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P H I L O S O P H Y   O F   N A T U R E

A General Introduction to the Study of Nature

by

Charles De Koninck

PART I.

Mimeo copy No. Fifteen

In making these suggestions I have presumed that this text will be used by second-year college students whose entire philosophical background consists in at most one year of logic.

Chapter I

THE KIND OF SCIENCE HERE TO BE STUDIED.

St. Thomas prepares us for the study of nature by means of a general preface which, although only a few paragraphs long, is of such vital importance that it seems well both to quote it in full, and to offer the beginner some assistance in seizing the main ideas which it contains. The first paragraph might be translated as follows :

"Since the treatise called the Physics, which it is our purpose to explain, is also the one that comes first in the study of nature, we must show, at its very beginning, what natural science is about — viz. its matter and subject. To this end, we should point out, on the one hand, that inasmuch as every science is in the intellect, and since a thing becomes intelligible in act insofar as it is more or less abstracted from matter, things, according as they are diversely related to matter, are the concern of different sciences. Again, since science is obtained by demonstration, and the middle term of demonstration is the definition, it follows, of necessity, that the sciences will be distinguished according to a difference in their mode of definition". (1)

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(1) - In the Leonine edition, this preface comprises nn. 1 to 4 of Lesson I. The recent manual edition of A.-M. Pirotta, O.P., numbers the paragraphs of the entire commentary from 1 to 2550. In the margin of this work we refer to the division of St. Thomas's text of the Leonine edition and, between parenthesis, to the numbers of the Pirotta manual text.

1. - Some meanings of the term 'science.'

In the very first sentence of the paragraph just quoted, several terms are used which require some attention here. They have already been treated in Logic. but it will be useful to call to mind certain principles regarding the nature of our thinking which simply must be grasped before we can hope to understand the kind of science that we are now being invited to study.

Because the word science is frequently used to signify widely different kinds of knowledge, and since St. Thomas, in this context, has in mind only one kind, we must first point out what this is. The expression 'natural science' as it is generally understood today, refers to a ~~incontrovertibly~~ type of knowledge that differs, nearly beyond recognition, from the ~~kind of knowledge~~ one that is intended by 'natural science' in this paragraph. When a single word is currently used to mean different things whose relationship is not clear on first sight, it may help to point out an example of something which, pertaining to the same general field — such as 'knowledge' — is manifestly not an instance of any of its recognized meanings. E. g., the knowledge that Socrates is now standing at that corner of this street may be very certain to him, or to someone else who sees him there, but we are not in the habit of calling this kind of knowledge 'science,' no matter how certain. The reason is not that it is merely knowledge of a strictly individual fact, for some such facts are said to have been established in a scientific way. When a historical fact has been ascertained as the result of an orderly approach, complying with definite rules that are susceptible

I doubt whether the average college student would know the meaning of this word. Could a simpler one be used?

of being verified — e.g. that Aristotle was not the author of the Liber de causis — we are wont to call this knowledge 'scientific.' And we all know what is meant when one historian is called 'more scientific' than some other who takes hearsay for fact. It is futile to quarrel over the use of the word 'science' in connection with such knowledge, and far better to enquire why it is actually so used. Again, of the observed relationship between the tides and the phases of the moon, or between the behaviour of people and the weather (comprising such items as suns and constellations), we say that they are scientifically certain. When the makers of consumer goods announce that their brand has been 'scientifically tested,' they refer to a process of examination performed according to accepted rules. "Any mode of investigation by which scientific or other impartial and systematic knowledge is acquired" is the description of Scientific Method found in an article under this heading in the Encyclopaedia Britannica.

All this suggests that the term 'science' has to do with knowledge obtained by some recognized means or process emphasized as impartial. It is implied that anyone who can grasp the means or can understand the process, ought to agree that what is discovered or proved by it, deserves his assent.

Among the studies called sciences, mathematical physics is often presented as so ideal in method and standards that the other departments of the study of nature are called scientific only in the measure that they approach its exactness. Now, what we must notice is that, if mathematical physics is called the most exact, it is because it attains more closely to the precision of mathematics itself, which is undoubtedly more rigourous than any other science. For mathematics proceeds, more than any other science, "in the mode of discipline" (1). In fact, when Aristotle mentions the 'disciplines' without qualification, he means mathematics. On the other hand, if we refused to consider as subjects of investigation those which are not amenable to the exactness of mathematics,(2) we would have to renounce even mathematical physics, if only because of its dependence upon sense experience.

→ I don't think such students would be familiar with the meaning of this.

To show what is meant by 'science' in the strictest sense of this term, we will therefore consider in illustration some examples of demonstration in mathematics

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(1) - St. Thomas, In Boethium de Trinitate, qu. 6, a. 1.
(2) - Cf. Aristotle, Metaphysics, II, c. 3, 995a; St. Thomas, ibid., lect. 5, nn. 334-337.

2. - Illustration from Mathematics.

The geometer accepts the meaning of the word 'triangle'; but he also proves that there is such a thing, as when, on the basis of the radius of a circle he constructs an equilateral triangle. The expression 'a plane figure having its three sides equal' has meaning, but from this alone it does not follow that there can be such a thing.[1] The name 'centaur' refers to 'half man and half horse,' but the truth of this meaning as a meaning does not suppose that there is such a being, nor that there could be. 'The diagonal of a square, commensurate with the side', has meaning, too; yet no such thing can be.[2]

To show, concerning the equilateral triangle, that it is, could hardly be done by pointing to a figure on the blackboard, so carefully drawn that its three sides are indistinguishable in length; for no amount of physical measurement could verify the exactness of 'equal sides.' To designate an actual horse would be enough to show that the name 'horse' stands for something that is; this does not hold for the subjects of mathematics. While the geometer assumes the continuum as 'what is divisible without end,' according to one or more dimensions, any subject of which he demonstrates some property, e.g. 'triangle,' must first be established by way of a construction to show

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(1) - On the difference between the meaning of a word, and the definition of what a thing is, see Post. Anal., II, c. 7; St. Thomas, ibid., lect. 5-6.

(2) - The question 'Can it be ?' is not the same as 'Can it be in nature ?'. Being is understood, here, of what is true; not of what is or can be in reality. In the present context, "'to be'(τὸ εἶναι) and 'is' (τὸ ἔστιν) mean that a thing is true and 'not to be' (μὴ εἶναι) that it is false. Similarly too in affirmation and negation; e.g., in 'Socrates is cultured', 'is' means that this is true; or in 'Socrates is not-pale' that this is true; but in 'the diagonal [of the square] is not commensurable with the side' means that it

that there 'is' such a thing. Demonstrations by way of construction are called 'quasi operational.' (1) Every attempt at proof by experience that 'the equilateral triangle' <u>is</u> (in the sense of 'true'), must prove hopeless (2). How, then, can we know of what we define as 'a plane figure having its three sides equal,' that it also <u>is</u> — in the sense of true ? Euclid provides the following proof :

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is false to say it is." (<u>Metaphysics</u>, V, c. 7, 1017 a 30. Cf. St. Thomas, <u>ibid</u>., lect. 9, nn. 895-896; <u>Quodl. IX</u>, a. 3, c. et ad 4.)

If someone said that the word 'horse' stands for a certain kind of vegetable, his account would not be true. Nor could we know whether a proposition is true or false unless we first grasp its true meaning.

(1) - St. Thomas, <u>In I Post. Anal</u>., I, lect. 2, n. 5. In this, the mathematical disciplines resemble, somewhat, the productive sciences. To construct a subject, e.g., a house, is the very purpose of the latter; they remain radically distinct, however, inasmuch as the construction of a subject is the very purpose of the latter, whereas in mathematics the construction is a means of discovery. (Ibid., lect. 41, n. 7.)

(2) - See, below, p.

Perhaps having two illustrations from Euclid would be too time-consuming to be practical in teaching. I would suggest leaving the first one in since it is simpler and would give the student an idea of the method employed, and only referring to the second one.

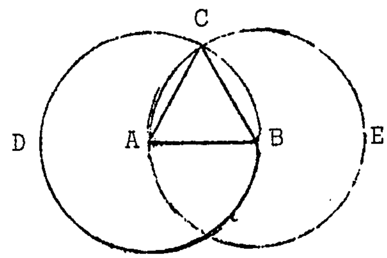
(i) - On a given finite straight line to construct an equilateral triangle.

Let AB be the given finite straight line.

Thus it is required to construct an equilateral triangle on the straight line AB.

With centre A and distance AB let the circle BCD be described; [Post. 3]

again, with centre B and distance BA let the circle ACE be described; [Post. 3]



and from the point C, in which the circles cut one another, to the points A, B, let the straight lines CA, CB be joined. [Post. 1]

Now, since the point A is the centre of the circle CDB,

AC is equal to AB [Def. 15]

Again, since the point B is the centre of the circle CAE,

BC is equal to BA [Def. 15]

But CA was also proved equal to AB; therefore each of the straight lines CA, CB is equal to AB.

And things which are equal to the same thing are also equal to one another; [C.N. I]

therefore CA is also equal to CB.

Therefore the three straight lines CA, AB, BC, are equal to one another.

Therefore the triangle ABC is equilateral; and it has been constructed on the given finite straight line AB.

[Being] what it was required to do.(1)

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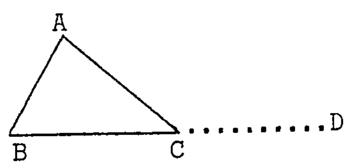
(1) - Book I, Proposition 1. The Thirteen Books of Euclid's Elements, translated by Sir Thomas Heath, Cambridge University Press, 1926, 3 vol., vol. I, pp. 241-242. Cf. St. Thomas, In II Post. Anal., lect. 6, n. 4.

This demonstration by way of construction shows that there is 'a triangle whose three sides are equal,' and that this is indeed a definition, not just of the name 'equilateral triangle,' nor even of a property, but of 'what it is to be such a triangle.' This kind of proof establishes that there is such a subject, and by means of its definition must be demonstrated in turn any property it may have. We must now turn to the kind of demonstration which establishes a commensurately universal property that follows with necessity from 'what its subject is.'

Let us take in illustration another proposition from Euclid :
In any triangle, if one of the sides be produced the exterior angle is equal to the two interior and opposite angles, and the three interior angles of the triangle are equal to two right angles. This statement is not self-evident. That 'the sum of the angles of the triangle equals two right angles' is a proposition requiring proof : it follows from something other than itself, from a reason already known. How is this reason known, and how does it lead to such a proposition ? Assuming certain demonstrations already provided, we quote the proof from Euclid :

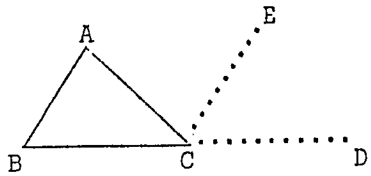
(ii) - Let ABC be a triangle, and let one side of it BC be produced to D;



I say that the exterior angle ACD is equal to the two interior and opposite angles CAB, ABC, and the three interior angles of the triangle

ABC, BCA, CAB are equal to two right angles.

For let CE be drawn through the point C paralleled to the straight line AB. [I, 31]



Then, since AB is parallel to CE, and AC has fallen upon them, the alternate angles BAC, ACE are equal to one another. [I, 29]

Again, since AB is parallel to CE, and the straight line BD has fallen upon them, the exterior angle ECD is equal to the interior and opposite angle ABC. [I, 29]

But the angle ACE was also proved equal to the angle BAC; therefore the whole angle ACD is equal to the two interior and opposite angles BAC, ABC.

Let the angle ACB be added to each; therefore the angles ACD, ACB are equal to the three angles ABC, BCA, CAB.

But the angles ACD, ACB are equal to two right angles [I, 13]; therefore the angles ABC, BCA, CAB are also equal to two right angles. Q. E. D. (1)

What is the exact reason from which this property is inferred ? It is none other than the definition of the subject to which, in the conclusion, we attribute the property 'to have the sum of its angles equal to two right angles.' Now the definition which, in this demonstration, is the middle term and contains the proper principles of the property is not just 'a figure enclosed by three straight lines,' but, as the first part of the proposition states, it is such a figure inasmuch as it has its

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(1) - Book I, Proposition 32. Heath, Ibid. pp. 316-317.

"exterior angle equal to the two interior and opposite angles." It is in this exact respect, brought out, 'made actual,' by means of a construction ("if one of the sides be produced")(1), that the triangle is both the subject and reason of the property 'to have its three interior angles equal to two right angles.' (2)

Knowledge of a necessary, universal and commensurate property acquired from the definition of its subject, is called 'science a priori,' because what is actually prior to the property is also first known by us. (We would never say : 'This figure is a triangle because it has its angles equal to two right angles' — which would be putting the cart before the horse.) Such knowledge, then, is science in the most rigorous sense of the word. But the name 'science,' let alone the adjective 'scientific', is not, in actual usage, reserved to such knowledge alone. For although in science proper we cannot acquire knowledge of the unknown except through the mediation of something else already and better known, not everything that is priorly and better known to us is also prior in itself. Hence it can happen that things better known in the sense of more intelligible in themselves, which would be

They probably won't know why, but perhaps this can be supplied by the teacher since it is a long story.

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(1) - Aristotle, Metaphysics, IX, c. 9, 1051 a 20 : "Geometrical constructions, too are discovered by an actualization, because it is by dividing that we discover them. If the division were already done, they would be obvious; but as it is the division is only there potentially. Why is the sum of the interior angles of a triangle equal to two right angles ? Because the angles about one point [in a straight line] are equal to two right angles. If the line parallel to the side had been already drawn, the answer would have been obvious at sight" (H.T.). Cf. St. Thomas, ibid., lect. 10, n. 1888 et sq.

(2) - Cf. St. Thomas, In II Post. Anal., lect. 1, n. 9.

the means of a perfect demonstration, cannot at once be reached or used, because what we know first is not always what actually comes first on the part of the known considered in itself.

In the study of nature we are usually forced to work backwards in this fashion. For example, we know the alternation of day and night before we know the reason for it — a reason which it took some time to discover. To know that this phenomenon has always taken place, in all recorded experience, is one thing; to know why it takes place, is another. The expression of the observed regularity, as a general proposition reached by induction, becomes a substitute for the definition required by science in the strict sense.

3. - Induction of self-evident principles from sense-perception.

It has just been stated that the propositions which, in the study of nature, we must often make do in place of definitions like those available in mathematics, are arrived at by induction. This term induction is another which we must now recall to mind, if we are to understand the import of St. Thomas's preface. By induction, in general, is meant thinking our way from particulars to universals. The main thing to notice in the beginning is that there are two basically different types of induction. One of them unnoticed in ordinary life, because it goes on unceasingly, and as unconciously as breathing. It would be difficult to say just when we first suddenly understood that 'it is impossible to be and not be at the same time and in the same respect,' or that 'nothing can be a whole and a part in the same respect.' But the fact is that our certainty about the most general principles, presupposed as it is to all reasoning, is preceded by an induction, so natural that it passes unobserved.

The other kind of induction which, now spontaneously, now deliberately, considers the particular cases within reach and concludes, from them, to a general proposition,(1) is familiar to us as the typical procedure of the arts and crafts as well as of experimental science in general. These propositions are used as principles, but they are not the reason for the regularities which they enounce.

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(1). This type of induction is analyzed in Priora Analytica, II, c. 23, 68b5. See also Albertus Magnus, ibid., Tract. VII, c. 4. The text of this important exposition of the Priora has been transcribed from the Borgnet edition, long out of print, and made available in mimeograph by Michel Doyon, 725, Chemin Ste-Foy, Quebec, 1951.

In comparing these two sorts of induction, it must be noted that they differ, not merely in the frequency or ease with which they are carried on, but more fundamentally in the role assigned to the enumeration of particular instances and in the certitude finally achieved. It may sound surprising, but an induction may terminate in complete certitude without all instances having been covered, as in the case of first, self-evident principles; and, on the other hand, may cover all instances without yielding a sufficient reason. The first and basic type of induction, whereby the mind moves from sense perception towards general, self-evident principles, is nothing like a complete enumeration, nor do we need as much. Indeed, a principle like 'it is impossible to be and not to be etc.,' or 'any two things which, in the same respect, are like to a third, are in that respect like to one another,' could hardly be the result of an examination of all the cases, of which there is no end. In the process of acquiring knowledge, propositions such as these are dependent on sensation, memory and experience; yet, once we grasp them, we see that they must hold good in all possible instances. In other words, it is characteristic of this first type of induction that no attempt is made to offer the survey of the particular cases as the proper reason for the truth of the universal proposition (1). Cases may be referred to by way of illustration, but the reason for the truth of such a principle is none other than what we intuit in any single instance — once we have reached this term.

Since in the kind of induction which we have just referred to, no amount of particular instances is ever sought as the reason for accepting the strictly universal proposition, it can scarcely be called science, except in a loose sense, inasmuch as it has great certitude and is a necessary preliminary to all science.[2]

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(1) - See Post. Anal., II, c. 19, 99 b 15. Cf. St. Thomas, ibid., lect. 20. — (On the distinction between sense-perception, memory and experience, see also Metaphysics, I, c. 1, 980 b 20 - 981 a 30. St. Thomas, ibid., lect. 1). — Of this universality Aristotle says that it is "at rest in the mind" inasmuch as it is then perceived as independent of the particular, variable, instances; although we are dependent upon the sensation of some instances, upon memory and comparison of the instances retained, which results in experience. If we had no such knowledge, no word we use could have any meaning except as vocal sounds such as are produced by the beasts, i.e. signs of a state of passion, as the dog's bark or the lion's roar. For this type of induction, modern logicians still refer to Aristotle, and call it "immediate" or "intuitive induction." (See, e.g. W.E. Johnson, Logic, Part II, chapt. VIII, Cambridge, 1922, pp. 188 et sqq.; Morris Cohen and Ernest Nagel, An Introduction to Logic and Scientific Method, Routledge and Kegan Paul, chapt. XIV, pp. 273 et sqq.) "Intuitive induction" is not a very happy expression, inasmuch as this induction and the intuition that follows it are not one thing. The "seeing" or intuition consequent upon the induction is not the proper effect of the induction itself.

(2) - Traditional philosophy accounts for this use of the word science. Cf. Post. Anal., I, 31, 88 a 5. St. Thomas, ibid., lect. 42, n. 9; and In VI Ethicor., lect. 3, n. 1145.

We must now turn our attention to the second type of induction, where the multiplicity and similarity of the particular cases are actually given as the reason for a general statement offered as a conclusion. In this kind of reasoning from particular to universal, the enumeration of the cases may be either complete or incomplete. By complete is meant an enumeration which exhausts all possible cases, implying, of course, that they are clearly limited in number. Now, even when complete enumeration is possible, such that the property x is shown to be true of every possible instance, the inductive argument may still fail to give a proper, universal reason for a general statement that is yet certain.(1)

An example, using the materials of geometry, will show what is meant by a complete enumeration failing to reach the proper reason for a proposition that is enounced by way of a conclusion. Suppose one established that 'the sum of the angles of any triangle is two right angles' by way of induction in that the method one chose was to verify this properly in each of the three kinds of triangle, "first in the equilateral, again in the isosceles, and afterwards in the scalene tri-

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(1) - "An error of this kind is similar to the error into which we fall concerning particulars : e.g. if A belongs to all B, and B to all C, A will belong to all C. If then a man knows that A belongs to everything to which B belongs, he knows that A belongs to C. But nothing prevents his being ignorant that C exists; e.g. let A stand for two right angles, B for triangle, C for a particular diagram of a triangle. A man might think that C did not exist, though he knew that every triangle contains two right angles; consequently he will know and not know the same thing at the same time. For the expression 'to know that every triangle has its angles equal to two right angles' is ambiguous, meaning to have the knowledge either of the universal or of the particulars. Thus then he knows that C contains two right angles with a knowledge of the universal, but not with a knowledge of the particulars; consequently his knowledge will not be contrary to his ignorance." Priora Anal., II, c. 20, 67 a 5 - 20.

angle." (1) Seeing that a rectilineal three-sided figure either has its three sides equal, two of its sides alone equal, or its three sides unequal, the general statement will be quite certain : 'In every kind of triangle, the sum of the angles is two right angles.' Yet the verification of the general statement by enumeration of all the possible kinds of triangle does not provide the commensurately one and universal reason why it is true of each kind. "... Even if one prove of each kind of triangle that it has its angles together equal to two right angles, whether by means of the same or different proofs; still, as long as one treats separately equilateral, scalene, and isosceles, one does not yet know, except sophistically, that <u>triangle</u> has its angles equal to two right angles, nor does one yet know that triangle universally has this property, even if there is no other species of triangle but these. For one does not know that triangle as such has this property, nor even that every triangle has it, except in a numerical sense; nor does one know it according to the species [triangle] universally, though there be no kind [of triangle] in which one does not recognize this property." (2)

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(1) - On whether or not Aristotle's mention of such proofs (<u>Post. Anal</u>., I, c. 5, 74 a 15-35) refers to a historical development of the theorem, see Heath, <u>op. cit</u>., vol. I.pp. 317 et sqq.

(2) - <u>Post. Anal</u>., I, 74 a 25-35. Cf. St. Thomas, <u>ibid</u>., lect. 11-12. — Inasmuch as 'triangle' and other types of plane figure, such as circle, divide the genus 'plane figure', triangle is a species which, with regard to the kinds of triangle that in turn divide triangle into species, has the nature of genus. Figure is called the 'remote genus', triangle 'proximate genus.'

In the study of nature, too, an induction is judged complete when some general proposition is taken as true because it has been verified of each member of an adequate division; as when it is said that "irritability (the power of responding to a stimulus) is the general property of living beings" because it is true of both animals and plants.(1) However, although this may be the reason why we believe the property to be common, it is not a commensurately universal reason, which must be one and adequate to all possible cases. The same qualification should be made of an argument showing that all mobile beings are bodies because both animate and inanimate things — an adequate division of mobile beings — reveal three spatial dimensions; yet this is far from being the commensurate universal reason why anything that can be in movement must be a body. A genuine demonstration would have to show that 'to be per se in movement' belongs primarily to body as such.

More often, however, the induction used in the study of nature cannot be made complete. We say, for instance, that 'every man is mortal.' Yet, if this proposition is considered to be general merely because no man has been known to survive, its basis is an induction that is necessarily incomplete. For all practical purposes, the proposition is sound, but it is not based on the reason why man is mortal : that 'no man has been

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(1) - Even this so-called complete induction is only hypothetical, inasmuch as it must assume that the terms of the division have been verified. Such tentative or dialectical use of the '<u>dici de omni</u>' provides a universality that was formerly qualified as "<u>ut nunc</u>," i. e. valid in all the cases actually known. Cf. St. Thomas, <u>In I Post. Anal</u>., lect. 9, n. 4.

known to survive' is not the natural reason why 'every man is mortal.' If the sun rises tomorrow, it is not because, in all human experience, it has always happened before.(1) So long as we cannot find the reason why they occur, the regularities observed in nature (such as the eventual death of every animate thing) will by themselves provide no strictly universal proposition. The reason why man, as well as any other animate thing, is mortal must be found in what is inseparable from being an animate thing, and therefore from being a man.(2)

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(1) - Aristotle's famous hypothesis of a radical difference between the phenomena on our planet and those of an astronomical scale, is a case in point. He assumed that the latter were entirely uniform, unaging and unalterable, from which he concluded that they could not be subject to contrary states, such as hot and cold, so that the heavenly bodies, e.g. the sun, were actually incorruptible. "The mere evidence of the senses [he said] is enough to convince us of this, at least with human certainty. For in the whole range of time past, so far as our inherited records reach, no change appears to have taken place either in the whole scheme of the outermost heaven or in any of its proper parts." (De Caelo, I, 3, 270 b 10)
"Nevertheless [St. Thomas adds, in his commentary, lect. 7, n. 6] this is not necessary, but only probable. For the more a thing is lasting, the more time is required to observe its change: for instance, the change that over a period of two or three years takes place in a man is not as readily observed as that which affects a dog, or some other shorter-lived animal, during a time of equal length. Hence one could say that while the heaven is naturally corruptible, it is so long-lasting that the whole span of time which memory can record is not enough to observe its change".

(2) - We shall see, in Part II, that any observed frequency in nature must set us on to seek a determinate reason.

5. - <u>The 'universal' of demonstration is not the same as the universal that is merely 'predicable of many'.</u>

In other words, the universal, as understood in strict science or demonstration —, of which an example is 'to have its three angles equal to two right angles' — must show the following characteristics : [a] it must be true of all instances that are under it (e.g., of each and every triangle; [b] its subject must belong to the very definition of the property (e.g., 'to have two angles equal to two right angles' implies triangle as having an exterior angle equal to the two opposite interior angles, viz. the per se subject of this property which follows from it with necessity); [c] it is primarily in that of which it is said (i.e. primarily in triangle as such, and not primarily in each one of its species).[1]

To assume that one has demonstrated that the triangle as such has the sum of its angles equal to two right angles by showing it to be true primarily of each one of its kinds, is to be satisfied with the mere appearance of a reason. In fact the statement : 'In every kind of triangle the sum of the angles is two right angles,' when it is understood as the result of an induction by complete enumeration, is not a demonstrative conclusion at all, but a mere restatement of something already known, viz. [a] that any triangle is either <u>e</u>, <u>i</u>, or <u>s</u>; [b] that <u>e</u>, <u>i</u>, and <u>s</u> each have their angles equal to two right angles.

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(1) - <u>Post. Anal</u>., I, cc. 4 & 5, 73 a 20 - 74 b 5.
St. Thomas, <u>ibid</u>., lect. 9-12.

What we are trying to show is that to establish something by induction as true of a class of things, is not to prove anything about the nature of the thing in itself. Such inductions, however exhaustive, will always suffer from this limitation. The reason is that a class, as such, is never the same thing as a universal. A class, or collection, may be no more than an incidental whole, *a mere heap;* a grouping which supposes something held in common by many objects, but not necessarily something pertaining to what they are in themselves. If, instead of meaning 'a rectilineal figure contained by three sides', which is one in notion, the term 'triangle' were used to stand primarily and immediately for the class of each and all triangles, 'triangle' could be said of no triangle whatsoever, neither of a kind nor of an instance of a kind. Where the term 'triangle' is intended to mean a class of things, to say triangle of equilateral, or of this particular one, would mean that 'equilateral' is the class of all triangles, whether equilateral or no. Likewise, if, ignoring the rules of supposition,[1] we interpreted 'man' to mean primarily and immediately the class 'men' (that is, all of the subjective parts of the universal nature 'man', viz. all beings of which 'man' can be predicated), then, to say 'man' of Socrates would mean that he is each and every man : Socrates and all men who are not Socrates, viz. all who have been, are, shall be, might

A mere heap, a grouping of things which, at least in some extrinsic respect,

Perhaps the example of the heap of heterogeneous things would be helpful.

What are the rules of supposition ?

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(1) - Cf. John of St. Thomas, Cursus Philosophicus, Logica, P. I, lib. II, cc. 10-12; Quaest. disput., q. 6 (edit. Reiser, t. I, pp. 29-35; pp. 166-182).

have been, and even 'all possible men.' Actually, a collection, as such, like an individual, can be predicated only of itself, viz. in a proposition of identity, 'A is A', 'Socrates is Socrates,' or 'All Greeks are all Greeks.'

If 'triangle' meant primarily and no more than the <u>class</u> of all triangles, the 'equilateral' could not even be called 'triangle' since this would imply that the class of all triangles is in the same respect both equal and unequal to only part of itself. It would be false to say : 'A rectilineal figure that has its three sides equal is a figure', or that 'it is a rectilineal figure,' or 'a rectilineal figure that has three sides.' For all these terms ('figure,' 'rectilineal figure', etc.), when used to signify collections <u>qua</u> collections, are equivalent to symbols, viz. the kind of arbitrary signs that are distinguished from names.

6. - <u>The object and subject of a science</u>.

By the 'object' of a science, in the strictest sense of the term science. we mean the kind of knowledge which is acquired as the result of demonstration. e.g. that 'the plane triangle has its angles equal to two right angles'. The object of science is therefore none other than the conclusion. in which something (e.g. 'to have its angles equal to two right angles') is said about something (e.g. 'triangle'). This object, then, is something complex : a composition of subject and predicate, which. in perfect science, follows from the definition of the subject (e.g.,to be a triangle is 'to have an exterior angle equal to...'") or from the substitute of a definition. By the 'subject' of a science, we mean that about which we have knowledge by demonstration, viz. the very subject of the conclusion or 'that about which' (e.g. 'triangle') something is asserted (e.g. the property 'to have the sum of its angles equal to...'").

Now the subject about which we assert something in the object or conclusion of the demonstration does not of course make its first appearance in the conclusion. Something has already been predicated of that same subject, in the principles or premises of the demonstration. E. g., of the triangle we said that 'it has its exterior angle equal to the two interior and opposite angles,' and it is in virtue of this that the conclusion follows, viz. that 'the triangle has its three angles equal to...". A. v., the subject of scientific knowledge is both(i) what is first known, viz. that about which we seek science,[1] and (ii) what is last known, viz. that same subject as possessing such or such a property. The subject, considered in the latter respect, is called the 'term' of the science.[2] There is, then, no contradiction in saying, on the one hand, that students should know "from the very beginning of their course... what the science is about", and, on the other hand, that "the last thing to be discovered in any science is what the science is really about".[3]

Although every demonstration produces scientific knowledge, a particular demonstration, obviously, does not constitute a science all by itself, since, if it did, there would be as many sciences as there are particular demonstrations. Rather, a single science, such as geometry, embraces many objects or conclusions, e.g. that 'the sum of the angles of a triangle is two right angles'; that 'the angle in a semi-circle is a right angle'; etc. And these form what is called the material object of a science. Now what is the principle that gathers such objects into a single science ? Why do certain conclusions belong to mathematics and not to the science of nature ? This will be what is called the formal object of the science.

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(1) - In geometry, that which is first known and about which we seek scientific knowledge, is magnitude; whereas the particular subjects are known by way of construction, as we saw. These, in turn, are known before the demonstration of their properties.

(2) - St. Thomas, In I Post. Anal., lect. 41, n. 7.

(3) - A. N. Whitehead, An Introduction to Mathematics, the Home University Library, pp. 8 and 223.

We have noted that the means by which we acquire scientific knowledge are none other than the definitions. Since the definition is the proper principle of the conclusion or object of science, what, for instance, do the definitions of geometry have in common ?

To make this point briefly, we propose the question : how could we show that in nature there is such a thing as an equilateral triangle ? By what method could we verify that this triangle cut in bronze has its three sides equal, or that its exterior angle is equal to the two opposite and interior angles ? By what means could we demonstrate that the angles of a metal triangle are equal to two right angles ? The only way would be a process of measurement by means of some standard or 'measure.' By 'measure' we mean 'that by which the quantity of a thing is known, primarily.' If the measurement is to be quite exact, the measure must be indivisible. Now, 'to be quite indivisible' is true only of the 'one' that is the principle of number; whereas of things, in nature, that are continuous, there can be no exact measure.

(So long as the measure can be divided, to the same extent the measured can be more exactly known.)

For, on the one hand, "the measure is always homogeneous with the measured : the measure of magnitudes is a magnitude, and in particular that of length is a length, that of breadth a breadth, that of articulate sound articulate sound, that of weight a weight, that of units a unit. (For we must state the matter so, and not say that the measure of numbers is a number; we ought indeed to say this if we were to use the corresponding form of words, but the claim does not really correspond - it is as if one claimed that the measure of units is units, and not a unit; number is a plurality of *units*.)"[1] On the other hand, the measure of a magnitude is itself a magnitude, and every magnitude *qua* magnitude is divisible without end. Hence, to be entirely exact, the standard of length would have to be both length and not length, divisible and indivisible. That is why, for all practical purposes, some length, chosen by convention, like the yard or the metre, is declared the correct standard.[2] The subdivisions of such a standard make possible some improvement in precision,[3] but can never attain the exactness of mathematics, nor permit the demonstration of a theorem.

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(1) - *Metaphys.*, X, c. 1, 1053 a 25.
(2) - *Cf. Aristotle*, *Metaph.*, X, c. 1, 1052 a 15 - 1053 b 8. *St. Thomas*, *ibid.*, lect. 1 and 2. - Sir Arthur Eddington, *Space-Time and Gravitation*, Prologue, pp. 1-16. *Of the standard of length* Sir Arthur said that "it has no length." This paradoxe may prove helpful to call attention to the difference between (a) length as 'to be extended according to one dimension' and (b) length as 'what is known by means of the measure of length.' The measure must have length in the first sense; it cannot have length in the second sense since, by definition, the standard of length cannot be measured - except *per accidens*, as when we express the ratio between the standard of one system of measurement, e.g. the meter, in terms of the standard of another system, e.g. the English, or the U.S. 'yard'; but in either case the measured ceases to be taken as the standard.
(3) - The metre, although of considerable magnitude, may be called the 'minimum of length', provided we mean 'the material object whose variations owing, e.g. to changes in temperature, can be more conveniently controlled; while the variations in a smaller object would be less noticeable.

The reason why we can achieve complete exactness in geometry is that the definitions we use are formally independent of, and have no reference to, the order of sense-experience, while the conclusions are established as following from such definitions with necessity. Yet geometry can demonstrate that there *is* a triangle whose sides are equal, and that the angles of any triangle are equal to two right angles. Why can we not do the same of a metal triangle ? A. v., why should the object of sense experience place such a limitation on exactness ? By explaining the words, from the quotation of St. Thomas, "a thing becomes intelligible in act insofar as it is more or less abstracted from matter," we may obtain the answer to this question, and show the reason for the distinction between the 'matter' and the 'subject' of a science.

Now the word 'matter' in 'abstraction from matter' and in 'the matter of a science' does not mean quite the same thing. First, what is this 'matter' from which we must prescind as an essential condition of science.

7. - <u>What is 'abstraction from matter' ?</u>

Both the Greek word ὕλη and the Latin <u>materia</u>, originally meant '<u>timber</u>'; then, more generally, 'building material', including stone as well as timber, bricks, cement, etc.: finally, the 'stuff' or 'that of which' anything is composed, e.g. the vapor of a cloud, the water of a wave, the sides of triangle, the terms of a syllogism, etc.

Now the original meaning of words is often necessary to understand the meaning of its later impositions. The reason is that the original meaning refers to what we know first and best. For instance, the word 'light' means primarily that which makes manifest to the sense of sight; then it is extended to knowledge of any kind, as when we say : 'Let us look at this problem in the light of new evidence'. The understanding of an extended meaning of a word depends upon knowledge of an original sense, as in the case of 'light', 'substance', 'matter', 'form', 'abstraction', etc. This does not imply that the understanding of an extended meaning depends upon knowledge of a word's authentic etymology. Whatever the philological origin of 'to illuminate', the kind of original meaning we have in mind here is sufficiently verified by pointing to what is the case when we switch on a light that enables us to see. Extended meanings of words express the order of our knowledge, for we name things as we know them, and the names of things not immediately known should first be verified of things first known.

I wonder whether "lumber" might not be a better word, for although timber has reference to construction, lumber seems to have a more proximate reference. Wood is called timber even when still in the forest, but lumber only after it has been cut.

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Manual →

Chenuse 708

March 54

Book I { The principles of the subject of this science.

Lesson I: The kind of Science Here to be Studied

Lesson II: What is meant by "mobile being"

Lesson III: Discussion of Parmenide's and Milissus's assertion that all things are on being

Lesson IV: Pas de titre

Lesson V:

Lesson ~~VI~~: IX: Anaxagoras provides the first hint of the solution

Lesson X: Restatement of the problem: absolute becoming

Lesson XI: Dialectical approach to the problem of absolute becoming

Lesson XIII: Matter and Form

Lesson XIV: The Conditions of Becoming

Lesson XV: Whether form is the good of matter

Book II: { The principles of the science of nature:

Lesson I: What is meant by nature

Lesson II: Matter and Form in relation to nature

Lesson III: Natural Doctrine and Mathematical Physics

Lesson IV: This Science considers ...

Lesson V: Whether the science of nature seeks knowledge of causes

Lesson VI: Division of Causes according to their modes

Lesson VII: Various opinions on "Fortune" and "Chance"

Lesson VIII: What Fortune is

Lesson IX: The reason why the philosophers of old ...

(?)

ch. II : The order of Procedure

ch. III: The Problem that mobility gives rise to...

{ grandes feuilles 8½x14

Pages suivies numérotées par CDK.

Première copie du "Manuel de Philo de la Nature" envoyée à Prentice Hall le 24 mars 1954.

Dans la lettre accompagnant ce manuscrit, M. De K. dit à propos de ce texte :

> "What I'm sending you under separate cover by airmail conveys barely one fourth of the complete ~~work~~ work ~~in~~ in which I intend to follow Aristotle's text as closely as I can. It is this change of method which I decided upon too late that is the cause of the delay. Book I is still largely the original outline. The first lessons of Book II as well; but from lesson VI ~~no~~ 19 on, you have a complete first draft which may give your copy-readers an idea of the method I follow. Much of Books V, VI and VIII are ready, but in French."

Lettre à Mr. James F. Leisy,
March 27th, 1954.

Voir : Corr. Prentice Hall.

Et encore à propos de ce texte, M. De Koninck écrit à Oesterle:

> "Last night, I sent to Mr. Leisy a mere 93 pages of manuscript on which only half were more than an outline of Books I and II."

Lettre à M. J-Oesterle
March 31, 1954.
Voir. Corr. Oesterle

The completed portion of the text begins on p. 44.

PHILOSOPHY OF NATURE

QUEBEC, March 1954.

Peenha - Hall

THE METHOD FOLLOWED

By Philosophy of nature I understand what Aristotle calls "the more philosophical parts" of the study of nature. This work is intended to be no more than a general introduction to such a study, leading to the specialized fields of physics, chemistry, and biology.

Although I follow as closely as I can Aristotle's Physics and Aquinas's commentary on that work leaving out those problems and discussions which are no longer relevant, my aim is purely doctrinal, not at all historical. The double-spaced text is largely a paraphrase and in parts direct translation. (The translations I use are those of Hardy-Gaye Oxford , Wicksteed-Cornford Harvard . The translation of St. Thomas is my own.) That text makes up the main body of the work. I have decided to follow the division of the leonine edition of St. Thomas's commentary, which is also that of Pirotta's recent manual edition. This should prove an advantage to the teacher who may wish to verify the fidelity of my exposé, making the latter more useful to the student as an introduction to further study of the original texts. I try to take into account the positions of modern philosophers on the various subjects discussed.

All marginal considerations are copied with single space. If the curriculum does not allow time to go through the whole work in one semester, the course may be confined to the main text.

As much as possible I try to avoid so-called "technical" terms, and have recourse, instead, to words in common usage.

INTRODUCTION

TO THE

STUDY OF NATURE

Foreword

Scope & aim of present work. Its limitations so great as almost to invalidate its claim to be an introduction to the science. Yet some sort of simple survey has to be written for beginners.

The order to be followed. No escape possible from that of Arist & St Thos, nor is it possible to abridge what they write. Only choice left is to present material in sequence observed by them with special emphasis on what beginner needs most, and simply to omit anything a beginner can do without. It is these omissions which are the difficulty. The author has used his best judgement and yet must acknowledge that he is attempting to lead students to a knowledge of a living form by offering for their study a few stray limbs and organs. Yet there seems no help for it if the book is to be kept within reasonable limits.

As the flimsiest but only available compensation for the doctrine which had to be sacrificed, the pages of this text bear marginal references to St. Thomas' great comment. on A's Physics. The student who is able to follow them up