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ST. THOMAS'S CONCEPTION OF NATURAL PHILOSOPHY AND ITS METHOD

The views of St. Thomas Aquinas on natural philosophy have been greatly overshadowed by his contributions to metaphysics and natural theology. One reason for this is that in the latter fields it is easily recognized that St. Thomas went far beyond Aristotle in offering distinctive solutions to the problems of essence and existence, creation, and God's existence and attributes (1). Another is the general eclipse into which natural philosophy or cosmology itself has gone in recent decades — one could say in recent centuries — owing to the rapid rise and acceptance of modern science and the philosophy implicit in its practice (2). Yet Aquinas himself was an excellent natural philosopher,

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(1) The extensive renewal in Thomistic studies that took place in the mid-twentieth century was prompted in large part by interest in metaphysical problems, owing to the studies of Etienne Gilson and others in the history of medieval philosophy and of Jacques Maritain in contemporary philosophy. Neither Gilson nor his disciples focused any attention on natural philosophy, however, and perforce they manifested no interest whatever in the philosophy of science. (Gilson once told me that he did not regard the philosophy of science as a legitimate field within the philosophical disciplines). Maritain and his disciples, on the other hand, were concerned to some extent with natural philosophy, but one of their main endeavors was to extricate it from modern science with its changing theories and revisionist attitudes. This caused them to limit its scope drastically from the way in which the discipline was conceived by St. Thomas. The obvious relevance of metaphysics for laying out and defending the *praeambula fidei* is another factor that explains the preference of recent Catholic thinkers for metaphysical studies over those concerned with the world of nature.

(2) The decline of Aristotelian natural philosophy can be traced to the Scientific Revolution of the seventeenth century, at which time observational evidence began to accumulate in support of a heliocentric universe as opposed to the geocentric Ptolemaic universe to which Aristotelian cosmology seemed irrevocably tied. Over the next three centuries the various Aristotelian tracts that were used in the universities to teach the *scientiae naturales* were successively superseded: the *De caelo et mundo* in the seventeenth century consequent on the work of Galileo, Kepler, and Newton; the *De generatione et corruptione* in the eighteenth

and he had a particularly acute knowledge of the methodology one must pursue when delving into nature's secrets. Living as he did some sixteen centuries after Aristotle, and benefiting from the considerable growth of knowledge of the universe during that period, he also was able to transcend Aristotle on a number of important points relating to man's knowledge of nature and the cosmos (3). St. Thomas's natural philosophy was therefore distinctively his own, and if it did not break so radically with Aristotle's as did his metaphysics, and on this account may still be regarded as a species of Aristotelianism it represented a type of « progressive Aristotelianism » that incorporated much that was new and that takes on special importance in our own day (4).

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century with the rise of modern chemistry; and the *De anima* and its associated works in the nineteenth century with the growth of modern biology. Yet troughout this time there was a continued search for the causes of natural phenomena, with the result that the new sciences themselves had foundations that were at least implicitly Aristotelian, as I have attempted to document in my two-volume *Causality and Scientific Explanation* (Ann Arbor: University of Michigan Press, 1972-1974; reprinted Washington: University Press of America, 1981). In recent decades courses in natural philosophy or cosmology have been on the decline in seminaries and Catholic institutions, mainly because of the diminished philosophy requirements in the aftermath of the Second Vatican Council. Furthermore, the decreased interest in nature has been accompanied by an increased interest in science, so that courses in the philosophy of science have tended to displace those in the philosophy of nature even in colleges and universities where an effort is made to teach all philosophical disciplines.

(3) Among St. Thomas's more important contributions, apart from those in methodology to be discussed below, were his analyses of the temporal relationships between cause and effect, his recognition of the hypothetical character of explanations of celestial motions employing eccentrics and epicycles, and his quite sophisticated treatment of place and of the possibility of motion through a void. For a general overview see my entry « Thomas Aquinas » in the *Dictionary of Scientific Biography*, ed. C. C. Gillespie, 14 vols., New York: Charles Scribner's Sons, 1970-1980, Vol. 1, pp. 196-200; more details are given in my « Aquinas on the Temporal Relationship Between Cause and Effect, « *The Review of Metaphysics,* 27 (1974), pp. 569-584, and « Natural Philosophy and the Physical Sciences, « *Philosophy and the Integration of Contemporary Catholic Education*, ed. G. F. McLean, Washington: The Catholic University of America Press, 1962, pp. 130-157.

(4) Unfortunately there is a tendency among intellectual historians to view Aristotelianism as a monolithic system that underwent little development from the death of Aristotle to the present. Like most « -isms », however, Aristotelianism is a complex movement made up of many versions, from the rather conservative teachings of Greek and Arab commentators to the progressive interpretations of the Scholastics. For a good survey see the entry « Aristotelianism » by J. J. Glanville in the *New Catholic Encyclopedia*, ed. W. J. McDonald, 15 vols., New York: McGraw-Fill Book Co., 1967, Vol. 1, pp. 799-809; also C. B. Schmitt, « Towards a Reassessment of Renaissance Aristotelianism », *History of Science,* 11

It is generally known and admitted, of course, that St. Thomas did not advocate or attempt to advance the type of radical or heterodox Aristotelianism that began to flourish in the arts faculty at Paris during the latter part of the thirteenth century and that led to the condemnations of 1270 and 1277 ([5]). What is not so generally appreciated is that a goodly number of these that were then condemned actually pertained to natural philosophy, and that on this account the discipline itself was considerably inhibited by the condemnations ([6]). One might even argue that philosophical movements developing after the condemnations, such as Scotism and Ockhamism, accord much less value to natural philosophy than does Thomism ([7]). Further, Aquinas's conception of natural philosophy and its method, if understood by the

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(1973), pp. 159-193. As a philosophy Thomism may be seen as a species of Aristotelianism, though much more progressive and open-ended than other versions focusing exclusively on philology and textual interpretation. Some evidence in support of this view is given in my « Thomism and Modern Science: Relationships Past, Present, and Future, « *The Thomist,* 32 (1968), pp. 67-83, and « The Case for Developmental Thomism », *Proceedings of the American Catholic Philosophical Association*, 44 (1970), pp. 1-16.

([5]) A recent study that investigates the position of St. Thomas vis-à-vis the heterodox Aristotelians of his day is that of Fernand van Steenberghen, *Thomas Aquinas and Radical Aristotelianism*, Washington: The Catholic University of America Press, 1980.

([6]) The more important theses relating to natural philosophy and medieval science have been translated into English by Edward Grant, ed., *A Source Book in Medieval Science,* Cambridge, Mass.: Harvard University Press, 1974, pp. 45-50. Grant's introduction and commentary give a balanced account of the influence of the condemnations on the subsequent development of natural philosophy and natural science.

([7]) In an essay entitled « Autonomous and Handmaiden Science: St. Thomas Aquinas and William of Ockham on the Physics of the Eucharist », printed in *The Cultural Context of Medieval Learning,* eds. J. Murdoch and E. Sylla, Dordrecht-Boston: D. Reidel Publishing Company, 1975, pp. 349-396, Edith Sylla has argued that Ockham's philosophy was more conducive to the development of modern science than was that of Aquinas. In so doing she overlooks the fact that Ockham's inspiration was at root theological, with the result that he had to weaken cognitive claims based on reason to make room for his faith commitment, just as Immanuel Kant was to do centuries later. St. Thomas, on the other hand, granted reason its full autonomy when exploring the world of nature so as to provide a rational foundation on which to erect his speculative theology. With regard to Scotism, Scotus's position is more difficult to evaluate in the absence of authentic texts detailing his natural philosophy, but his voluntarism caused him generally to devalue the power of reason for laying bare the secrets of nature. He too was inhibited by the condemnations of 1270 and 1277, and thus could not be as straightforward as Aquinas in advancing the claims of reason against the theological orthodoxy of his day.

theologians of his day at Paris, could well have averted the condemnations themselves. Indeed, it was St. Thomas's understanding of nature that grounded his concept of being and the metaphysics he was able to elaborate, to say nothing of his theology, which history has shown to be both consonant with Christian revelation and the Catholic faith ([8]). Apart from these broader ramifications of his natural philosophy, St. Thomas's views on its methodology were open to quick assimilation of the scientific advances that came after his death, and, as my own recent discoveries have shown, exerted an important influence on the « new science » that was to be formulated by Galileo in the early seventeenth century ([9]). Because of the key role Thomism could play in this development, it takes on special value for bridging the gap between natural philosophy and the many sciences that seem to compete with it on the twentieth-century scene ([10]).

These are some of the reasons one might adduce for the importance of the subject being addressed in this symposium. Yet the topic is not an easy one, for it cannot be approached adequately without a deep knowledge of the texts of Aristotle on which St. Thomas commented, both in their Greek original and in the various forms in which the *libri logicales* and the *libri naturales* arrived in the Latin West, to say nothing of Aquinas's commentaries and related *opuscula,* the extensive

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([8]) For Aquinas, the study of natural philosophy is necessary to establish a subject for the science of metaphysics, for it is the evidence for the existence of separated substance arrived at by the end of the *Physics* and of the *De anima* that alerts one to the fact that being is not necessarily material, and so can be studied for the characteristics it shares as either material or immaterial. If immaterial substances did not exist, as St. Thomas observes, then natural philosophy itself would be « first philosophy ». See his *In VI Meta.*, lect. 1; also *In VII Phys.*, lect. 2; *In III De anima,* lect. 10; *In Boeth. de Trin.*, q. 5, a. 1; and *In IV Meta.*, lect. 5.

([9]) Some of the basic studies that connect Galileo with the developing Thomistic tradition of the Collegio Romano appear in my *Prelude to Galileo*: *Essays on Medieval and Sixteenth-Century Sources of Galileo's Thought.* Boston Studies in the Philosophy of Science, Vol. 62. Dordrecht-Boston: D. Reidel Publishing Company, 1981 — see especially Essays 8 through 10, pp. 129-252. More detailed evidence is provided in my *Galileo's Early Notebooks*: *The Physical Questions.* A Translation from the Latin, with Paleographical and Historical Commentary. Notre Dame: Notre Dame University Press, 1977.

([10]) In this respect Thomism, though systematically developed long before the rise of modern science, can provide the foundation for a realist philosophy of science that is based on, and acknowledges the importance of, a philosophy of nature. I have assembled a collection of my essays that make this point in *From a Realist Point of View*: *Essays on the Philosophy of Science*, Washington: University Press of America, 1979.

development of his thought in the Thomistic tradition as it came to be juxtaposed to that of competing « Schools », and the various philosophies of science that have developed since the seventeenth century [11]. It would be impossible to treat all these matters in any detail in a brief essay, and yet they should at least be mentioned so as to locate what will be stated in proper perspective and focus.

Sources in Aristotle and Albert the Great

The roots of St. Thomas's conception of natural philosophy are obviously to be found in Aristotle, particularly in the latter's teachings in the *Physics* and the *Posterior Analytics,* and more proximately in the teacher who formed St. Thomas's mind and heightened his appreciation of the Aristotelian corpus, St. Albert the Great, who exposed these and other works for the enlightenment of his fellow Dominicans [12]. The topics in the *Physics* that bear most directly on the scientific character of natural philosophy and its method are to be found in the second book of the *Physics,* for it is in this locus that Aristotle analyzes the subject of natural science, *phusis;* explains how it is different from the subject of mathematics; enumerates the types of causes through which it demonstrates; points out the existence of chance and contingency in the operations of nature; and, finally, in a key passage in its final chapter, stresses that nature's necessity is of a special type because of the contingent matter with which it deals, and so cannot be *haplos* but can only be *ex hupotheseos* [13]. The latter expression, *ex hupotheseos,* reappears in Aristotle's other physical writings, and is explained at fuller length in his *De partibus animalium* [14]. Unfortunately it

(11) Some facets of this development, and particularly the use made by Aquinas of Greek and Arab commentaries on Aristotle, are of course treated in other essays in this volume.

(12) There has been a tendency to undervalue St. Albert's role in St. Thomas's intellectual formation, despite the lip-service paid to the former as Aquina's teacher within the Dominican Order. The recent centennial celebrations for both (Aquinas's in 1974 and Albert's in 1980), however, have supplied new information that will be helpful in reassessing the relationships between master and disciple. Studies that provide useful analyses concerning the subject of this essay will be found in J. A. Weisheipl, ed., *Albertus Magnus and the Sciences,* Toronto: Pontifical Institute of Mediaeval Studies, 1980; F. J. Kovach and R. W. Shahan, eds., *Albert the Great: Commemorative Essays,* Norman: University of Oklahoma Press, 1980; and G. Meyer and A. Zimmermann, eds., *Albertus Magnus Doctor Universalis 1280-1980,* Mainz: Matthias-Grunewald-Verlag, 1980.

(13) ARISTOTLE, *Physics,* II.9, 199b33-200a16.

(14) For a listing and analysis of the more important texts, see my « Aristotle

did not attract much attention from commentators before Albert and Thomas, and in modern English translations its meaning is obscured by translating it as « from hypothesis » or « hypothetically », thereby creating the impression that nature's necessity is only hypothetical and that its method must be hypothetical also. This translation presents difficulty in terms of understanding how the study of nature. with its contingency, can achieve the status of *episteme* or *scientia,* since hypothetical reasoning is more generally associated with dialectical inquiries than with strict science in the Aristotelian sense.

Aristotle's companion treatment of the requirements for *episteme* or scientific knowledge is the *Posterior Analytics,* and in both books of this work expressions occur that cast doubt on the possibility of natural philosophy achieving true epistemic status. In the first book, for example, stress is placed on the requirement that demonstrations must be concerned with matters that are necessary and eternal, and thus there cannot be science of « perishables » — precisely the category of entity with which natural science must habitually deal ([15]). Then, in the second book, Aristotle seems to argue forcibly for the simultaneity of cause and effect, thus ruling out the possibility of achieving any certitude in cases where causes achieve their effects through motion and over a period of time — again a situation that seems to characterize most phenomena in the order of nature ([16]). Despite the difficulties these texts create, however, Aristotle spells out procedures for demonstrating the properties of infrequent occurrences such as eclipses and rainbows; for arguing from effects to their causes, as the natural philosopher must frequently do, and then returning from causes to effects again to give *propter quid* demonstrations; and for employing mathematical reasoning to achieve certitude even in the order of nature ([17]). From the general cast of his expositions in the *Physics* and the *Posterior Analytics* there can be no doubt that Aristotle regarded natural philosophy as an *episteme phusike,* but precisely how it achieves this status is not transparently clear from his writings ([18]).

St. Albert the Great wrestled with this problem and made a number

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and Galileo: The Uses of *Hupothesis* (*Suppositio*) in Scientific Reasoning », in D. J. O'MEARA, ed., *Studies in Aristotle*, Washington: The Catholic University of America Press, 1981, pp. 47-77.

([15]) *Posterior Analytics,* I. 8, 75b21-36.

([16]) *Ibid.,* II. 12, 95a10-96a20.

([17]) *Ibid.,* I. 8, 75b32-36; I. 13, 78a22-79a16; I. 9, 75b36-76a30; and I. 27, 87a31-38.

([18]) See *De partibus animalium,* I. 1, 639b24-640a7. I have addressed this problematic in the essay cited above in note 14.

of important contributions to its solution that later influenced Aquinas. While aware that parts of the natural sciences will not rise above the level of dialectics, Albert consistently applied the canons of the *Posterior Analytics* in elaborating his commentaries on the *Physics* and in his specialized treatises devoted to the different types of natural bodies, namely, those of the heavens, elements and compounds, minerals, plants, animals, and man, to show how the ideals of *scientia naturalis* can be realized in these various subject matters ([19]). In his exposition of the *Physics,* moreover, Albert is at pains to point out how mathematical demonstrations differ from those found in the study of nature: the mathematical disciplines are concerned with a necessity that is absolute, whereas the natural philosopher is invariably dealing with a necessity that is only suppositional ([20]). The reason for this, in Albert's view, is that the mathematician works with internal causes alone, i.e., with matter and form, which cannot be impeded in their operation, whereas the naturalist analyzes his subject in terms of both internal and external causes, adding the agent and the end to matter and form as his proper principles of explanation. Nature clearly acts for an end — and no medieval had doubts about the truth of that axiom — but since external causes can be impeded it does not always attain the end it intends. Thus Albert is aware that one must reason « on the supposition of the end » being attained when formulating demonstrations in the science of nature ([21]).

Making the point somewhat differently, Albert observes that in mathematical proofs the premises have a necessity in themselves as well as in relation to the conclusion they generate, and thus they incorporate a twofold necessity, one a necessity of inference or consequence (*necessitas consequentiae*) and the other a necessity of conclusion or consequent (*necessitas consequentis*) ([22]). In demonstrations relating to natural processes, on the other hand, he maintains that there is no *necessitas consequentis* because the end result of a natural process is never automatically assured; yet one can discern within such a process a *necessitas*

([19]) Details of this application are provided in my « The Scientific Methodology of St. Albert the Great », in *Albertus Magnus Doctor Universalis 1280-1980* (note 12 *supra*), pp. 385-407. See also my entry « Albertus Magnus » in the *Dictionary of Scientific Biography* (note 3 *supra*), Vol. 1, pp. 99-103.

([20]) Albertus Magnus, *Physica,* lib. 2, tr. 3, c. 5, ed. Borgnet 3:172a-173a. For an analysis of these and related texts, see my « Albertus Magnus and Suppositional Necessity in the Natural Sciences », in *Albertus Magnus and the Sciences* (note 12 *supra*), pp. 103-128; also the article cited in the previous note.

([21]) *Ibid.,* 3 : 173b.

([22]) *Ibid.,* 3 : 173b-174b.

consequentiae, i.e., a necessity of proper inference, by basing one's reasoning on the supposition of causes not being impeded and so of nature's ends being regularly attained. Thus in a natural demonstration the end or *finis* can be made to serve as principle in the same way as premises serve as principles in a mathematical demonstration. It is in this way that Albert would understand Aristotle's use of the expression *ex hupotheseos*: there is a necessity « from the hypothesis of the end» or *ex conditione finis* in the order of nature, and this necessity is sufficient to ground a strict *scientia naturalis provided* one knows how to seek out demonstrations in the radically contingent subject matter with which it is normally concerned (23).

St. Albert explains this technique at some length in his *Physics* commentary, and then elaborates on it in more detail in his *De animalibus,* where he shows how it can be utilized to raise the study of animals and their organs to the causal or scientific level (24). Unfortunately, however, he does not make reference to it in his exposition of the *Posterior Analytics,* which is rather perfunctory and was probably composed before his physical writings, and thus one reading his methododological treatises alone would not be alerted to his knowledge of its use.

Methodology in Natural Philosophy

Being Albert's student, it is not surprising that St. Thomas benefited from these insights of his mentor and was able to develop them in a systematic way. Most of Thomas's own commentaries on Aristotle came late in his teaching career, but even his early exposition of Boethius's *De Trinitate* shows his enduring concern with the natural sciences and the modes of reasoning that serve to differentiate them from mathematics and metaphysics (25). The fact that he turned from his *Summa theologiae* toward the end of his life to write commentaries on the *Physics,* the *De caelo,* the *De generatione et corruptione,* and the *Meteorology* indeed attests to the importance he attached to natural philosophy, and this not only in its most general part dealing with *ens mobile in communi* but also with its special disciplines that treat of the phenomena of nature in all their specific detail.

Already in his commentary on the *Posterior Analytics,* moreover,

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(23) *Ibid.,* 3 : 174a.

(24) ALBERTUS MAGNUS, *De animalibus,* lib. 11, tr. 1, cc. 2-3, ed. Stadler, *Beiträge zur Geschichte der Philosophie des Mittelalters,* 15 : 765-778.

(25) *In Boeth. de Trin.,* qq. 5-6. See Leo Elders' helpful commentary on this work, *Faith and Science,* Rome 1974.

Aquinas had addressed the methodological problems raised by defective agents, non-eternal occurrences, and temporal intervals between cause and effect to show how these need not rule out the possibility of demonstrative knowledge of nature in all its contingency ([26]). He introduces the Latin equivalent of Aristotle's expression from the *Physics, ex hupotheseos,* in fact, into his exposition of the *Posterior Analytics,* explaining there that in cases like these demonstrations must be made *ex suppositione finis* — essentially the same doctrine contained in Albert the Great's physical writings ([27]). (In his commentary on Bk. 2 of the *Physics* Aquinas further analyzes this technique.) ([28]). Other topics that reveal his awareness of the connections between the *Analytics* and the *scientiae naturales* are his defense of the validity of *a posteriori* demonstration, the possibility of converting *a posteriori* demonstrations into *propter quid* demonstrations under certain circumstances, the order of causal explanation to be followed in arriving at definitions of natural entities, the value and limitations of mathematical middle terms when employed in the *scientiae mediae,* and the indispensable character of induction and sense experience as both the starting point and terminus of natural reasoning ([29]). One might remark that, of all the thirteenth-century Latin commentators on the *Posterior Analytics,* St. Thomas had best command of the both the theory and practice outlined in its two books, and he surely utilized its teaching with consummate skill not only in structuring the questions of his famous *Summa,* but also in laying bare the reasoning employed by Aristotle himself in the various treatises on which he commented ([30]).

The main principles of St. Thomas's natural philosophy are of course laid out in his exposition of the *Physics,* which for him constitutes the most general part of *scientia naturalis,* that concerned with *ens mobile in communi,* preparatory to taking, up a detailed consideration of all types of changeable being in their various manifestations. Because of its generalized orientation, many thinkers in recent times have come

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([26]) *In I anal. post.,* lect 16, and *In II anal. post.,* lects. 10-12.

([27]) *In I anal. post.,* lect, 16, n. 6. and *In II anal. post.,* lect. 7, n. 2 and lect. 9, n. 11.

([28]) *In II Phys.,* lect. 15, n. 2.

([29]) *In II de anima,* lect. 3, n. 245; *In I anal. post.,* lect. 23; *In II Phys.,* lect. 15, nn. 5-6; *In I de caelo,* lect. 3, n. 6; *Boeth. de Trin.,* q. 6, a. 1.

([30]) For Aquinas's use of the *Posterior Analytics* in structuring questions of his *Summa theologiae,* see my *The Role of Demonstration in Moral Theology: A Study of Methodology in St. Thomas Aquinas,* Washington: The Thomist Press, 1962. With regard to his Aristotelian commentaries, it is generally recognized that St. Thomas is one of the best of the Latin commentators, meriting the title of « The Expositor » on the basis of his methodological acumen in analyzing the arguments and proofs in the text available to him.

to regard the *Physics* as the only truly philosophical part of Aquinas's treatment of the *scientiae naturales,* and to relegate his remaining physical writings to the antiquarian junk-heap as of little more than historical interest (31). Such a view does violence to Aquinas's conception of natural philosophy and its integrating value for the special disciplines that go to make up its domain. For St. Thomas there is no distinction between *philosophia naturalis* and *scientia naturalis*: both *philosophia* and *scientia* are for him *cognitio certa per causas,* and the essential difference between the *Physics* and the remaining natural treatises lies only in the that the former is concerned with a general analysis of nature and change whereas the latter are more specific and concrete in the subjects of their consideration (32). Admittedly it is easier to formulate demonstrations at the general level of the *Physics* than it is to do so at levels of specific concretion, but such an admission does not provide the basis for an arbitrary demarcation between « philosophy » and « science », as this is generally accepted in the present day. The more Thomistic view would see the *scientiae naturales* as an integral discipline that aims to secure demonstrative knowledge of the whole of nature, that can do so with some facility in its more general considerations, that recognizes the difficulty of rising above dialectics on points of specific detail, but that does not give up in its search for demonstrations in its special domains simply because these do not yield themselves readily on first-hand examination of the world in which we live (33).

The Aristotelian theory of demonstration is thus the key to St. Thomas's conception of the scope and method of natural philosophy or natural science, the two being equivalent in his terminological usage. What serves to explain the apparent difference between the *Physics* and the more detailed physical treatises can perhaps be explained by

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(31) This seems to be the consensus of most of the manualists who have attempted to relate St. Thomas's teachings to modern thought, and it follows as a logical consequence of Jacques Maritain's program to insulate natural philosophy from the positive sciences of the present day.

(32) The foremost proponent of this teaching is Charles De Koninck, who formulated it in his « The Unity and Diversity of Natural Science », in V. E. SMITH, ed., *The Philosophy of Physics,* Jamaica, N.Y.: St. John's University Press, 1961, pp. 5-24, and in numerous other writings.

(33) Such is the thesis advanced in my *Causality and Scientific Explanation* (note 2 *supra*), which was adumbrated in the essay cited in the following note and in my « Toward a Definition of the Philosophy of Science, « *Mélanges à la mémoire de Charles de Koninck,* Quebec: Les Presses de l'Université Laval, 1968, pp. 465-485; both of these essays have been reprinted in *From a Realist Point of View* (note 10 *supra,* pp. 131-159 and 1-21 respectively).

the fact that most of the demonstrations that characterize the former as « the general science of nature » are of the *a priori type,* and thus seem closer to metaphysical kinds of argument that are regarded as « philosophical » in the present day. A brief review of some of the demonstrations that are sketched in the *Physics* may serve to make clear the content of such demonstrations, and how they prepare for other, more difficult, *a posteriori* demonstrations that are essential for the integral perfection of natural philosophy ([34]).

One might question whether there are any demonstrations offered by Aristotle and recognized by St. Thomas in the first two books of the *Physics*; certainly it seems clear that there are no *a priori* or *propter quid* demonstrations, and the only problem is whether an *a posteriori* or *quia* demonstration might be concealed in them. Bk. 1 is concerned with identifying the principles of changeable being, and Aquinas recognizes that Aristotle proceeds largely in a dialectical mode throughout his analysis ([35]). He does observe, however, that Aristotle begins to determine the truth regarding such principles in ch. 5 of Bk. 1, and this he does first *per modum disputationis ex probabilibus procedendo* in chs. 5 and 6, and then in ch. 7, says St. Thomas, « he determines the truth *per modum demonstrationis* » ([36]). Does this mean that, for Aquinas, Aristotle actually demonstrates the existence of *materia prima,* for example, arguing from effects that are more known to us (e.g., substantial change) to their proper cause which is more known in the order of nature? This is one interpretation of Aquinas's expression *per modum demonstrationis,* and it is consonant with sixteenth-century understandings of Aristotle's methodology, such as that of Jacopo Zabarella ([37]). But if an argument of this type is demonstrative, it can be such only in the sense of an *a posteriori* demonstration, since it argues from effect to cause and not vice versa. In Bk. 2, on the other hand, even this possibility would seem to be excluded, for the second book is concerned with nature as the subject of natural science. Now Aristotle explicitly teaches that no science can demonstrate the existence of its proper subject, and he and Aquinas both insist that nature is so

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([34]) A schematic presentation of the principal demonstrations that are to be found in the *Physics* and in the modern counterparts of the treatises *De caelo, De generatione, De anima,* etc., will be found in my « Some Demonstrations in the Science of Nature », The Thomist Reader 1957, Washington: The Thomist Press, 1957, pp. 90-118 (reprinted; see previous note).

([35]) *In I Phys.*, lects. 1-9.

([36]) *Ibid.,* lect. 10.

([37]) See Antonino Poppi, *La Dottrina della scienza in Giacomo Zabarella,* Padua: Editrice Antenore, 1972, esp. pp. 313-326.

obvious to us as not to require demonstration, the latter even reproving Avicenna for his attempting this impossible task ([38]). The first two books of the *Physics,* therefore, being concerned with delineating the principles of natural things (Bk. 1) and of natural science (Bk. 2), set up the possibility of erecting demonstrations on such principles without themselves providing demonstrations of the properties of the changeable in a strict and proper sense.

However, the next four books, Bks. 3 through 6, do propose to investigate such properties and show how they are coextensive with all of changeable being. The pervasive property, to be sure, is change or process, in the sense of the Greek *kinesis,* and Aristotle lays out two definitions of this: the first is that it is the act of a being in potency precisely as such, and the second that it is the act of the mobile *qua mobile* ([39]). Aristotle does not explicitly point out the connection between these two definitions, but Aquinas comments on this and observes that the first is a formal definition whereas the second is a material definition, being related to the first as a conclusion to its principle ([40]). Stated otherwise, one definition gives the formal cause of *motus* and the other its material cause; and since the formal cause is prior to the material and can be used to demonstrate it, as Aquinas points out in the *Posterior Analytics,* the conclusion he signals fulfills the requirement for the first *propter quid* demonstration in natural philosophy ([41]). The demonstration involves the two internal causes of chance or process, namely, form and matter, and effectively uses the definition of the form to isolate the proper matter or subject in which it will invariably be foud. Change or process is an imperfect actuality that is found only and always in the changeable *qua* changeable. Its proper subject therefore is the changeable, i.e., the entity that undergoes motion or change, and so it is not necessarily found in the agent that initiates change, whereas it must invariably be found in the patient that undergoes it ([42]). This conclusion has obvious and important ramifications for the analysis of motor causality as employed by St. Thomas throughout his major writings ([43]).

Other demonstrations in the later books of the *Physics* follow this

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([38]) *In II Phys.*, lect. 2, n. 8.

([39]) *Physics,* III. 1, 201a10 and 201a28.

([40]) *In III Phys.,* lect. 4, n. 1.

([41]) *In II Anal. Post.,* lect. 8, n. 3.

([42]) *In III Phys.,* lect. 4, n. 1 and passim.

([43]) See my « The Cosmological Argument: A Reappraisal », *Proceedings of the American Catholic Philosophical Association.* 46 (1972), pp. 43-57, reprinted in *From a Realist Point of View* (note 10 *supra*), pp. 313-327.

general pattern as they investigate all of the properties, conditions, and concomitants associated with change as found in the moveable. The second part of Bk. 3, for example, isolates the proper subject of the infinite when studied in natural philosophy; since here its formal definition is « that outside of which there is always something », its commensurate matter is the sensible continuum, where it can be said to exist, but only potentially, because it is there always associated with magnitude conceived under the aspect of privation ([44]). Bk. 4 takes up the measures of the changeable and of change itself, namely, place and time, and demonstrates that being in place is a property of all bodies externally contained by other bodies and so serves to define a natural order among them ([45]); time, on the other hand, measures the existence of the radically changeable, i.e., everything that comes to be and passes away, and indeed is materially rooted in process itself ([46]). As a consequence every motion or change in the kinetic sense must take place in time, time itself is found wherever there is *motus* (i.e., everywhere), and a universal time must be associated with the most regular continuous motion in the universe ([47]). In Bk. 5 are investigated the species of *motus* consequent on all these considerations: the basic demonstration is that change or process is possible strictly speaking only in those categories of being that allow for contrariety, namely, in location, quality, and quantity, thus giving rise to the three corresponding species of *motus*: local motion, alteration, and augmentation ([48]). The *mutatio* that takes place in the category of substance is between contradictories and therefore cannot be motus, nor can it take place in time and so must be instantaneous ([49]). Bk. 6 investigates the quantitative parts of process, and proves that whatever undergoes successive change or *motus* must be a divisible object or body ([50]). And Bk. 7 makes use of this conclusion to demonstrate—and Aquinas identifies the proof as a demonstration *propter quid*—that anything undergoing motus must be divisible into parts on which the motion of the whole depends, and as a consequence cannot be moved by itself (*per se primo*) but must be moved by another ([51]). It is this argument, of course, that sets up the regress

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([44]) *In III Phys.*, lect. 12, n. 10.
([45]) *In IV Phys.*, lect. 7, n. 2, and lect. 8, nn. 6-7.
([46]) *Ibid.*, lect. 20, n. 12.
([47]) *Ibid.*, lect. 22, n. 5; lect. 23, nn. 2 and 11.
([48]) *In V Phys.*, lect. 4, n. 1.
([49]) *Ibid.*, lects. 2-3.
([50]) *In VI Phys.*, lect. 5, n. 10; cf. *In I Phys.*, lect. 1, n. 4.
([51]) *In VII Phys.*, lect. 1, n. 3; for a complete analysis of this demonstration see the essay cited in note 43 *supra*.

to the First Unmoved Mover and so establishes the existence of an incorporeal or immobil being whose study can ground the science of metaphysics.

All of these demonstrations, it should be noted, make use of the internal causes of form and matter, understanding form in the sense of formal definition and matter in the sense of proper subject in which the corresponding form will be found ([52]). A similar procedure, it may be observed, is carried into the *De anima*, where the definition of the soul, « the primary actuality of a physical bodily organism », is said to be proved or demonstrated ([53]). In explicating this passage Aquinas notes that « every demonstration must begin from something more knowable to us than the thing to be made known by it », but that demonstrations in the natural sciences are made differently from those in mathematics, which are usually made a priori ([54]). Those in natural science, on the other hand, are invariably made *a posteriori* from effects to causes. Aristotle's demonstration, Aquinas states, may be summarized as follows:

> The first principle of life in things is the actuality and form of living bodies; but soul is the first principle of life in living things; therefore it is actuality and form of living bodies ([55]).

This argument, Aquinas goes on, « is clearly *a posteriori,* for in reality the soul is the source of vital activities because it is the form of a living body, and not vice versa » ([56]). But even here it may be remarked that the force of the demonstration is still carried through internal causes, for it is only the formal cause and its formal effect in the matter-form composite of which it is a part that enter into the proof proposed by Aristotle.

([52]) The reason for this is that the properties associated with changeable being may be regarded as so many accidental forms that have their existence in a substance composed of the basic principles discovered in Bk. 1. The proper defining procedure, therefore, consists in determining the conditions attending a subject of this type that enable each such form to come into being in that subject. The resulting demonstrations are therefore *a priori,* and indeed *propter quid,* in the sense that they use part of the *quod quid* (the accidental form itself) to reason to the proper matter (the material counterpart, also included in the *quod quid*) in which it is found. Cf. St. Thomas, *In I anal. post.,* lect. 16, n. 5; *In II anal. post.,* lect. 8, nn. 9-11; *and In II Phys.,* lect. 11, n. 2 and lect. 15, nn. 2 and 6.

([53]) *De anima,* II. 1, 412a28-412b1.

([54]) *In II de anima,* lect. 1, n. 213; lect. 3, n. 253.

([55]) *Ibid.,* lect. 3, n. 253.

([56]) *Ibid.*

The Special Sciences of Nature

The problems of natural philosophy become more complicated when one leaves the general considerations of the *Physics* and the *De anima* to move into the areas of the special sciences — the Aristotelian counterparts of the modern disciplines of astronomy, mechanics, chemistry, botany, and zoology. The reason for this, as I understand it, is that these sciences are more concerned with the interactions between bodies of various types and thus are forced to deal with causes that are external to the subject treated in addition to those that are internal to it. Of the demonstrations that have already been mentioned, all conclude with absolute necessity, and thus they are similar to those employed by the metaphysician and the mathematician; for them it is not necessary to follow the methodology signaled by both Aristotle and Aquinas as characteristic of natural philosophy. Yet the *scientiae naturales* in their entirety must be devoted to the study of *motus* or process in all of its ramifications, and it is absurd to think that either Aquinas or Aristotle would have rested content with a mere examination of the principles or most general considerations that serve to explain the many processes taking place in nature.

As soon as one devotes oneself to the study of a particular kind of *kinesis,* however, and realizes that this will only be instantiated in individual cases where an occasional defect can occur, one sees the enormous difficulty of continuing on with the project of *scientiae naturales.* Matter is not only impenetrable to the human intellect; it also proves refractory to nature's goals themselves. Agents that act over a period of time, and therefore attain their ends only gradually, are quite different from causes that are simultaneous, and so coexistent, with their effects ([57]). Aquinas was quite aware that not every individual olive seed will produce a full-grown olive plant, and that not every individual human being will be born with two hands. Freaks and monsters inhabit the natural world, no less than perfectly formed specimens. How, then, are science and demonstration possible in such a contingent world? On one condition alone, namely, that it is somehow possible to circumvent, in the demonstrative process, the defective operation of causes that lack the efficacy to produce their intended effects, that cannot work with the material defects they encounter, or that cannot persist over the time required to reach their goals. This is why Aristotle maintained that one must demonstrate *ex hupo-*

([57]) For a full discussion of this point, see « Aquinas on the Temporal Relation Between Cause and Effect » (note 3 *supra*), reprinted in *From a Realist Point of View* (note 10 *supra*), pp. 115-130.

theseos in natural philosophy. Aquinas, following Albert, refined that expression and held that demonstrations in the *scientiae naturales* must generally be made *ex suppositione finis,* that is, on the supposition that nature's ends will be achieved regularly and for the most part, even if not with the mathematical necessity that would guarantee their absolute occurrence. If one starts with an effect that is regularly, though not invariably, produced in the order of nature, one can use one's experience with nature to reason, on the supposition of the effect's attainment, to the various antecedent causes that are required for its production ([58]).

It is this possibility, and the methodology it presupposes, that permit the *scientiae naturales* to fulfill the apodictic requirements of *scientiae* in the strict sense. Through its recognition one can speak of a science of eclipses, and a science of rainbows, and a science of medicines (we would call it pharmacology in the present daw), and a science of « the parts of animals » as Albert the Great conceived it, the medieval counterpart of our modern zoology ([59]). A science of the heavens and of the elemental constituents of the universe proves more difficult to elaborate, and both Aristotle and Aquinas were aware of this, simply because of the very remoteness of their subject matters from sense experience ([60]). People frequently forget, however, that Aristotle himself found it necessary to invoke mathematical premises when making the transition from the *Physics* to the *De caelo,* for the help mathematics could give in solving problems about the movements of both heavenly and elemental bodies ([61]). In the *Physics* he had pointed out how the naturalist's principles differ from the mathematician's, but it is important to note that he did not rule out there the doctrine of the *Posterior Analytics* on subalternated sciences ([62]). A

([58]) See the essay cited in the previous note; also *Causality and Scientific Explanation* (note 2 *supra*), Vol. 1, pp. 71-80.

([59]) The first three types of scientific argument are discussed successively in Aquinas's commentary on Bk. 1 of the *Posterior Analytics,* lects. 16 and 25, and on Bk. 2, lect. 11, while the fourth is analyzed in « Albertus Magnus on Suppositional Necessity in the Natural Sciences », (note 20 *supra*), pp. 120-125.

([60]) Note St. Thomas's comments *In II de caelo,* lect. 4, n. 3 and lect. 7, nn. 4-5, and *In I Meteorologicorum,* lect. 1, n. 9 and lect. 11, n. 1.

([61]) St. Thomas himself defends this procedure at the beginning of his commentary on the *De caelo*; see his *In I de caelo*, lect. 3, n. 6.

([62]) See *Physics* II. 9 and *Posterior Analytics* I. 9. The way in which Aquinas made use of this doctrine in his own physical reasoning is explained in « St. Thomas, Galileo, and Einstein », *The Thomist,* 24 (1961), pp. 1-22, reprinted in *From a Realist Point of View* (note 10 *supra*), pp. 67-88; see also *Causality and Scientific Explanation* (note 2 *supra*), Vol. 1, pp. 80-88.

mathematical physics — to use the modern term — was for him a very real possibility, even if he had but a most rudimentary knowledge of how it could one day achieve the results we now associate with it. By Aquinas's time considerable advances had been made in the *scientiae mediae,* as he himself called them, and it is noteworthy that he accorded them the status of true sciences, and indeed included the highest science attainable by the human intellect, sacred theology, among their number (63).

St. Thomas's attitude toward the role of quantitative explanation in natural science is thus very important for the development of my thesis, and so warrants at least brief consideration and some exemplification. I should caution, however, that I do not believe St. Thomas himself was aware of the long and arduous process that would be involved in applying mathematics to the study of nature so as to yield demonstrations. Surely he was not to see any striking successes along such lines in his lifetime, and thus I shall have to make use of intervening history to show how his principles could be, and in fact, often were, applied to make what we call « modern science » the reality it now is (64).

The Use of Quantitative Techniques

For St. Thomas, quantity is one of the common properties of natural entities and so can be used to lead one from effect to cause and thus to knowledge of the definitions or natures of such entities.

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(63) *Summa theologiae,* I, q. 1, a. 2. For a discussion of the type of subalternation involved, see *The Role of Demonstration in Moral Theology* (note 30 *supra*), pp. 39-43. References to the *scientiae mediae* are to be found in St. Thomas's *In I anal. post.,* lect. 37, n. 2; *In II Phys.,* lect. 3, n. 8; and *In Boeth. de Trin.,* q. 5, a. 3, ad 6.

(64) Here is perhaps the proper place to stress the extreme difficulty of using St. Thomas's writings to justify a systematic break between philosophy and science. The procedure followed by Maritain, wherein he used a theory of abstraction developed by the seventeenth-century Thomistic commentator John of St. Thomas (Jean Poinsot) to establish epistemological distinctions between natural philosophy and modern science (labeling the latter as empiriological or empiriometric in character) forced him to use scholastic terminology that is largely unintelligible to thinkers in the present day. It also had the general effect of relinquishing all of modern science to a positivist interpretation along lines suggested by Pierre Duhem, even though Maritain himself repudiated such an interpretation. A safer procedure, in my view, is to pursue the path of history rather than that of scholastic analysis. In this way each stage of science's development can be treated in its proper context, while at the same time proper credit can be given to medieval and scholastic thinkrs for laying the methodological foundations on which subsequent developments were based.

Being « common », however, imposes a restriction on quantity as an explanatory factor, for sometimes it can lead to merely dialectical (today we would say « hypothetical ») explanations, whereas at other times it can lead to truly demonstrated results. The use of eccentrics and epicycles to explain planetary motion is a good example of how Aquinas saw mathematical explanations as merely dialectical, whereas the arguments he developed to prove the earth is a sphere — first from the quantitative effect of the projection of its shape on the moon during a lunar eclipse, and then by the figure generated by its parts tending in uniform fashion to a common center of gravity — show how he saw that it could be used to yield both *quia* and *propter quid* demonstrations [65]. What is noteworthy here is that the mathematical physics he envisaged had to employ *suppositiones* to get it off the ground, as it were, so as to be able to utilize mathematical principles when reasoning about natural causes and effects. Now the use of a *suppositio,* for St. Thomas, need not invalidate the strictly scientific character of the reasoning associated with it; we have already seen how he invokes reasoning *ex suppositione* to circumvent the defective operation of extrinsic causes so as to make possible a natural science of contingent things [66]. The *suppositiones* required for his *scientiae mediae* are somewhat more sophisticated and run greater risk, one might say, than those employed in the biological examples we have already given. Sometimes the mathematics they entail will not be able to be shown empirically to fit the natural phenomena they propose to explain, whereas in other cases they will. The Ptolemaic theory is a good example of the first, and Aquinas explicitly recognized this [67]. With regard to the second, he cites geometrical optics, or « the science of the rainbow », as capable of yielding *propter quid* explanations of this meteorological phenomenon [68]. I doubt that St. Thomas knew enough optics to be able to formulate, and experimentally verify, the *suppositiones* behind this proof, but I have no doubt that, a generation after his death, a German

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(65) For documentation, see the references cited in note 62 *supra.*

(66) Unfortunately the Aristotelian and Thomistic use of *suppositio* (and its derivate forms, such as *supponere,* etc.) in scientific reasoning is largely misunderstood in the present day. My essay cited in note 14 *supra* is a preliminary attempt to remedy this misunderstanding. Father Leo Elders has reminended me of an additional text (not discussed in the essay) where Aquinas indicates that both motion and nature must be « supposed » (*est necessarium motum et naturam supponi*) before one can formulate a *scientia naturalis* — see *In I Phys.,* lect. 2, n. 18 and cf. *In II Phys.,* lect. 1, n. 148. Many similar usages can be located of course, in the *Index Thomisticus.*

(67) *Summa theologiae,* I, q. 32, a. 1, ad 2; *In II de caelo,* lect. 17, n. 2.

(68) *In I anal. post.,* lect. 25.

Dominican by the name of Theodoric of Freiberg succeeded in doing precisely that and therefore in placing geometrical optics on its modern footing (69).

With regard to mechanics, and its two main branches, statics and dynamics, the story is more complex. Even within Aquinas's lifetime, however, Jordanus Nemorarius — whom some identify with Jordan of Saxony, fifth Master General of the Dominican Order (70) — delineated the precise *suppositiones* necessary to formulate a *scientia de ponderibus* (the medieval « science of weights »), which facilitated the later experimental study of inclined planes and weights positioned on them (71). St. Thomas himself questioned the validity of Aristotle's dynamical rules in Bks. 4 and of the *Physics,* wherein Aristotle attempted to formulate ratios between the forces moving bodies, the resistances they encounter, and the velocities that result (72). He further proposed that motion through a void, were such to occur, would not be instantaneous, and this contrary to the prevailing Averroist interpretation of Aristotle (73). In a different context, Albert the Great considered the circular motion of fire when it had ascended to the inner concavity of the moon's orb, and likened this to the way in which a flame rotates when it reaches the top of a furnace (74). This led to the apparently innocuous question whether such a motion would be natural or violent for fire, which was taken up by later thinkers to argue for the possibility of a *tertium quid* between natural motion and violent motion, a *motus medius,* neutral or intermediate between the two, that once initiated and in the absence of external resistance would go on forever (75).

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(69) For full details, see my *The Scientific Methodology of Theodoric of Freiberg,* Fribourg: The University Press, 1959; I have translated into English a substantial excerpt from Theodoric's explanation of the rainbow for *A Source Book in Medieval Science* (note 6 *supra*), pp. 435-441.

(70) Arguments *pro* and *con* this identification are given in R. B. THOMPSON, *Jordanus de Nemore and the Mathematics of Astrolabes:* DE PLANA SPERA, Toronto: Pontifical Institute of Mediaeval Studies, 1978, pp. 10-17.

(71) See J. E. BROWN, « The Science of Weights », in D. C. Lindberg, ed. *Science in the Middle Ages,* Chicago: The University of Chicago Press, 1978, pp. 179-205, for some details of Jordanus's contribution. Additional texts in English translation will be found in S. Drake and I. E. Drabkin, eds., *Mechanics in Sixteenth Century Italy,* Madison: University of Wisconsin Press, 1969.

(72) *In IV Phys.,* lect. 12, n. 8.

(73) *Ibid.,* n. 10.

(74) ALBERTUS MAGNUS, *De Caelo,* lib. 1, tr. 1, c. 4, ed. Borgnet 4:15b-16a.

(75) For an of this development, see my *Prelude to Galileo* (note 9 *supra*), pp. 207-271, 313-314, and 334-335.

Finally, in the sixteenth century the Spanish Dominican, Domingo de Soto, showed how a theory of impetus could be assimilated into Thomistic physics, and used it to correct Aristotle's « rules » for falling bodies. Soto's formulation, that their motion is *uniformiter difformis* or increases « uniformly difformly », actually adumbrated Galileo's « law of falling bodies » by some eighty years, for it is equivalent to stating that freely falling bodies accelerate uniformly throughout the time of their fall (76). And with regard to Galileo himself, my recent researches have shown that his writings are replete with references to the various *suppositiones* necessary to establish the « new science » of motion. The demonstrations he formulates, indeed, are made explicitly *ex suppositione,* Aquinas's precise expression, and are backed up, we now know, by extensive experimentation to show how, by employing proper suppositions, one can circumvent the various *impedimenti* moving bodies encounter from extrinsic causes that might otherwise invalidate the results one can calculate for their motions (77).

Once « physics », in the modern sense, was thus able to achieve « scientific status », in the sense of the *Posterior Analytics,* it would take two or three more centuries before the *De caelo,* the *De generatione,* the *De animalibus,* and similar treatises coud be rewritten to formulate the modern specialized sciences of astronomy, chemistry, and biology. Neither St. Thomas nor Thomists have played an appreciable role in that enterprise, which we now refer to as the « Scientific Revolution », and I would not make any further claims for historical influence in that development. What is important, however, is that all of this growth can be assimilated within St. Thomas's conception of natural philosophy, his *scientiae naturales,* once one understands the basic methodology he saw as underlying the study of nature (78).

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(76) How Soto arrived at this result is explained in my « The Enigma of Domingo de Soto: *Uniformiter difformis* and Falling Bodies in Late Medieval Physic », *Isis,* 59 (1968), pp. 384-401, reprinted in *Prelude to Galileo* (note 9 *supra*), pp. 91-109.

(77) The documentation is provided in my « Galileo and Reasoning *Ex suppositione*: The Methodology of the *Two New Sciences* », in R. S. Cohen et al., eds., *Proceedings of the 1974 Biennial Meeting of the Philosophy of Science Association,* Dordrecht-Boston: D. Reidel Publishing Company, 1976, pp. 79-104, enlarged with an appendix in *Prelude to Galileo* (note 9 *supra*), pp. 129-159.

(78) The rediscovery of the classical demonstrations on which the modern sciences of physics, chemistry, and biology have been erected is not an easy task, although it has been assisted in recent decades by the growth of the history of science as an academic discipline. Apart from my preliminary efforts cited in notes 33 and 34 *supra,* I would direct attention also to the study of Filippo Soccorsi, *De vi cognitionis humanae in scientia physica,* Rome: Gregorian University Press, 1958.

The Supposition of Nature

Earlier I stated that Aquinas's view of natural science, if properly understood and accepted, could have averted the condemnations of 1270 and 1277, and I should like now to return briefly to that point. Obviously St. Thomas was interested in safeguarding God's absolute power and the possibility of miracles whereby God himself could set aside the order of nature ([79]). For him, therefore, all of natural philosophy can be scientific only *ex suppositione,* that is, *ex suppositione naturae,* on the supposition of there being nature, of there being natural kinds with all their properties and established laws of operation ([80]). St. Thomas's way of conceiving the *scientiae naturales* was therefore « scientific » without being absolutist in any sense, and on that account could pose no threat whatever to theology. But Bishop Tempier and others saw his science as a metaphysics that would place rational limits on God and on the divine power. And unfortunately in our own day there are many who try to make natural philosophy into a metaphysics once again, this time not to the detriment of theology, but to the more serious detriment of the special sciences that contribute so abundantly to our understanding of nature.

A double advantage thus accrues in the late twentieth century for those who attempt to understand what St. Thomas Aquinas attempted to do in the thirteenth century for the study of the world of nature. They learn how natural philosophy can have its autonomy from metaphysics and theology, while at the same time provide a solid foundation on which a science of being and a science of God can ultimately be erected. They learn, in addition, how our modern sciences can be seen in essential continuity with the *scientiae naturales* of ancient, medieval, and Renaissance thought. Thus the way is opened for a reintegration of science with nature, for a philosophy of science that can avail itself of the rich resources of a philosophy of nature, as man faces the environmental and ecological crises that must be overcome to make his successful entry into the twenty-first century ([81]).

([79]) Aquinas touches on this point when discussing the suppositional necessity that God's will imposes on creatures see his *Q. D. de potentia,* q. 5, a. 4.

([80]) See note 66 *supra.* The expression *ex suppositione naturae* was taken up by Jean Buridan at the University of Paris in the fourteenth century, when heading off Ockham's attempt to deny the scientific character of human knowledge of nature and ethics. For the appropriate references see my « Buridan, Ockham, Aquinas: Science in the Middle Ages », *The Thomist,* 40 (1976), pp. 475-483, reprinted in *Prelude to Galileo* (note 9 *supra*), pp. 341-348.

([81]) An urgent plea for « The Emergence of Post-Modern Science » that would meet the needs of mankind in the next century along such lines has been voiced by STEPHEN TOULMIN in *The Great Ideas Today 1981,* Chicago: Encyclopaedia Britannica, 1981, pp. 68-114.