taken here in the sense of the *Posteriora Analytica* — they meant that which we aim to know scientifically. And what is it that we eventually come to know scientifically? Where do we find it expressed? In first propositions that are self-evident? These may be either remote or proper principles of science, but they are not known in a scientific way, i.e., by way of demonstration in the narrow sense of this term. Some of these principles are known immediately by all, namely maxims or *dignitates*, whereas most of them are appraised only by those who have more experience and training. Examples of the first would be that 'it is impossible to be and not to be, simultaneously and in the same respect', or that 'the whole is greater than any of its parts' — at least in the case of number and dimensional quantity. (There are extended meanings of 'whole' and 'part,' as in the case of a 'logical whole,' which is identical, severally, with each of its subjective parts, as St. Thomas explains in *Metaph.* V, lect. 21. But I refer now to the domain of quantity, where three is greater than the two which it contains, and the circumference of a circle greater than any of its segments.) These principles we know immediately, though by way of induction.

An example of principles which are known immediately to the trained mind would be that the incorporeal does not occupy a place, which is plain from the definition of place, namely 'the first, immediate and immobile inner surface of the surrounding body'; or the principle that 'the exterior angle of a triangle is equal to the two interior opposite angles.' Such principles are immediately knowable and, like the maxims, are not acquired by demonstration from a previous knowledge of causes. But it is knowledge obtained by syllogistic demonstration that we call science in the strict sense of the *Posteriora Analytica*. This is most literally so and most obvious in the case of mathematics. Here, from the definition of the subject, we infer a property — a *propria passio* — belonging to it. Take the example of the triangle. From its definition as 'a three straight-sided figure, whose exterior angle is equal to the two opposite interior angles,' we infer the property that every plane triangle, no matter what kind (equilateral, isosceles, or scalene), has its three angles equal to two right angles. This is what we know scientifically, namely the conclusion, in which the property is attributed to the subject because of the definition of this subject — the definition being the middle term in the demonstration.

Such conclusions are the objects of science. St. Thomas explains this in his commentary on the *Posteriora Analytica*, I, lect. 4 and 10. To know scientifically (*scire*) is to understand the truth of a conclusion by way of demonstration. That is why we say *scientia est conclusionum;* conclusions are demonstrated enunciations, whereas enunciations that are principles of demonstrations are propositions in the strict sense of this term. When I propose to you an enunciation that is not self-evident, you may understand what I mean; but you will not understand its truth until you are made to see *how* it follows from something already known as true. Then the enunciation about a property belonging to the subject will be *quod erat demonstrandum*. Like the premisses of a demonstration, the object of scientific knowledge (the *scibile*) is therefore something complex: a conclusion, in which a property is predicated of the proper subject that is its cause — as shown by the definition of this subject, from which the property is derived and expressed in the conclusion.

Any single science achieves, of course, a multitude of conclusions, all of them objects of scientific knowledge. What do we mean, then, by *the* object of a science? Here is where we distinguish between formal and material objects. The latter, the material object, embraces all the conclusions arrived at by inference from enunciations which either contain the definition of their subjects, or which are sufficiently warranted by enumerative induction. (This type of induction rarely provides us with more than a *universale ut nunc* — a provisional universal that does not produce science

proper.) What, then, makes a science to be one, so that we can speak of the distinct or proper object of a science? Where is the principle of such a unity to be found? It is to be found in the mode of defining. How, for instance, did we define the triangle? In the case of experimental science, all definitions will contain sensible matter, a reference to what is experienced through sensation. This applies to all changeable things, to physical body (as distinguished from mathematical) and even to the intellectual soul — for the latter too is the first act of a natural organized body, i. e. a body equipped with tools. If you want to define snub, it will not do to describe a mere figure, a special type of curvature. You will have to add bone, cartilage, nerve, etc. If a definition is to be of something natural, the definition must imply sensible matter, even when the definitum is not composed of sensible matter — as in the case of the soul. In other words, this will apply to animals, plants, and to their parts ; to quanta, atoms, stars and galaxies, and even to entities which we cannot immediately sense, such as high temperatures, which are homogeneous with what we sense, and can be visibly recorded. (In a sense there are no such things as celestial bodies in the way that Socrates is a body; they are agglomerations of bodily substances, like crowds, and the livelier among them are mostly gas, which, in its fashion, is just as physical and corporal as an oak tree.)

Notice, however, that we *can* abstract a curve from sensible matter and a whole number as well. There is no reference to sense experience or sensible matter in the following definition of the circle: 'a closed plain curve such that all of its points are equidistant from a point within called its center.' This mode of defining differs widely from the first. It is proper to mathematics: it abstracts a form from a subject without which it could not exist, but apart from which our mind is able to consider it and to demonstrate its properties as so considered. (This special mode of defining does not make of mathematics a science formally and simply one. Though it abstracts from sensible matter, it does not abstract from intelligible matter, this matter being none other than the substance qua immediately subject to quantity which is the order of its parts, such as the continuity of a line or the elements of a number. Now, the intelligible matter of the continuum is far more potential than that of number, and the one is not reducible to the other. Hence it is that geometry and arithmetic each have their own mode of defining. Read St. Thomas, *In XI Metaph.* lect. 4.)

* * *

We are not concerned with these divisions here tonight. The illustrations were brought in to show what is meant by the *object* of a science. We must now face what is called the *subject* of a science. Dr. Adler called the objects of philosophy and science 'what they are about.' But this is precisely what St. Thomas calls the subjects of the sciences, namely *de quibus est scientia.* In our example from geometry, the triangle is the subject. Notice, now, that the triangle and its definition were already contained in the premisses, and that the triangle appears again in the conclusion: we first know the subject — the *subjectum scibile* — as that about which we seek to know a property; in this regard it is *that about which* we seek scientific knowledge and from which this knowledge is to be inferred — provided the subject is immediately known. In the conclusion, the object of science, we express knowledge of a certain universal commensurate property pertaining to that subject. Here the subject *is* known scientifically — it is a *scitum.* The subject, so taken, is therefore contained *within* the object of a science. ?!

* * *

As to Dr. Adler's second point ('there is the difference in how they go about giving us knowledge of their object, — i.e. a difference in their methods'), I fail to see what he has in mind. He is not very helpful when he adds: 'These [methods] would seem to be two significant ways in which one body of knowledge can differ from another, one having to do with *what* is known, and the other with *how* it is known.' On the contrary, if it be science we are after, we must know *what* it is about which we seek to know something in a scientific way, and it is also essential that we should know *how* to go about acquiring such knowledge. Different sciences have different subjects and different methods, no doubt. However, even when the formal subject (taken from the mode of defining) is the same, one and the same science can still use different methods. Not only each science, but each branch of a single science may stand in need of diverse methods. Physics (in Aristotle's sense) and psychology are parts of one and the same science; but they use quite different methods, as St. Thomas explains in the *De Anima* (I, lect. 1 and 2), the first being mainly based upon external experience, the latter upon the internal experience of being alive. And when, in this same science of physics, we apply mathematics to nature,

the method again becomes widely different: for we will now have to do with movement *qua measurable* (*In Boethium de Trinitate*, q.5, a.3, ad 5).

But none of this has anything to do with a distinction between philosophy and science. I would agree that the sheer act of measuring is not a philosophical activity, and that a computer is not, as such, a philosopher; he can, in fact, be replaced by a machine. But there is no reason to divorce mathematics, mathematical physics or experimental biology from philosophy. The various departments of knowledge about nature all arise from wonder and aim to dispel ignorance, while on the other hand their mode of defining is the same, namely, *cum materia sensibili*. Sense experience is their last resort, if it is knowledge of nature that these materially diverse sciences are after. Even when formally distinct, as in the case of mathematical physics, the subject-term of these sciences remains the same. And for this reason, the intermediary sciences are 'more natural' than mathematical (*Physics II*, 2).

We are often told of a distinction between philosophical psychology and scientific or experimental psychology. This is a distinction that I do not understand. Take the beginning of the *De Anima*, where Aristotle shows that even here we must provide *natural* definitions as distinguished from the logical or dialectical. His example is that of 'anger.' It is true that anger is 'a desire for vengeance.' But this definition is purely formal, somewhat like the definitions of mathematics, i.e, 'per species.' Now, in mathematics, formal definitions are sufficient to the subject, since the subject is abstract; anger, however, is also something physical, as may be seen in the behaviour of any person in a rage. If we are to form a natural definition of *what* anger is, we will have to add something to that 'desire for vengeance,' such as 'attended by an effervescence of the blood about the heart.' A psychology which would confine itself to formal definitions would be no more than dialectical. (Notice, however, that this natural definition of anger is itself only dialectical, but dialectical in a different sense. For propositions — and a definition is virtually a proposition — may be called dialectical for two different reasons: either because the composition or division of the known terms which it comprises is no more than probable; or because one or both of the terms themselves are insufficient, which is the case of purely formal definitions of natural things. We have to do with something less than dialectical when the terms are themselves

no more than likely constructs, even though they have some basis in experience. Such was the case of Aristotle's 'incorruptible' heavenly bodies, and of Dalton's atoms.) In the definition of anger as 'a desire for vengeance attended by an effervescence of the blood around the heart,' the former part is certain, though dialectical; the latter part, taken by itself, is natural, yet dialectical qua insufficient even as a natural definition. Natural, because it refers to something sensible; dialectical because no more than provisional. An instance of the first meaning of dialectical would be 'all swans are white' — so long as we did not know that there are black ones. That was an instance of a universal *ut nunc*. We now realize that 'white' is not their common property. We have likewise been relieved of 'all crows are black'. Such is indeed the case of most universalized terms derived from an experience that does not provide *per se nota:* they are provisional. (Just think how often the supposed cause of malaria has changed during these last two thousand years of medicine; or how 'atoms' have been modified since Dalton's days — and they are getting more and more unexpectedly non-atomic, i.e. quite divisible. In his famous lecture on Group Theory, the late Sir Arthur Eddington went so far as to say that atoms are in the main the theatre of demonstrably unknown and unknowable operations.)

* * *

It might be relevant to point out, in this connection, the difference between speculative certitude, and a certitude that is sufficient for practical purposes. After all, though suggested by relativity theory — the best available but certainly provisional — the Bomb *did* explode. In fact, so far as mathematical physics is concerned, practical success is the only guarantee that we are on the right track; but this should not be mistaken for speculative certitude. We do in fact construct highly efficient machines on the basis of shaky theory.

Here, then, I would make a distinction between the strictly scientific investigation of nature, which does not take us very far, and the tentative or dialectical approach to it. I would even go further and state that most of our knowledge of nature remains in the realm of instrumental fictions

of which atoms and genes are good enough examples. But in practice they are very potent fictions; and they do bring us ever nearer to speculative truth (speculative, not in the Anglo-Saxon sense, but in that of Aristotle). From this it is plain that not everything a science is about is scientifically known. Most of what we call natural science remains finally this side even of likelihood; which amounts to saying that most of it is not science in the strict sense of this term, nor even dialectical in the first sense described. Now, if you want to restrict philosophy to the strict sense of science, then a distinction will stand between philosophy and 'science' as this term is now commonly understood — and as it was often understood even in Aristotle's time, and as he himself frequently used it (just as he sometimes calls the enthymeme a demonstration, which it *is* in the primitive sense of the word, though in one that is quite distinct from its meaning in the *Posteriora Analytica*).

It is what St. Thomas calls the *temperamentum philosophicum* that sets a man on to seek knowledge even of the humblest things and to indulge in hypotheses. It is in the man who confines himself to a narrow domain and to one particular method of investigation, ignoring all else, that we find ground for a distinction between philosophy and what this man would call science. (But even here, if he believes that his knowledge is the only kind worth while, he is still philosophizing.) In other words, if the distinction is to have some basis, I would seek it in a distracted scientist, but not in the science itself. So far as science is concerned, such a distinction is purely incidental, whereas the distinction between science in the sense of the *Posteriora Analytica* and dialectic is *per se*.

It so happens that the things we know with great certitude are the most general and confused, as Aristotle and St. Thomas point out in *Physics* I, 1. But the *complementum scientiae* requires that we reach out toward things in their differences and seek to know the causal principles that give rise to them, instead of resting in the vague generalities we know first; we must reach out even to the vagaries of meteorology (see St. Thomas's *Prooemium* to the *De Meteorologicis*). Philosophical temperament demands nothing less. Plainly, the ideal of philosophy is an impossible one. No mathematician, physicist, or biologist knows more than a fraction of his subject, as any of them will tell you. But this, again, is purely incidental to the sciences themselves. We will have a divorce between philosophy and science only when the specialist in a particular

branch of natural philosophy goes off on his own to ignore all that *he* does not know; and then it is not Science but *his* science, which has been cut off from philosophy.

* * *

Let us consider a concrete case of problems which, though about the same thing, must be resolved along very different lines — so different that some people are led to believe such problems belong to wholly specifically distinct bodies of knowledge. Take the question of time. You remember how St. Augustine opened his discussion of what time is. He said something to the effect that he seemed to know so long as no one asked him. Aristotle had raised the same question. We sometimes forget that both of them provided an answer and that it was much the same. At any rate, Aristotle, after a lengthy, quite necessary, dialectical approach, laid down the following definition: 'the number of movement according to the before and after (found in movement).' This definition is quite unintelligible outside the context of the Philosopher's long discussion leading up to it. In terms of mathematical physics, it has no meaning at all. (And for some this is proof that it is without meaning.) For the present purpose, let us assume that it does have meaning, that it is, besides, a good definition, and a virtually true proposition. Aristotle goes on to show how it implies that time is composed of the non-existent past and future divided by the indivisible instant. Only the evanescent instant of time is actually outside the mind. Time in any amount, taken as a whole, requires mind looking before and after into the non-existent past and future, so that without mind there is no more of time than its indivisible, which is not a time. St. Thomas says the same about movement itself (*In IV Physic*, lect. 23): if there were no intellect, there would be no more than the 'moment,' the indivisible of movement, which is not itself a movement.

But what can the mathematical physicist do with definitions of that kind, or with their consequents? Nothing whatsoever. And the reason is that the 'mathematical physicist' may be construed as a kind of abstraction, whereas the complete physicist bears in mind the concrete whole of nature — at least as an ideal. Though certain problems of the physicist can be resolved only by the application of mathematics, even then he is still a physicist, namely, one who seeks knowledge of nature. But if a

man confines himself to the special problems of mathematical physics as if they alone were relevant, he is like a brick-maker who would ignore bricklaying. The brick-maker is indeed a specialist, but if he does not know what bricks are for, if, in his mind, bricks have nothing to do with building, he is a specialist of a rather specious kind — like a mathematical physicist who would believe that nature raises no problems other than the kind he works on. The mind that diverts bricks from what they are for, is performing a negative abstraction, no matter how solid and well-shaped the bricks may be: such a mind does not grasp *why* they should be that way; it is satisfied that they should in fact be so and so.

The basis of mathematical physics is, of course, measurement, to determine, for instance, the rate at which bodies fall, or the speed of light; and yet we may also seek to learn what these things are. Now, regarding time, how do we pass from one type of problem to the other? Notice, first of all, that Aristotle faced both types of problems in point of time. Having defined it, he shows that time, as the measure of movement, since a measure must be homogeneous with the measured, will be, not just movement, but a particular movement which, by reason of its regularity and speed, will have the nature of measure with regard to all other movements. All this has to do with the first type of problem the physicist must face. Still, it is the last point made that raises the second type of problem, for we were left in the dark as to where this particular time-movement is to be found. The ancients — and even we for practical purposes — see the standard of time in the diurnal movement of the firmament. It is now known, however, that the diurnal movement is neither the limit of velocity nor of uniformity. Where, then, is the constant of motion to be found? In the speed of light? Whatever the answer, it will be a provisional one. In this domain, any generalisation or hypothesis will eventually be outstripped in the spiralling progress of interwoven experiment and theory.

The latter type of knowledge is of course not the kind described in the *Posteriora Analytica:* it is not scientific in this sense. It advances toward the status of science in the manner that a variable converges to a limit. But I insist: the type of problem in question remains philosophical, while the tentative solutions are not scientific in the sense just referred to. In other words, very little of natural philosophy is science in the sense of rigorous demonstration. If you want to confine the meaning of the term

to those generalities which, ideally at least, can be settled once and for all, you will implicitly identify philosophy with science in the strictest meaning of this term, to distinguish it from every body of knowledge that remains in a state of investigation; philosophy will be a discipline that diverts attention from problems that cannot be definitively solved. Such an attitude is a possible one, but is surely the very opposite of the philosophical temperament exhibited in the *De Coelo*, where Aristotle declares, concerning investigation of the structure of the heavens, that we must look upon eagerness to seek even tenuous solutions of the difficulties involved as evidence of modesty rather than of rashness, if the seeker, out of thirst for philosophy (*philosophias dipsa*), is led to accept even slight indications in a field where it is very difficult to see one's way, surrounded as one is by such unfathomable obscurities (II, 12). Following his master, St. Thomas frankly states that the whole theory of incorruptible celestial bodies rests upon meager experience and can be no more than a provisional attempt to save appearances: *nec tamen hoc est necessarium, sed probabile* (I, lect. 7). Such investigation arises, nonetheless, from a thirst for philosophy.

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We left the problem of time at the point where we raised the question of where the prime time-keeper is to be found. The rotation of the earth may be good enough to start with, but we must persevere in search of an ideal standard. Yet the crux of the matter is that the definition of this standard will be an idealization dependent upon the rotation that is directly measurable. This example will allow us to appreciate the difficulties that beset the philosopher of nature as he moves on toward the problems of mathematical physics. He must get down to measure. Now, the most basic measure in physics is that of length, as you can see from the graduated scales of clocks, weighing-machines and thermometers. What is length? Here is another of those definitions which at this juncture will no longer do: ' that according to which a thing is extended in one dimension.' What we now want to know is ' how to measure length.' Assuming that ' a measure is that by which the quantity of a thing is first made known,' we now must raise the question ' what is the measure or standard of length? ' The above definition does not provide the answer. (It is much like saying

that an elephant is ' a four-legged animal, ' or even ' a thing of a certain kind ' ; which is true enough, but so is a mouse a four-legged animal. And who can ride a mouse?) Definition, in the strict sense, as *ratio quam nomen significat*, is of universals only.

But what *does* the physicist now use as the standard of length? The meter. How do we ' define ' this meter? *Webster's* describes it correctly as follows: " the distance between two lines on a certain platinum-iridium bar kept at the International Bureau of Weights and Measures in Paris, when this bar is at 0° C. or 32° F. Copies of this bar are kept elsewhere." The point is that, in the field of physics, all measurements refer to this particular object — a ' singular ' that we have constructed and chosen as the standard. It is universal in a very material sense, which is implied by ' Copies of this bar are kept elsewhere.' It is not universal in the sense that ' measure' is, or of ' man ' as distinguished from ' *this* man Socrates.' Do you realize what this means for mathematical physics as a ' science '? It will not be scientific knowledge in the sense of the *Posteriora Analytica*. But it does solve speculative problems, tentatively, and does lead, nonetheless, to practical results of cosmic proportions.

Now, the difference between the questions ' what is time? ' and ' what is the cosmic clock? ' or ' where is time to be found concretely? ' does not warrant a distinction between philosophy of nature and ' science. ' However, in Aristotelian terms, which are exactly those of St. Thomas as well, it does point to a distinction between methods in the philosophy of which these are branches, to a distinction between strictly scientific conclusions and the provisional solutions or theoretical constructions which a thirst for philosophy leads one to undertake.

The late Ludwig Wittgenstein was aware that some people point to those distinct types of problems. According to Norman Malcolm's notes (*Ludwig Wittgenstein, A Memoir*), he said : " It may be objected to our (Wittgenstein's) method as follows: ' If some one asks what *time* is, you ask in return, 'How do we measure time?' But time, and the measurement of time are two different things. It is as if someone asked 'What is a book?' and you replied, ' How does one obtain a book?' "(Wittgenstein goes on to side-step the distinction in his usual way.) I fail to see how the distinction can be done away with. Is it not obvious that to the questions

' What is a house? ' and ' How does one go about acquiring a house? ' you would not expect the same answers? ' To be a shelter ' and ' to build ' or ' to buy one ' are surely not the same (although the action of building would go into the definition of a house).

Let us return to Dr. Adler's distinction. He says that philosophy has ' to do with *what* is known, and the other (i.e., ' science ') with *how* it is known. ' Perhaps he has in mind something like the difference between '*what* time is' and '*how* we measure it.' He might have been more explicit. At any rate, I fail to see how this distinction between different types of problems should lead one to think of philosophy as opposed to 'science' even as this latter term is understood nowadays. I would say that, if philosophy is narrowed down to what is scientific in the strict sense (of the *Post. Anal.*), we would then have to distinguish it from the investigations which lead to no more than tentative solutions that at least save the appearances. But the whole point is that the pursuit of philosophy naturally leads one right on into this realm, where all is forever under construction, and to ponder the import and status of these temporary achievements.

Dr. Adler's terminology is, nonetheless, widely accepted nowadays, as we have already conceded. We must also admit that it has some basis in historical fact and modes of thinking. (Another example: Eddington and Jeans assumed that a philosopher had to be either an idealist or a materialist. This has been in fashion for some time.) After all, a man can get quite far in mathematical physics or in experimental biology without ever asking questions of the first type. Yet, though he refuse to call himself a philosopher, what he knows responds all the same to philosophical questions.

Another basis for the kind of distinction which Dr. Adler attempts can be found in the fact, already mentioned, that no scientist today can know more than a fraction of his own branch of science. But this merely points to a fragmentation of knowledge as possessed by individuals. It is likewise true that most scientists never become aware of the ' most *obvious* difficulties ,' such as ' what a cause is ,' ' what movement is ,' ' infinity ,' ' place ' and ' time ,' or ' what it is to be alive ' — problems that will, for most people, remain forever in debate. But this only goes to show that the ' most obvious ' difficulties may well be at the same time the most difficult to discuss. It does not follow that these are philosophical, as distinguished

from the so-called scientific problems; nor that they are not necessary to a fuller development of a given branch of science.

I may appear to belabour a minor issue, even to quibble over words. Nevertheless, if, apart from the distinction between strict science and dialectic or even between these and the symbolic constructions and so-called logical fictions by means of which we approach nature, we insist on dividing the philosophical spirit from that of 'science,' philosophy on the one hand, and this new rootless kind of science on the other, will each become entirely empty. Unless we bring these various departments of natural science together ideally (however unattainable the ideal itself may be), we will instead corroborate and help to fix the sorry state that we are witness to. I fully agree on this point with the German theoretical physicist, Pasqual Jordan, when he says (in *Physics of the Twentieth Century*) that the increasing independence of natural scientific branches from philosophy after Aristotle's time to the present has simultaneously emptied philosophy of its original content and problems. Distinctions are of course to be made, and I have given you some examples; but there is no reason why these different modes of questioning should go off quite on their own. (Some people object to a Ph.D. obtained for a dissertation on the activities of slugworms. On the contrary, the implication that such research is the business of a Doctor of Philosophy, has the backing of sound tradition — now little understood by the 'philosophers.')

The difficulty of managing the ever-expanding fields of natural science is a practical one. For instance, you, in particular, must take a course in philosophy. Unless you have some philosophy of nature, metaphysics will be entirely empty. For the term and principle of the subject of this science can be known only *per viam causalitatis et negationis*. Unless you first study the effects, what knowledge could you obtain of their first cause? If you do not know what movement is, if you can do no more than interpret the name by pointing to an instance of it, what could you eventually mean by an 'Unmoved Mover'? What is it that the negations will be negations of? If it be granted that some philosophy of nature is prerequisite to metaphysics, time will not allow you to move on very far in the order of nature's concretion. You will have to confine yourself to the most general and obvious problems (and they, as we hinted, may be, nonetheless, the most difficult). The point is that you should be constantly aware

of the limitations you are subject to; these are inherent to the kind of intellect we have, to the vastness and intricacy of nature, and to the time we need to learn. Still, if you have a philosophical temperament, you will wonder about elephants and frogs, and not just about 'animal' in general. If you are talking about 'mobile being,' it does not matter much whether you have an elephant in mind or an oak-tree. But as you go on to distinguish various kinds of movements, and if you have the time do delve into an order of greater concretion, you will eventually inquire into the ways in which worms and geese get around; you will want to know how oysters grow, and how the human brain develops, and where they came from and how. (Not only the 'basic problems' of Wallace and Darwin were philosophical, but also the hypotheses which they devised.)

Aristotle was concerned with all these subjects. And do you know why he showed such keen interest in them? In his introduction to the *De Partibus Animalium* he states that the philosopher should not recoil from examining even the lowlier things of nature. 'For if some have no graces to charm the sense, yet even these, by disclosing to the mind the architectonic spirit that designed them, give immense pleasure to all who can trace links of causation, and are inclined to philosophy. Indeed, it would be strange if mimic representations of them were attractive, because they disclose the mimetic skill of the painter or the sculptor, and the original realities themselves were not more interesting, to all at any rate who have eyes to discern the reasons that determined their formation... Every realm of nature is marvellous: and as Heraclitus, when the strangers who came to visit him found him warming himself at the furnace in the kitchen and hesitated to go in, is reported to have bidden them not to be afraid to enter, as even in that kitchen divinities were present, so we should venture on the study of every kind of animal without distaste, for each and all will reveal to us something natural and something beautiful.'

Such was, to Aristotle, the ultimate purpose of studying the physical world: a deeper knowledge of the art and power of the divine Artisan (*hè dynamis hè dèmiourgèsasa*) that fashions natures. I fail to see why knowledge of these things should be torn away from the love of wisdom and left to drift off on its own. It is true that the mind, in its attempt to grasp the ultimate concretion of nature, is set on a course upon which it

will remain *quasi in statu motus existens* — to quote an expression used by St. Thomas to explain the second meaning of 'rational process' (*In Boethium de Trinitate*, q. VI, a. 1.). But to move towards a term is far better than to be arrested in unfulfilled vacuity for sheer lack of wonder about 'the greater matters.'

Another reason to support Dr. Adler's position that philosophy and science are quite distinct may be found explicitly stated by Lord Bertrand Russell. This British philosopher tells us that, while we know of 'purpose' in human affairs and we may suppose that there are cosmic purposes, in science it is the past that determines the future, not the future the past. Therefore, he concludes, 'final' causes do not occur in the scientific account of the world. In other words, the scientific outlook must disregard what are now called 'values.' And this is plainly true when we confine ourselves to mathematical physics, as Aristotle himself had shown in the *Posteriora Analytica* (I, 13). Being formally mathematical, this branch of natural philosophy must abstract from the 'good' or final cause. Though nature acts for an end, final causes will not occur in the mathematical account of the world, no more than in mathematics itself. I mean that a triangle does not have such or such a property because it is good to have it so. As is shown in Book XIII, c.3, of the *Metaphysics*, mathematical things do not have the nature of good or final cause since they cannot, as such, have physical existence; yet, the chief forms of beauty are order and symmetry and definiteness, which the mathematical sciences demonstrate in a special degree. When natural philosophy borrows reasons from mathematics it will, to that extent, prescind from the good as a reason for a thing's being or occurring thus and so. But this does not render the outlook of mathematical physics a non-philosophical one, though it is easy enough to say so, and may in fact be true of a given scientist.

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But I am rambling on too long and about to exceed Dr. Adler in time. Still, I would like to mention one more point in connection with what I have just said. I refer to the now widely accepted distinction between philosophy and mathematics — as if the latter were not the most exact of philosophical sciences! (Cf. St. Thomas, *In Boethium de Trinitate*, q. VI, a.1.) I mean mathematical science and not the philosophy of mathematics

which in Aristotle and St. Thomas is metaphysical and not mathematical (*Metaph.* XI, lect. 1).

Why should we want to divorce mathematics from philosophy? The reason is similar to that which appears to support the distinction made between philosophy and 'science.' In the modern version, mathematical entities are defined in terms of the operations that can be performed upon them, and these operations are those of calculation. Now the Greeks — and this was already quite clear in Plato (*Republic* VII, 6) — distinguished between the science of arithmetic (*arithmètikè*) and the art of computation (*logismos* or *logistikè*). Operations of calculation are in the main mechanical. If you attend to what the symbols you are using may stand for, you will probably get all mixed up and do a bad job. You must perform the operations automatically, as is so easy in algebra. That is why you can confide the most involved and lengthy calculations to electronic hardware which may be far more efficient for the simple reason that in this domain one does not have to know, nor reflect upon, what one is doing.

To the Ancients, *logistikè* — of which modern algebra and calculus are considerable developments — was no more than an *organon*, an instrument, or handmaid, as it were, of mathematical science. When performing a demonstration in true arithmetic (now called number theory) or in geometry, you cannot do without calculation. But this calculation alone is not the demonstration. In Euclid, demonstrations are always scrupulously cast in syllogistic form. The middle term, the definition of what the subject is, *that* is the crux of the matter. But machines, executing for us the operations of calculation, do not syllogize. When we speak of mathematics nowadays, we attend to these operations, but not to the reason that employs them for the sake of demonstration. I do not mean that modern mathematics does not demonstrate. The point is that the demonstrative form is not brought to the foreground. (Some people even try to demonstrate that there is no demonstration. After all, one may reason correctly before, and without expressly attending to, the second intentions of logic.) The modern mathematician may usually be compared to the man who reasons without exhibiting the process of reasoning itself. 'He reasons well' now often means 'he is a good computer.' That is presumably why some can say that computing machines reason just as well as we do — and even better! Now, if mathematics is reduced to this

we will not call it philosophy. But is mathematical science to be identified with an ever-expanding system of computation? It is far more than this even in modern number theory, which still tackles the problems of ancient arithmetic such as 'Is there a last prime number?' If you look into the way this problem is handled, you will see that the definition (in the strict sense of this term) of prime number is being used as a middle term ; but no one will tell you so.

* * *

We should be very much concerned with mathematics as a philosophical science, since, for us, it is science in its most rigorous form and a model for all the other sciences, no matter how different and more involved their methods will be. Its certitude is far greater than that of metaphysics (cf. St. Thomas, *In Boethium de Trinitate*, q. VI, a. 1, c.: *Ad secundam quaestionem. . .*) though it would be foolish to demand its equal in certitude as the *sine qua non* of every science (*Metaph.* II, 3.). The *metaphysicalia* are more certain in themselves, but not to us. Metaphysics is far more abstract, remote, and difficult than we are nowadays led to believe. We even try to present it as if it were quite simple and amenable to beginners in philosophy, who have no logic, mathematics, or natural science. Actually the minds of beginners, if it is metaphysics that they start from, are being cluttered with unidentifiable words, which can please only the untrained mind. Some, realizing the difficulty of communication in the subject, resort to special intuitions, held to be a privilege of the few. In this conception, the metaphysician is a fellow who just sits there and stares at the existent, caring little *what it is* that exists, overlooking even the many meanings of the term 'existence.' Instead of indulging in this brand of private revelation, we would do far better if we induced our students to read wholesome poetry — which they should have done before embarking upon philosophy in the first place.

Mathematics is a most important subject, for unless you have this model science in mind before going into metaphysics, or even before investigating nature, you will move about at random, unable to evaluate what you are doing and to appreciate where your knowledge falls short of science proper. (I know this idea is most unpopular in scholastic milieux today.) General logic is even more basic, difficult as it is.

By the way, it is sometimes said that logic and mathematics should be taught first because they are so easy. But this opinion confuses logic and mathematics with logistic, the art of calculation. Logic as a science is extremely difficult. St. Thomas faced the objection that logic, in particular, since it is so arduous, should *not* be taught to beginners. Why start from what is so difficult? To this he replies that in learning we begin with what is easier, provided necessity does not require us to proceed otherwise. For it is sometimes necessary to start, not from what is easy but from that upon which further knowledge depends. And this is the reason we must begin with logic, not because it is easier than the other sciences, for it is extremely difficult (*habet enim maximam difficultatem*), treating as it does of second intentions, but because the other sciences depend upon it, inasmuch as it teaches the mode of procedure common to all sciences. For we must first know the method of a science before knowing the science itself, as Aristotle says in *Metaphysics II* (Cf. *In Boethium de Trinitate*, q. VI, a. 1, ad 3). In his commentary, St. Thomas adds that it is absurd to try to do otherwise (lect. 3). He did not confuse logic with the mechanics of logistic, which, once you know how to manipulate the symbols, is easy enough.

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But even the value and function of logic are not easily described. The logic that is first to be studied is not meant to provide us with an organon appropriate to each and every science, nor even to all the ramifications of a single science. As St. Thomas points out in *Metaphysics II* (lect. 3), logic is to be studied before the other sciences, because it provides a mode of procedure that is common to them all; whereas the method that is proper to each of the several sciences must be taught at their respective beginnings. And by the *singulae sientiae* he does not mean only the sciences that are formally distinct by their mode of definition and subject. Natural science is formally one by reason of its term and mode of defining, but its several branches or material parts have different methods. The first two books of the *Physics* are about the general method to be followed in the study of nature, but the *De Coelo*, namely, cosmology, and the *De Generatione et Corruptione*, followed by the *De Meteorologicis*, each have their special approach. (See St. Thomas's *Prooemia* to these works.) Then, the manner in which living things are to be investigated will again differ widely

from the sciences just mentioned, while the methods of those former branches will not be put aside. Just take a look at the first pages of the *De Anima*, and then read all of Book I *De Partibus Animalium*. And as these various departments progress, their method too will evolve in the very process of investigation. Still, they all have the same formal subject, mobile being — known through sensation or homogeneous with what is sensed — while the material subjects are so diverse that no one has a head big enough to contain them. We now realize more than ever before the tyranny of time to which we are subject in the process of learning.

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Dr. Adler told us that ' mathematics deals with mathematical problems only; it does not answer botanical questions, nor can it criticize or refute answers to botanical questions. ' The matter, again, is not so simple. Mathematics provides many reasons in reply to biological questions in general, and to botanical and zoological ones in particular; for botany and zoology are in some measure subalternated to mathematics. Just read Herman Weyl's *Symmetry* (Princeton University Press). Even Aristotle said that it is the physician's business to know, from experience, *that* circular wounds heal more slowly, whereas it is the geometer's to know the reason *why* (*I Post. Anal.*, 13). The latter example, however, is not one of strict subalternation; for a practical science, though subordinate to a speculative one, cannot be subalternated to it. But I agree that botany does not solve mathematical problems (though it might, incidentally, give rise to one of them). The only reason for this that I can see is that their modes of defining, their principles and subjects, are formally distinct.

From what I have said it should be plain that the very term ' science ' is an analogical one, which to us is verified *per prius* of mathematics, seeing that, more than any other science, mathematics proceeds *per modum disciplinae*. It is here, in mathematics, not in metaphysics, that we have the greatest so-called ' metaphysical certitude.' In other words, even when the term ' science ' is taken in the narrow sense of knowledge acquired by syllogistic demonstration, it still has many meanings : it refers to a whole cluster of concepts one of which is primary to us, although considering things in themselves it may refer to what is really most secondary of all. (Cf. St. Thomas, *In Metaph.* V, lect. 5.) The word ' science ' stands

for one thing in ' the science of nature '; it means quite another when one branch of this science is called a science. It means something else again in ' the science of agriculture,' which is practical.

* * *

I have repeated over and over that the problem raised by Dr. Adler is not as his presentation of it suggests. His way of looking at it does not take into account the unfathomable breadth of nature, the complexity and debility of our mind and its devious modes of knowing. Our knowledge of nature is not infused and prior to the things we know; we are dependent upon the things themselves to know them. This makes all the difference. It is the reason why we must resort to abstraction, to symbolic construction and fictions; it is the reason why we make actually intelligible things that in themselves are not. The things that are most knowable to us are in fact least knowable in themselves — except in mathematics, where the two are the same. What we know first and foremost is in itself the least intelligible; and that which in itself is most intelligible lies far beyond the reach of our positive knowing. Our mind is barely a shadow of intellect. The best things we come to know in philosophy are attained by reasoning, not by intellection.

I will not go into what Dr. Adler says about Revelation and Theology. This would take us too far. (Notice, however, the analogical character of the word ' science ' as applied to Theology, which is the only science we have that is both formally speculative and formally practical.) Our present concern was with what he had to say on philosophy and science. I know that his position is the common one. However widely accepted, I do not think it can bear the light of perennial philosophy.