PONTIFICAL FACULTY OF PHILOSOPHY
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THE MANNER OF DEMONSTRATING IN NATURAL PHILOSOPHY

A DISSERTATION

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INTRODUCTION

The Logical Positivists, with their principle of verification,[1] have laid great stress upon method, even to the point of practically identifying meaning and method. Although a method based on a radical sensism has not been felicitous for philosophy, still perhaps indirectly these neo-positivists will be of real service to philosophy by pointing out to Thomists a weakness in their own understanding of the philosophy of nature.

The Aristotelian logic is intended to be a method for attaining truth "in an orderly and easy manner and without error."[2] Generally, Scholastics have been faithful to their body of logical doctrine as *logica docens,* although it must be admitted that the current manuals miss much of the riches hidden away in St. Thomas' Commentaries on the *Organon.* However, modem Scholastics, while adhering to their logic in principle, have not always been successful at putting it into practice in building up the various branches of philosophical science. Likewise, the discursive method being used in most modern books of Thomist philosophy tends to obscure the artificial logical procedure whereby a demonstration is constructed.[3] We may charge that sci-

1 Cf. H. Van Laer, *Philosophico-Scientific Problems.* Chap. 3, "The Principle of Verification," pp. 28-58.

2 "... ordinate, faciliter et sine errore." (St. Thomas, *In I Post. Analyt.,* lect. 1, n. 1.) The editions of St. Thomas' works used in this dissertation are marked with an asterisk in the bibliography. The Latin text will not be given in the footnotes whenever an authoritative English translation has been used.

3 It is noteworthy that the Holy See prefers the use of the syllogistic form in the presentation of prooofs. "In quaestionibus *speculativis* sive Theologiae sive Philosophiae adhibeatur methodus quam scholasticam vocant, non neglecta, tam in proponendis argumentis quam in afferendis, disputandis, solvendis difficultatibus, forma *syllogistica.* Hac autem methodo auditorum mentes ita excolantur, ut apti paratique efficiantur non solum ad falsa systemata erroresque antehac

entitle logic is in practice often replaced by mere natural logic.

Whether the above judgment is too severe need not concern us now. The reasons for it will become more apparent in the course of our study. The fact in which we are interested is that logic is only a general method applicable to all the sciences. It has to be specified for each individual science.

> There are different ways of seeking truth; so a man must be instructed as to how arguments are to be received in each of the sciences. It is not easy for a man to grasp two things at one time, for while he is attending to them both, he can grasp neither. So it is absurd for a man at the same time to seek sciences and the method of science. Therefore, one must first learn logic before the other sciences, because logic gives the common manner of proceeding in all the sciences. But the method proper to each individual science should be given toward the beginning of each science.[4]

Almost all of Book Two of Aristotle's *Physics* is taken up with the principles and method of the science, a thing conspicuously absent in *our* manuals of natural philosophy. It is very important in our times that we not only have

exortos dijudicandos et refutandos, sed etiam ad discernendas et ex veritate aestimandas sententias novas quae forte in disciplinis theologicis vel philosophicis exoriantur." (Sacra Congregatio de Seminariis et Studiorum Universitatibus, "Ordinationes ad constitutionem apostolicam 'Deus scientiarum Dominus' de Universitatibus et Facultatibus Studiorum ecclesiasticorum rite exsequendam." Text from *Enchiridion de Statibus Perfectionis,* η. 360.)

4 "Diversi secundum diversos modos veritatem inquirunt; ideo oportet quod homo instruatur per quem modum in singulis scientiis sint recipienda ea quae dicuntur.—Et quia non est facile quod homo simul duo capiat, sed dum ad duo attendit, neutrum capere potest; absurdum est, quod homo simul quaerat scientiam et modum qui convenit scientiae. Et propter hoc debet prius addiscere logicam quam alias scientias, quia logica tradit communem modum procedendi in omnibus aliis scientiis. Modus autem proprius singularum scientiarum, in scientiis singulis circa principium tradi debet." (Zn *II Meta.,* lect. 5, n. 335.)

truth, but know that we have it and know how we have attained it.® Thus, a certain amount of preoccupation with methodology is especially necessary in a world that is hastening toward the quagmire of scepticism,

In the primary sources of our Aristotelian-Thomistic tradition we have a wealth of material on the method of building up the science of nature that we call natural philosophy. This present study intends to bring to light some of this too little known doctrine. This is not to be merely a historical study, either of Aristotle's or St. Thomas' doctrine, although the works of these two great thinkers will constitute our main source. We will feel free, however, to draw from any other sources, old and new, that we find helpful.

In order to reach the heart of our subject, the manner of demonstrating in natural science,® we have to make a number of preliminary considerations. First of all we must say what is meant by the Aristotelian-Thomistic concept of demonstration and science and how it differs from other types of knowledge. We must clarify the meaning and extent of what we understand by the term *natural science.* It is impossible to determine the method of natural philosophy according to the thought of Aristotle and St. Thomas, unless we understand their integral view of this science. Therefore, we will have to explain their process of beginning and developing natural philosophy and also the noetic status they claimed for it.

8 Cardinal Zigliara, in a footnote (B) to St. Thomas' second Lectio on the *Posterior Analytics* (Leonine edition, p. 143) says: "Quae de praecognitione deque praecognitionis modo disseruntur a s. Thoma cum Aristotele tantae sunt necessitatis, ut si quis ea non intime penetraverit, vim naturamque demonstrationis ignoret necesse sit; atque ideo a scientificis cognitionibus arcebitur: *cum. sapiens nullatenus sit dicendus, qui suae scientiae rationem intimam impotens est ostendere."* (Italics ours.)

9 St. Thomas speaks of natural philosophy as "natural science." We will discuss in later chapters the extent of this natural science and its relation to the experimental sciences of nature.

It is our hope that our study may be some small contribution to what Jacques Maritain has called "a sort of renaissance of the philosophy of nature."[7]

7 *Philosophy of Nature,* p. 151.

CHAPTER I

THE ARISTOTELIAN-THOMISTIC CONCEPT OF DEMONSTRATION

Demonstration is a crutch, whereby we compensate for the imperfection of our intellect. An angel does not need to demonstrate. In one intuition of an intelligible form, an angel contemplates all that is knowable in it.[1] The full light of the angelic intelligence focusses upon its natural object and in one act knows its essence and all its attributes.

With us men, however, it is different. Our nature holds the lowest rung of intellectual beings. We cannot attain the perfection of knowledge by one powerful insight into the essence of an object. Because of the weakness of our intellectual light we must come to full truth progressively, by a laborious and often painful process of reasoning from known truths to those that are unknown.[1] We must also seek our knowledge, not in the full light of immateriality, but conformably to our nature, in the shadows of matter, in the world of sense. The object of our knowledge is a form hidden away in individual corporeal matter, an object that our mind must first disengage from matter and to which it must give an immaterial manner of existing, in order to be one with that object in the vital act of knowing. Even so, that object retains connotations of the matter from which it has been drawn. It takes further processes of refinement before the mind can fathom the full intelligibility of its object. The goal of all its labors, the greatest triumph it can expect, is to come to *some* knowl-

[1] Cf. *Summa Theologiae,* I, q. 58, a. 3; a. 4.

[1] "Quaedam vero sunt inferiores (intellectus), quae ad cognitionem veritatis perfectam venire non possunt nisi per quemdam motum, quo ab uno in aliud discurrunt, ut ex cognitis in incognitorum notitiam perveniant; quod est proprie humanarum animarum." *(De Veritate,* q. 15, a. 1.)

edge of the immaterial natures existing beyond the scope of its ordinary vision.[3]

It is important to realize that the act of understanding, the act called technically *intellectus?* or intuition, is the most perfect manner of knowing. It is an *intus legere,s* a reading, as it were, of truth in the very essence of an object.[3] When we speak of such intuition of essence, however, we must not form too lofty a concept of it. We do not grasp essences directly and at a glance. Essences are known to us only by means of their sensible manifestations or properties.

> The name *intellect* arises from the intellect's ability to know the most profound elements of a thing; for to understand *(intelligere)* means to read what is inside a thing *{intus legere).* Sense and imagination know only external accidents, but the intellect alone penetrates to the interior and to the essence of a thing.[7]

In a sense we can say that we "reason" to essences, understanding by "reason" the act of the cogitative power, often called the particular reason. This collates recurring sensible manifestations and presents an *experimentum,* or gen-

[1] *"Necesse est dicere quod intellectus noster intelligit materialia abstrahendo a phantasmatibus, et per materialia sic considerata in immaterialium aliqualem cognitionem devenimus, sicut e contra angeli per immaterialia materialia cognoscunt." *(Summa Theol.,* I, q. 85, a. 1.)

[4] "Nomen intellectus dupliciter accipi potest. Uno modo secundum quod se habet ad hoc tantum a quo primo nomen impositum fuit; et sic dicimur proprie intelligere cum apprehendimus quidditatem rerum, vel cum intelligimus illa quae statim nota sunt intellectui notis rerum quidditatibus, sicut sunt prima principia, quae cognoscimus cum terminos cognoscimus; unde et intellectus habitus principiorum dicitur." (De *Ver.,* q. 1, a. 12.)

[3] *Summa Theol.,* II-II, q. 8, a. 1.

[•] "Intellectus enim simplicem et absolutam cognitionem designare videtur; ex hoc enim aliquis intelligere dicitur quod interius in ipsa rei essentia veritatem quodammodo legit; ratio vero discursum quemdam designat, quo ex uno in aliud cognoscendum anima humana pertingit vel pervenit." *(De Ver.,* q. 15, a. 1.)

[7] *De Ver.,* q. 1, a. 12.

eralized sense image, from which, the active intellect abstracts a species representative of the essence. Moreover, the mind does not apprehend an essence perfectly in one act. The first concept of a thing is vague and imperfect. It represents the essence as a something, a material being. It takes successive acts before the mind distinguishes the specific features and differentiates it from other beings, thereby forming a definition. This first definition does not exhaust the intelligibility of the essence; it is only the start. It is the work of judgment and reasoning that rounds out the first vague understanding of the essence and furnishes us a complete definition.[8]

Whereas understanding is a perfect manner of knowing, reasoning is essentially an imperfection. It is proper only to us men. Neither God nor the angels reason. They simply understand. All that we learn by our plodding rational processes is known in a simple glance by a higher intellect[9]

This distinction between understanding and reasoning must never be lost sight of throughout our study of demonstration. Demonstration is a reasoning process. It puts the finishing touches on our knowledge. It brings it to its fullest perfection. Yet demonstration is imperfect as a manner of knowing, even in us men. We have also that other and more noble manner of knowing, understanding, which St. Thomas calls a participation of the angel's way of knowing.[10] Understanding is, in fact, the beginning and prerequisite of our reasoning process. Reasoning and demonstration would be impossible unless we had some simple grasp of truth from which to start. Because of the importance of this, let us read a passage where St. Thomas clearly and concisely explains it.

> Now all movement proceeds from what is at rest, as Augustine says. For rest is the term of motion, as is said in the *Physics.* Thus, movement is related to rest as to its source and its term,

[8] *Summa Theol.,* I, q. 85, a. 5.
[9] Ibid.
[10] *De Ver.,* q. 15, a. 1.

> *as* is reason, also, which is related to understanding as movement to rest and generation to existtence.... It is related to understanding as to its'"] source and its term. It is related to it as its source because the human mind could not move from one thing to another unless the movement started from some simple perception of truth, and this perception is understanding of principles. Similarly, the movement of reason would not reach anjrthing certain unless there were an examination of that which it came upon through discursive movement of the mind. This examination proceeds to first principles, the point to which reason pursues its analysis. As a result, we find that understanding is the source of reasoning in the process of dis-, covery and its term in that of judging.[11]

An appreciation of the act of understanding will save us from the mistake of wanting to have all our knowledge demonstrated. To do so would be to destroy the very process of demonstration.[12] For the present our discussion of understanding and its difference from reasoning has purposed to give us a general introductory idea of what demonstration is. We have seen that it is our human way of extending our knowledge beyond our first weak insights into its object. It is our method of overcoming the imperfection of our composite nature and stretching out to greater vistas of understanding. We may say that demonstration is pressing out the pulp of knowable objects in order to extract from them the last drops of intelligibility.

Aristotle gives two definitions of demonstration; and in doing so he is making use of a principle which it will not be inopportune to point out even at this early stage, since the principle is cardinal to the manner of demonstrating in

[11] *De Ver.,* q. 15, a.1.

[12] Cf *Metaphysics,* Bk. 4, Chap. 4, 1006a 5-10: "Some indeed demand that even this shall be demonstrated (principle of non-contradiction), but this they do through want of education, for not to know of what things one should demand demonstration, and of what one should not, argues want of education. For it is impossible that there should be demonstration of absolutely everything (there would be an infinite regress, so that there would still be no demonstration.)"

natural science. First, he defines demonstration by reason of its final cause; then, through its material cause. St. Thomas gives the following explanation, which he will repeat many times in the course of his commentaries on the works of Aristotle.

> In all things that are ordained to an end, the definition through final cause is the reason for the definition through material cause and also the middle term for proving it. For example, because a house is a shelter to protect us from cold and heat, it has to be constructed of stones and wood. So Aristotle here gives two definitions of demonstration: one is taken from the end of demonstration, which is to *know (scire)*; from this is concluded the other, which is taken from the matter of demonstration.[13]

By reason of its end Aristotle thus defines demonstration: "By demonstration I mean a syllogism productive of scientific knowledge, that is, the grasp of which is *eo ipso* such knowledge."[14] The Latin equivalent of this definition is: "Demonstratio est syllogismus scientialis, idest faciens scire."[15]

With John of St. Thomas[16] we may profitably consider

[13] "In omnibus quae sunt propter finem, definitio, quae est per causam finalem, est ratio definitionis, quae est per causam materialem, et medium probans ipsam: propter hoc enim oportet ut domus fiat ex lapidibus et lignis, quia est operimentum protegens nos a frigore et aestu. Sic igitur Aristoteles de demonstratione dat his duas definitiones: quarum una sumitur a fine demonstrationis, qui est *scire;* et ex hac concluditur altera, quae sumitur a materia demonstrationis." (In I Post. Analyt., lect. 4. n. 2.)

[14] *Ἀπόδειξιν δε* λόγω *συλλογισμόν επιστημονικόν. επιστημονικόν δε λέγω καθ' δν τω εχειν αυτόν επιστάμεθα.* (*Post. Analyt.,* Bk. 1, Chap. 2, 71b 18.) The Greek text is that given in the Leonine Edition of St. Thomas' Commentary. It is the Didot text, which the editors compared with other editions, both old and recent. Cf. p. xxxvii. In the course of this study we will give the Greek text of quotations from Aristotle only when it helps in an understanding of the doctrine.

[15] *In I Post. Analyt.,* lect. 4, n. 9.

[16] *Cursus Philosophicus Thomisticus,* (ed. Reiser), Vol. I, pp. 773, 774.

each element of the definition: (1) syllogismus; (2) faciens (or "efficiens," as he defines it); (3) scire.

Demonstration is said to be a syllogism, as designating the form of argument required for it. Syllogism, we must remember, is Aristotle's own invention for the attainment of truth. He worked out an elaborate science of formal logic, whose parts are all orientated to the syllogism. So all the doctrine of formal logic is presupposed for demonstration. We must content ourselves with merely indicating this fact in passing. It is noteworthy, however, with respect to demonstration, that the first figure of syllogism is the vehicle of demonstration. It alone concludes universally and affirmatively, enabling us to predicate a definition or a proper attribute of our subject; and it is by means of this figure that the other figures are resolved to immediate premisses, of which we shall speak later.[17]

Demonstration is secondly a syllogism *productive* (efficiens) of scientific knowledge. If we consider scientific knowledge, or science, as a habit, then we say that the habit is generated by the whole process of demonstration. But we are here concerned with science as an act. In this case, then, it is the premisses that are productive of the scientific conclusion, and this in two ways: effectively and formally.

The premisses are said to be the efficient cause of the conclusion.

> The principles of demonstration are related to their conclusions as the active causes of natural things are related to their effects. Hence in the Second Book of *Physics* the propositions of the syllogism are placed in the genus of efficient cause.[18]

It is in the light of the premisses that the conclusion is

[17] Cf. *Post Analyt.,* Bk. 1, Chap. 14, 79a 18-33. St. Thomas *In I Post. Analyt.,* lect. 26.

[18] "Principia autem se habent ad conclusiones in demonstrativis sicut causae activae in naturalibus ad suos effectus (unde in II *Physicorum* propositiones syllogismi ponuntur in genere causae efficientis)." (In *I Post. Analyt.,* lect. 3, n. 1.)

inferred. The premisses are extrinsic to the conclusion and give the intellect the power to assent to the conclusion.[18] The conclusion is truly a new being, an actualization of what was only virtually contained in the premisses. Therefore, as in the case of any transition from potency to act, there must be an efficient cause. The possible intellect, determined by the premisses, is moved by the active intellect to consent to the conclusion. The premisses concur as instrumental causes.[20] When the premisses are not certain or the inference not clear, the motive power of the will is needed to make the intellect assent, as happens in the act of faith.

The premisses are said to produce the conclusion formally, in that the objects known in the premisses *specify* the judgments whereby the premisses are known, and so virtually and mediately specify the assent of the conclusion.[21]

Finally, demonstration is said to yield *scientific knowledge*. The Latin noun *scientia* and the verb *scire* translate the corresponding Greek *επιστήμη* and *ἐπίστασθαι*.[22] These are technical terms with Aristotle and have a very precise meaning. It is significant to note that Aristotle adopted

18 Cf. John of St. Thomas, *op. cit.,* pp. 758-762.

20 "Intellectus in actu principiorum non sufficit ad reducendum intellectum possibilem de potentia in actum sine intellectu agente; sed in hac reductione intellectus agens se habet sicut artifex, et principia demonstrationis sicut instrumenta." (Qu. Disput. *De Anima,* a. 4, ad 6.)

21 "Formaliter autem ipsa obiecta seu res cognitae, quae istis notitiis repraesentantur ipsosque actus cognoscitivos praemissarum specificant. Et quia veritas et obiecta principiorum virtualiter continent veritates illatas, virtualiter etiam et mediate specificant assensum conclusionis, qui explicite et formaliter tendit in ipsam veritatem conclusionis." (John of St. Thomas, *op. cit.,* p. 774.) The premisses are also the material cause of the conclusion. *In II Phys.,* lect. 5, n. 9.

22 The adverb *ἁττλω* is frequently added. The Latin equivalent is *simpliciter.* The Oxford translators of Aristotle's works use the term: "unqualified scientific knowledge" or "in an unqualified sense of the term to *know''* (71a 26; b 8.)

the term *επιστήμη,* which for Plato meant the contemplation of the subsistent Ideas, a knowledge that was thought to be immutable and eternal. The word *επίστασθαι* is a derivative of *ϊστασθαι,* which means to stand or come to a stop. In the seventh book of *Physics* the etymological connection is brought out.

> The terms "knowing" and "understanding" imply that the intellect has reached a state of rest and come to a standstill.[23]

The intellect is awakened to scientific inquiry "by wondering that things are as they are." The scientific process "must end in the contrary and, according to the proverb, the better state,"[24] that is, a state of rest and satisfaction.

What is Aristotle's concept of this knowledge that will perfectly quiet the mind? He says of it:

> We suppose ourselves to possess unqualified scientific knowledge of a thing when we think that we know the cause on which the fact depends, as the cause of that fact and of no other, and, further, that the fact could not be other than it is.[25]

He does not attempt to prove his definition. It is not necessary to do so. For in fact, it is quite evident that scientific knowledge is such, since such knowledge is claimed both by those who actually possess it and by those who only think that they have it. The human mind spontaneously searches for just such a type of truth. Therefore, Aristotle could say in the first sentence of his Metaphysics: "All men by nature desire to know."[20]

" Tç> *yàp ήρεμήσαι καί στήναι την διάνοιαν επίστασθαι καϊ φρονεΐν Χόγομεν. (Physics,* Bk. 7, Chap. 3, 274b 10.)

14 Metaphysics, Bk. 1, Chap. 2, 983a 14, 18.

11 Post. Analyt., Bk. 1, Chap. 2, 71b 9sq.

" 980a 22. It is to be noted, however, that Aristotle also used the term "science" in a broader sense as including any certain knowledge. "Not all knowledge *(επιστήμη)* is demonstrative: on the contrary, knowledge of the immediate premisses is independent of demonstration." (Post. *Analyt.,* Bk. 1, Chap. 3, 72b 19.) St. Thomas says of this: /'Sciendum est tamen quod hic Aristoteles large accipit scientiam

Let us now, with the help of St. Thomas' commentary, try to bring out the significance of Aristotle's definition of science.

Scientific knowledge, as defined, means *perfect* knowledge of a thing, a knowledge that will completely satisfy the natural inquisitiveness of our minds. Science aims at uncovering for us the essence of its object in all its virtuality. By the act of intuition, or understanding, we come to some imperfect knowledge of a universal essence and embody it in a general definition. But such a definition must be refined and perfected by a study of the causes and properties of the object. When we note the constant recurrence of some attribute of an object, we are led to inquire the cause of this constancy. Why, for instance, should men be risible, or why does the moon occasionally suffer eclipse? Our natural desire to know is not quieted by the mere knowledge of the existence of some fact; it seeks to know the "why," the cause of that fact. And when the fact is a property of an object, the cause will be the essence of the object. From properties we come to know essences, the natural object of our intellect.

> In the speculative sciences we search after definitions, by which we understand the essences of things through the division of a genus into differences and through the examination of a thing's causes and accidents, which contribute a great deal to our knowledge of the essences.[27]

Not only the intrinsic causes of a thing, but the extrinsic causes, especially the final cause, throw light on an essence. The end is the cause of the other causes, the reason why there should be such a form and such matter. And a univocal agent is in some way similar to its effect, according to the dictum: "Omne agens agit sibi simile." Therefore,

pro qualibet certitudinali cognitione, et non secundum quod scientia dividitur contra intellectum, prout dicitur quod, *scientia est conclusionum et intellectus principiorum." (In I Post. Analyt.,* lect. 7, n. 6. Cf. lect. 42, n. 9; lect. 44, n. 3.)

27 *In Librum Boethii De Trinitate,* q. 6, a. 4, corp.

we do not know a thing perfectly until we know its causes.[28] "The knowledge of the causes of any genus is the end attained by the inquiry of the science."[29]

Let us note that Aristotle has said: "We suppose ourselves to possess unqualified scientific knowledge of a thing when we think that we know the cause *on which the fact depends."* We are seeking, in other words, the cause of the fact, not the cause of our knowledge of the fact, the cause *in essendo,* not that *in cognoscendo.* To use Aristotle's example, we know that the planets are near, because they do not twinkle.[30] However, non-twinkling is not the cause of the nearness of the planets, but merely an effect of it, which becomes for us the cause of our knowledge of that nearness. The reason why we seek the cause *in essendo* is that:

> To have scientific knowledge of something is to know it perfectly, which means perfectly to apprehend its truth. Now the principles of a thing's existence and of its truth are the same, as is evident from the Second Book of *Metaphysics.* Therefore, if one knows perfectly, he must know the cause of the thing known.[31]

In order to demonstrate a scientific conclusion, moreover, we must know the cause of any fact under consideration "as the cause of that fact and of no other."[32][33] The

28 With Cajetan we must understand "cause" in the broad sense of "reason" or "virtual cause," as when we demonstrate in metaphysics that the immutability of God is the reason for His eternity; if God had a cause of His eternity, it would be His immutability. Cf. note i, Leonine Edition of St. Thomas' Commentary on the *Posterior Analytics,* p. 151; John of St. Thomas, op. cit., pp. 775-776.

33 "Nam cognitio causarum alicujus generis, est finis ad quem consideratio scientiae pertingit." *(In Metaphysicam,* Proenium.)

«° *Post. Analyt.,* Bk. 1, Chap. 13, 78a 30.

51 "Scire aliquid est perfecte cognoscere ipsum, hoc autem est perfecte apprehendere veritatem ipsius: eadem enim sunt principia esse rei et veritatis ipsius, ut patet ex II *Metaphysicae.* Oportet igitur *scientem,* si est perfecte cognoscens, quod cognoscat causam rei scitae." *(In I Post. Analyt.,* lect. 4, n. 5. Cf. *In II Meta.,* lect. 2, n. 298.)

33 Post. Analyt., Bk. 1, Chap. 2, 71b 11.

Latin text that St. Thomas used does not contain the phrase "and of no other." St. Thomas' interpretation of the other part: "as the cause of that fact" is the following:

> If one were to know the cause only, he would not yet know the effect in act (which is unqualified scientific knowledge), but only virtually (which is knowledge *secundum quid* and as it were *per accidens).* So in order to have unqualified scientific knowledge, one must know also the application of the cause to the effect.[33]

Finally, scientific knowledge must tell us "that the fact could not be other than it is."[34] There must, in other words, be a necessary connection manifested between the subject and predicate of a scientific conclusion. Necessity is the essential and specifying element of science. No other type of knowledge would ever satisfy the natural inquiry of our mind, for if the fact could be otherwise, then perhaps in this case it is otherwise, and the mind is again delivered over to wonderment.

> Demonstration is said to be of necessary things and from necessary principles. It is of necessary things, because that which is simply demonstrated cannot happen to be otherwise. We say simply demonstrated in distinction from a demonstration "ad hominem".... But because the causes of the conclusion in demonstrations are the premisses—for demonstration gives knowledge in the unqualified sense, which can be only by means of a cause—then the principles of the syllogism have to be necessary and impossible to be otherwise. For from a non-necessary cause there cannot follow a necessary effect.[35]

33 "Si autem cognosceret causam tantum, nondum cognosceret effectum in actu, quod est scire simpliciter, sed virtute tantum, quod est scire secundum *quid* et quasi *per accidens.* Et ideo oportet scientem *simpliciter* cognoscere etiam applicationem causae ad effectum." *{In I Post. Analyt.,* lect. 4, n. 5.)

34 *Post. Analyt.,* Bk. 1, Chap. 2, 71b 12. Cf. *Nicomachean Ethics,* Bk. 6, Chap. 3, 1139b 18-24.

35 "Demonstratio enim dicitur esse necessariorum, et dicitur esse ex necessariis. Necessariorum quidem esse dicitur, quia illud, quod

We can have science of contingent and mobile things, but it must be under some aspect whereby they are necessary. "Nothing is so contingent as not to have some necessary aspect to it."[36] We shall treat in a later chapter the kind of necessity to be found in material objects.

In these three notes we have the Aristolian concept of scientific or perfect knowledge, the fruit of demonstration. It consists of knowledge through a cause, as actually exercising its causality, and as necessitating the effect. Because science is intellectual and not sense knowledge, it is obviously of a universal nature, abstracting from sensible individuals.

Granting Aristotle's idea of scientific knowledge, the end of demonstration, then what kind of premisses are needed to produce such a knowledge? In stating the conditions of the premisses, Aristotle concludes a definition of demonstration from its material cause. Putting this definition into form, we can say that demonstration, or a scientific syllogism, is a syllogism that proceeds from or is composed of premisses that must be "true, primary, immediate, better known than and prior to the conclusion, which is further related to them as effect to cause."[37]

The premisses of demonstration must be true, "for that which is non-existent cannot be known."[38] If an alleged fact is not true, it is non-existent, and so cannot be an object of knowledge. Every cause, moreover, produces an

simpliciter demonstratur, non contingit aliter se habere. Dicitur autem simpliciter demonstratum ad ejus differentiam quod demonstratur in demonstratione quae est ad aliquem, et non simpliciter; quod in quarto libro dixit demonstrare ad hominem arguentem.... Sed, quia causae conclusionis in demonstrationibus sunt praemissae, cum demonstratio simpliciter scire faciat, quod non est nisi per causam, oportet etiam principia, ex quibus est syllogismus, esse necessaria quae impossibile sunt aliter se habere. Nam ex causa non necessaria non potest sequi effectus necessarius." (In V *Meta.,* lect. 6, n. 838.)

[36] "Nihil enim est adeo contingens, quin in se aliquid necessarium habeat." *(Summa Theol.,* I, q. 86, a. 3. Cf. q. 84, a. 1, ad 3.) Our transi.

[37] Post. *Analyt.,* Bk. 1, Chap. 2, 71b 20.

[38] 71b 25.

effect like unto itself; false premisses can *per se* produce only a false conclusion. *Per accidens,* however, a true conclusion can come from false premisses, as in the example: Every man is a stone. Every pearl is a man. Therefore, every pearl is a stone.

Demonstration must likewise have premisses that are primary and immediate. Aristotle explains his meaning of these notes in his customary concise and cryptic manner:

> The premisses must be primary and indemonstrable (i.e. immediate); otherwise they will require demonstration in order to be known, since to have knowledge, if it be not accidental knowledge, of things which are demonstrable, means precisely to have a demonstration of them.... In saying that the premisses of demonstrated knowledge must be primary, I mean that they must be the "appropriate" basic truths, for I identify primary premiss and basic truth. A "basic truth" in a demonstration is an immediate proposition. An immediate proposition is one which has no other proposition prior to it.[39]

Aristotle seems to equate primary and immediate premisses. We can, however, note some slight distinction between the two. Premisses are immediate, according to St Thomas, when they are indemonstrable, that is, when they have no medium whereby they can be demonstrated. They are primary "in relation to other propositions that are proved through them."[40] Let us, for greater clarity, quote the remark of John of St. Thomas with regard to these two notes:

Ibid., 71b 27-28; 72a 6-8. "Appropriate basic truths" translates *ἀρχων οικείων,* the Latin equivalent of which is "ex propriis principiis."

40 "Demonstrativa scientia, idest quae per demonstrationem acquiritur, procedat ex propositionibus *veris, primis* et *immediatis,* idest quae non per aliquod medium demonstrantur, sed per seipsas sunt manifestae (quae quidem *immediatae* dicuntur, in quantum carent medio demonstrante; *primae* autem in ordine ad alias propositiones, quae per eas probantur.)" *(In I Post. Analyt.,* lect. 4, n. 10)

> Demonstration is said to be from primary and immediate—that is, from *per se* known—premisses, which are not demonstrated through any middle term.... They are *primary* with respect to those (propositions) that are proved through them; they are *immediate,* because they lack a middle term to demonstrate them. Accordingly, these two particles are not superfluous, but explain different formalities, namely that (1) a proposition is not demonstrated by another, which is what is meant by lacking a middle term, and (2) it is apt to demonstrate others, or to hold a primacy among them, which is what is meant by being primary.[41]

Primary and immediate, then, are two formalities of the same thing: of a *per se* known, or self-evident, proposition. In general, a *per se* known proposition is one whose predicate is contained in the notion of the subject.[42] Every *per se known* proposition is also primary and immedi-

[41] "Dicitur ex primis et immediatis, id est ex per se notis, quae non per aliud medium demonstrantur, ut explicat D. Thomas *I Poster.* lect. 4. Et dicuntur *primae* respectu earum, quae per illas probantur, *immediatae* vero, quia carent medio demonstrante illas, ut dicit S. Doctor. Itaque non sunt superfluae illae duae particulae, sed explicant diversas formalitates, scilicet propositionem non esse demonstratam ab alio, quod est carere medio, et esse aptam demonstrare alia seu primatum inter alia tenere, quod est esse primam." (John of St. Thomas, *op. cit.* Vol. I, p. 775.)

[42] "Quaelibet propositio, cuius praedicatum est in ratione subiecti, est *immediata* et per *se* nota, quantum est in se." *(In I Post Analyt^* lect. 5, n. 7.) A proposition may be self-evident in itself, though not to us, such as that God exists: the predicate is identical with the subject, but not evidently so to us. Or a proposition may be self-evident both in itself and to us, such as is the principle of non-contradiction, which is spontaneously known by all men. Some such self-evident propositions are known not by all men, but only by the learned, that is, by those who know the definitions of subject and predicate and thus know their identity. It is to be noted that sometimes a demonstration will proceed from a premiss that is not immediate, but proved by another science, from which it is borrowed and accepted in place of an immediate premiss. Ibid., and note k (Leonine). Cf. *Summa TheoL,* I, q. 2, a. 1.

ate.[43] This is not to say that every *per se* proposition is primary and immediate, for all propositions in demonstration, as we will show, must be *per se,* although they may in some cases be conclusions through a middle term: a mediate proposition is *per se* in the sense of essential, though it is known *per medium.*[44] The premisses of the first of a series of demonstrations must be *per se* KNOWN to us.

Since demonstration of premisses cannot proceed backward to infinity, we must arrive at some propositions that are evident to us without demonstration, at some propositions of which we are spontaneously aware that the sub-^ ject and predicate are identified or united. This of course' does not mean that every demonstration has to have immediate premisses. In a series of demonstrations in which a premiss of one is the conclusion of a preceding, it is sufficient that the first demonstration of the series be from immediate premisses.[45]

Though the premisses of only the first demonstration have to be immediate, all the propositions in any demonstration have to be *per se.* Therefore, we must take some time to expand this notion of *per se* propositions. Since necessity is the specifying element of science, our premisses as well as our conclusion must have this element of necessity. If one of the premisses is contingent, the con-

43 "Et quia omnis propositio per se nota est immediata, explicatur negative, quatenus est immediata, et positive, quatenus est per se nota." (John of St. Thomas, *op. cit.,* Vol. I, p. 767.)

44 "Circa praedicatum per se advertendum est, quod in communi loquendo est illud, quod opponitur praedicato per accidens. Et per accidens aliquando est idem, quod per aliud; aliquando est idem, quod non essentialiter, sed accidentaliter et contingenter. Et similiter per se aliquando dicitur idem quod immediate seu non per aliud; aliquando idem quod necessario et essentialiter." (John of St. Thomas, op. cit., p. 769.)

45 "Et sic oportet quod demonstratio ex immediatis procedat, vel statim, vel per aliqua media." *(In I Post. Analyt.,* lect 4, n. 14. Cf. In *V. Meta.,* lect. 4, n. 801.)

elusion will be so also, since an effect cannot be greater than its causes.

Now, what is necessary must be predicated of a subject *per se,* either as a definition or property of it. Any attribute of a subject that is not *per se,* is merely contingent: it can be absent. Therefore, we cannot demonstrate a necessary inherence of it.

There are four ways in which a proposition can be *per se.* But first we must observe that the preposition *per* designates a causal relation; for instance, the body lives *per animam* (formal cause) ; a body is colored *per superficiem* (material cause or proper subject) ; water is heated *per ignem* (efficient cause).[46] Thus, when the subject is itself the cause of the predicate, we have *per se* or essential predication.

The first manner of predicating *per se* is to attribute to a subject something that pertains to its form or essence, that is, a definition or a part of a definition. The second manner takes the preposition *per* as signifying material cause, that is, the proper subject of some form or attribute that cannot be defined without reference to its subject of inherence. Such a "proper passion" depends for its being on its subject, and so can be understood only in relation to it, as "equal" includes "number" and "isocèles" includes "triangle" in their definitions.[47] A third mode is mentioned here only to exclude it: it occurs when *per se* designates, not a causal relation, but rather a "standing alone" or subsistence. Socrates, for instance, cannot be attributed to some subject; rather, *he is a* subject of attribution. So we have here, not a mode of predication, but a mode of being; it does not concern demonstration, because it deals with the singular, whereas science can concern only the universal, for only universals can be defined.

46 Cf. *In I Post. Analyt.,* lect. 10, n. 2. The analysis that follows is taken from Post. *Analyt.,* Bk. I, Chap. 4 and 5 and from St. Thomas' Commentary, lect. 9-14.

« Cf. *In VII Meta.,* lect. 4, n. 1342-1346.

The fourth kind of essential predication is most important for demonstration, because it points formally to the causal relation between subject and predicate, rather than to the relation of predicating, as does the second mode/[8] This means that the predicate is the proper effect of the causal action of the subject. The predicate is considered formally as an effect, not formally as a thing defined in relation to its subject.[49] Moreover, the predicate will often be in the operative order: a property (e.g. a faculty) or a proper operation of the subject, such as: the runner ran, the doctor worked a cure. Aristotle calls this a "consequential connection."

> **If...** there is a consequential connection, the predication is essential; e.g., if a beast dies when its throat is being cut, then its death is also essentially connected with the cutting, because the cutting was the cause of death, not death a "coincident" of the cutting.[80]

48 "Denique quartus modus dicendi per se non est modus praedicandi vel essendi, sed causandi, et definitur ab Aristotele: 'Quando aliquid inest propter ipsum,' id est quando significatur ratio propria, a qua causatur." (John of St. Thomas, *op. rit.,* p. 770.) This causal relation, according to St. Thomas, may be efficient or any other. "... quartum modum, secundum quod haec praepositio *per* designat habitudinem causae efficientis vel cuiuscunque alterius. Et ideo dicit quod quidquid inest unicuique propter seipsum, *per se* dicitur de eo." *(In I Post. Analyt.,* lect. 10, n. 7.) Essence is the efficient, final and material cause of all its proper accidents. Cf. *Summa Theol., I,* q. 77, a. 6, c and ad 2. Properties are said to "emanate" from essence. Cf. John of St. Thomas, *op. rit.,* Vol. II, pp. 267-270.

49 The second and fourth mode of predicating do in fact usually coincide, though there is a formal diversity. The formality of the second mode is that of predication, founded upon the definition of the predicate as including the subject. The fourth mode regards rather the causal relation, in that the predicate depends for its existence upon the subject, its proper cause. Because of the importance of this distinction, we transcribe here a footnote from the Leonine edition of the Commentary on the *Posterior Analytics* (note p, p. 178): "Circa quartum modum perseitatis, inquit Caietanus, diligenter adverte subtilissimam s. Thomae expositionem, secundum quam iste quartus modus distinguitur a secundo formaliter, quia perseitas secundi est formaliter perseitas praedicationis (quatenus subiectum

It is to be noted that the fourth kind of essential predicate can be accidental as regards its actual *esse:* the runner need not always be running; his running is a contingent accident. But in regard to causality, there is an essential relation.®1

The Scholastics subdivided the modes of essential predication into *per se primo* and *per se secundo.* The first designates that the predicate is of the definition of the subject or a property and is convertible with it, because it adéquates the universality of the subject. The predicate is never found apart from the subject, nor the subject, from the predicate. The second excludes convertibility.

This *per se primo* predication is at the very heart of the Aristotelian-Thomist demonstrative theory. Aristotle calls it *καθόλου,* which is translated by the Scholastics as "universale" and by the Oxford translator as "commensurate universal." This latter is an excellent term, and we shall make frequent use of it.

Aristotle gives the following definition of the commensurate universal:

> I term commensurately universal an attribute which belongs to every instance of its subject, and to every instance essentially and as such; from which it clearly follows that all commensurate universals inhere *necessarily* in their subjects.53

ponitur in ratione praedicati, uti supra dictum est), sed perseitas in quarto modo est perseitas causalitatis formaliter (quatenus scilicet praedicatum attribuitur subiecto ratione alicuius causalitatis). Et quia contingit quandoque quod idem sit per se causa alicuius et per se subiectum eiusdem, ut patet de subiecto respectu propriae passionis; ideo quandoque secundus modus et quartus... coincidunt in unam propositionem secundum diversas eius conditiones (ratione nempe *subtecti* et ratione *causalitatis). Ex.* g., in hac propositione: *Animal rationale mortale* est *risibile,* subiectum *(animal)* ponitur in ratione praedicati et subiectum est propria causa illius praedicati."

"Post. *Analyt.,* Bk. 1, Chap. 4, 73b 13-15.

51 John of St. Thomas, *op. cit.,* Vol. I, p. 772.

52 *Post. Analyt.,* ibid., 73b 26.

«/Ma., 26-28.

We note three elements in the commensurate universal. (1) It applies to any random instance of its subject, that is, to all the inferiors of a universal subject and at all times.[54] (2) It applies essentially. (3) It applies as such, that is, the universality of the predicate must be proportioned to or as broad as the universality of the subject. The predicate must belong to the subject by reason of the specific nature of the subject, not by reason of any generic characteristic that it shares with other things. Or to put it in another way: "An attribute belongs commensurately and universally to a subject when it can be shown to belong to any random instance of that subject and when the subject is the *first thing* to which it can be shown to belong."[55] It can be said, for example, that every rock is colored. But the predicate here is too broad for the subject; it is not commensurate. Color applies to rock not as such (as rock), but as a surface; therefore, many other beings besides rocks are colored. To have three angles equal to two right angles is a property commensurate with triangle, not however with isosceles triangle. Likewise, risibility is commensurate with rationality. However, sensibility is not commensurate with man, but with animal. Nor is sight commensurate with animal, but rather to some unnamed universal, since not all animals have the sense of sight. Reproduction is not commensurate with animal, as it belongs also to vegetable, nor with living beings, because some living beings (e.g. spiritual beings) do not reproduce; it is, however, commensurate with living bodies. Breathing, likewise, is not commensurate with animal.[55] There are some properties that do not belong commensurately to any particular things at

[54] *Ibid.,* 73a 27-30.

[55] *Ibid.,* 73b 33. Cf. 74a 1-4: "The demonstration, in the essential sense, of any predicate is the proof of it as belonging to this first subject commensurately and universally: while the proof of it as belonging to the other subjects to which it attaches is demonstration in a secondary and unessential sense."

[56] Cf. Post. *Analyt.,* Bk. 1, Chap. 13, 78b 15-27.

all, but to *being* as such; for instance, existence, actuality, causality, goodness, truth. Scientific knowledge of such can be had only in a science that treats of *being* as such as its subject.

We can begin to see now what a lofty ideal of scientific knowledge Aristotle and St. Thomas had. It is obviously not an easy thing to come by, nor can we hope to know everything in this perfect manner of commensurate universality. Moreover, we can expect that many errors will be made in determining what properties and subjects are commensurately universal. For instance, we could attribute a predicate commensurately to a subject that is actually too narrow or too broad for it; that is, we could attribute to a species what belongs to a genus, and vice versa.[57] How can we know when we have the commensurate universal? We can do no better than give the rule in the words of Aristotle himself:

> When, then, does our knowledge fail of commensurate universality, and when is it unqualified knowledge? If triangle be identical in essence with equilateral, i.e., with each or all equilaterals, then clearly we have unqualified knowledge: if on the other hand it be not, and the attribute belongs to equilateral *qua* triangle; then our knowledge fails of commensurate universality. "But," it will be asked, "does this attribute belong to the subject of which it has been demonstrated *qua* triangle or *qua* isosceles: What is the point at which the subject to which it belongs is primary? (i. e. to what subject can it be demonstrated as belonging commensurately and universally?") Clearly this point is *the first term in which it is found to inhere as the elimination of inferior differentiae proceeds.* Thus the angles of a brazen and isosceles triangle are equal to two right angles: but eliminate brazen and isosceles and the attribute remains. "But"—

[87] Aristotle devotes Chapter 5 of the First Book of Posterior *Analytics* to discussing three kinds of errors that can be made in determining the commensurate universal. Cf. St. Thomas' Commentary, lect. 12.

> you may say—"eliminate figure or limit, and the attribute vanishes." True, but figure and limit are not the first *differentiae* whose elimination destroys the attribute. "Then what is the first?" If it is triangle, it will be in virtue of triangle that the attribute belongs to all the other subjects of which it is predicable, and triangle is the subject to which it can be demonstrated as belonging commensurately and universally.[58]

Now that we have precised the meaning of essential and commensurately universal predication, we must see exactly how they are used in demonstration.

Demonstration is the conclusion of a syllogism in which an attribute is predicated commensurately of its proper subject. Now, the proper subject is included in the definition of the attribute, as was shown above, and the proposition containing them both is in the second mode of essential predication. The subject is also the cause of the attribute, in the fourth mode of predication. "Hence, conclusions of demonstration include a twofold manner of essential predication, namely the second and the fourth."[59] Formally, however, the conclusion is in the second mode.

This conclusion is proved through a middle term that is a definition of both the subject and the attribute,[80] a definition that tells us *quid* and *propter quid.*[61] The major premiss, then, whose predicate is the attribute and whose subject is the definition expressing the cause of the attribute «βά whim-subject is-thc definition oxpreaBing-the-causc of-the aUribatfr is in the fourth mode of essential predication. The minor premiss contains the subject of the conclusion, to which is predicated, in the first mode of predication, its

[a] *Ibid.,* Chap. 5, 74a 33-b 4. (Italics ours.)

[59] "Unde conclusiones demonstrationum includunt duplicem modum dicendi *per se,* scilicet secundum et quartum." *(In I Post Analyt.,* lect 10, n. 8.)

[«°] "Ex definitione subiecti et passionis sumatur medium demonstrationis." *(Ibid.,* lect. 2, n. 3.)

[81] "Omnis quaestio est quodammodo quaestio medii, quod quidem est quod *quid est* et *proper quid."* *(In II Post. Analyt.,* lect. 2, η. 1.)

own definition. The conclusion, then, is in the second mode.®2

An example will help to clarify the above principles. Let us take the syllogism: "Every rational animal is capable of science. Man is a rational animal; therefore, man is capable of science." The conclusion is the second kind of essential predication, where a property is ascribed to a commensurate subject. The middle term, rational animal, is a definition indicating *quid,* or the essential definition of man in the minor premiss (first mode) and *propter quid* of the attribute in the major premiss (fourth mode). For the essence of the subject is the cause of all the properties that naturally flow from it.®3

If the major premiss is not in the fourth mode, then the middle term will not be shown as the cause of the attribute, and the syllogism will be only explicative. The same would hold if the conclusion were in the first mode: it would not predicate a proper attribute of the subject, but only its definition, which would give no new truth besides that already known in the premisses. If, however, the definition concluded is a definition by some other cause, different from and flowing from the definition that serves as middle term, then it is as an attribute of the subject.®4

We have now discussed three of the elements in the definition of demonstration, namely that the premisses have

"Sciendum autem est quod cum in demonstratione probetur passio de subiecto per *medium,* quod est definitio, oportet quod prima propositio, cuius praedicatum est passio et subiectum est definitio, quae continet principia passionis, sit *per se* in *quarto modo; secunda* autem, cuius subiectum est ipsum subiectum et praedicatum ipsa definitio, in *primo modo.* Conclusio vero, in qua praedicatur passio de subiecto, est *per se* in *secundo modo." (In I Post. Analyt.,* lect. 13, n. 3.)

®3 Cf. Note t in the Leonine edition of the Commentary on the *Post. Analyt.,* p. 189.

·* A good summary of the doctrine on demonstration may be found in the little opusculum *De Demonstratione.* Mandonnet considers this work apocryphal, but Grabmann and Michelitsch, with greater probability, accept it as an authentic work of St. Thomas.

to be true, primary and immediate. We still have three more of the notes: that the premisses must be prior to, more known than, and causes of the conclusion. The first three elements concern the premisses in themselves; these last three concern them in relation to the conclusion.

The premisses must be the cause of the conclusion, "because we have scientific knowledge when we know causes."[65] We pointed out earlier that from the standpoint of the formal inference, the premisses are instrumental causes of the conclusions. From the standpoint of the scientific knowledge produced, the middle term, contained in each of the premisses, is the cause of the inherence of the attribute in the subject, as made known in the conclusion. The middle term can be any of the four causes, depending on the nature of the subject matter being demonstrated, for a thing can be defined in terms of any of its causes. But, as we have noted, in the perfect type of demonstration, demonstration *propter quid,* the cause will be the true ontological cause of the conclusion, *causa, in essendo,* not just the cause of our knowledge of the conclusion, *causa in cognoscendo.* Moreover, we must have *per se* and proximate causes, according to what we said above about the need of primary and immediate premisses. A remote cause is not immediate; it is generic and has to be contracted by a specific difference in order to be proportioned to a specific effect. Hence, it is not convertible with the effect and therefore lacks the note of necessary connection. However, it can sometimes happen that a remote cause is convertible with its effect and thus can yield a demonstration *propter quid.* This is called a remote cause only by reason of position or order;[66] it is not contracted by a specific difference extrinsic to it; rather, the further determination of it is something that it already has intrinsically or else something that is

65 "Quia tunc scimus, cum causas cognoscimus." *{In I Post. Analyt.,* lect. 4, n. 15.)

66 *A cause is remote either by reason of predication, i.e., in the logical order, when there is a relation of genus to species, or by reason of order or position.

merely a material condition. Hence the cause is really convertible with the effect. For example, "Every spiritual substance acts by free will." We can use this proposition to demonstrate *propter quid,* even though it is a remote cause. For a spiritual substance acts, not of itself, but through faculties; however, these it has of itself and convertibly with itself.®7

Finally—a point necessary with respect to metaphysics—the cause need not be a physical cause, but it can be a metaphysical or virtual cause, not really distinct from the effect.®§

Because the premisses are causes of the conclusion, they must be prior and better known: prior because the causes must precede their effect; more known because they cause our knowledge of the conclusion and thereby must be more perfect in the order of knowledge, according to the causal axiom, "Propter quod unumquodque tale et illud magis."

We must dwell for a moment on this fore-knowledge (i.e. prior and more known) required in the premisses of demonstration. We may enuntiate a general principle about it in the words of St. Thomas: "The premisses of demonstration are prior and more known simply and according to their own nature, and not in relation to us."®9 For us,

e7 Cf. Note t, IVa, Leonine Edition of the Commentary on the *Posterior Analytics,* p. 239. Cf. note b, p. 234.

Cf. John of St. Thomas, op. *cit.,* p. 775-776: "De demonstrationibus propter quid, respondetur non requiri, quod semper procedant ex causa, quae formaliter sit causa et physice, sed sufficit, quod virtualiter vel metaphysice, ita quod unum se habeat ut ratio alterius, etsi non sit causans alterum, sicut immutabilitas est ratio aeternitatis et perfectio bonitatis, etc. Quod vero dicitur de prima passione respectu essentiae, respondetur illam quidem causari et dimanare ab essentia, sed quia essentia est subiectum, de quo debet demonstrari, non potest demonstrari de ipsa essentia nisi per ipsammet essentiam. Unde in re caret medio, per quod demonstratur, quia est idem cum subiecto; accipitur tamen a nobis definitio essentiae quasi medium demonstrationis non rei, sed ratione distinctum."

e»"Ea, ex quibus procedit demonstratio, sunt priora et notiora simpliciter et secundum naturam, et non quoad nos." *{In. I Post. Analyt.,* lect. 4, n. 15.)

objects close to sense, namely singular material objects, are prior to and more known than universals. It is through the senses that our intellect comes to know universal essences. We work up from the bottom of the cognitional scale, from the material toward the immaterial.[70] The natural hierarchy of knowable objects, beginning with those that are prior and more known *secundum naturam,* is just the opposite. Since immateriality is the formal constitutive of knowledge, the more known objects are those that are more immaterial, more actual, more perfect. Strict scientific knowledge proceeds from cause to effect. The cause has more actuality, more perfection, more being than the effect. Hence, the cause in itself has more knowability than the effect, so that the premisses in which the cause is known are more known than the conclusion in which the effect is known.

What, then, will be the nature and extent of the foreknowledge we need in order to have a strict demonstration?

Demonstration, it has been remarked, is a reasoning process, pertaining to the third act of the mind. It presupposes simple apprehensions and definition of the terms involved, namely, the subject, predicate and middle term. It requires also two immediate judgments, whereby the subject and predicate are seen to be essentially related to the middle term.[71] The definitions and propositions that are the premisses of demonstration are called its principles, that is, its *ἀρχαί,* its beginnings, sources or points of origin.[72] One must also know, as a preliminary to demon-

70 Cf. *Summa Theol.,* I, q. 85, a. 3; *In I Physica,* lect. 1, n. 7; *In I Post. Analyt.,* lect. 4, n. 15,16.

71 "Id cujus scientia per demonstrationem quaeritur est conclusio aliqua in qua propria passio de subiecto aliquo praedicatur: quae quidem conclusio ex aliquibus principiis infertur. Et quia cognitio simplicium praecedit cognitionem compositorum, necesse est quod, antequam habeatur cognitio conclusionis, cognoscatur aliquo modo subjectum et passio. Et similiter oportet quod praecognoscatur principium, ex quo conclusio infertur, cum ex cognitione principii conclusio innotescat." *(In I Post. Analyt.,* lect. 2, n. 2.)

72 "Principium syllogismi dici potest non solum propositio, sed etiam

strafing, the basic principle of the formal inference, namely the principle of non-contradiction. However, this is spontaneously known by all and may therefore be passed over here.

There are two ways of knowing anything: to know that it exists *(quia est)* and to know what it is *(quid est).* In order to know anything, we must first know that it exists, either in the mind or in reality; for what does not exist does not have any being whatever and is therefore unknowable. When we ask about a proposition the question *an sit,* we are inquiring whether it has the being proper to a proposition: does the predicate inhere in the subject? in other words, is the proposition true? Once we know the existence of a thing, we inquire its nature: *quid sit,* that it, we seek a definition of it, either of its essence *(quid rei)* or of its name *(quid nominis).* Obviously we cannot have a definition of a proposition, for definition pertains to essences known through simple apprehension, not to judgment.

Regarding the subject of a scientific conclusion we must know its existence and its real definition, which we predicate of it in the minor proposition. For the definition of the subject is the middle term in our demonstration. Of the attribute, however, we cannot have foreknowledge of its existence, for its existence in the subject is what we want to demonstrate. Neither, than, can we know its essence, "for before we know whether a thing exists, we cannot properly know what it is: non-beings do not have délitions."[73] Besides, the proper subject enters into the definition of the attribute. Hence, we must be satisfied with a nominal definition of the attribute?[73]

.definitio." "Principium demonstrationis sit propositio immediata." *(Ibid.,* lect. 5, η. 9, η. 1.)

[73] St. Thomas* doctrine is given in the following text: "Horum autem trium, scilicet, principii, subiecti et passionis est duplex modus praecognitionis, scilicet, *quia* est et *quid· est.* Ostensum est autem in VII *Metaphysicae* quod complexa non definiuntur. *Hominis* enim albi non est aliqua definitio et multo minus enunciationis alicuius. Unde cum principium sit enunciatio quaedam, non potest de ipso praecognosci *quid est,* sed solum *quia* verum est. De *passione* autem

The doctrine we have explained thus far by commenting on each element of the two definitions of demonstration applies properly to demonstration *propter quid,* or as Aristotle's Oxford translator aptly renders it, "knowledge of the reasoned fact."[74] It will help us to an accurate understanding of scientific demonstration if we contrast it with other forms of proof.[75]

First, there is a distinction between *demonstratio universalis,* or the perfect type where there is commensurate universality between subject and predicate, and *demonstra^ tio particularis,* where an attribute is predicated of a particular subject through a middle term which is the proper and commensurate subject of the attribute; for example, an isosceles has three angles equal to two right angles because it is a triangle.[754] In this type of demonstration, even though the attribute in the conclusion is not commensurate with the subject, yet it is shown to belong to it because of its participation in the nature of the proper subject: the attribute belongs to the particular subject not by reason

potest de ipso quidem sciri *quid est,* quia, ut in eodem libro ostenditur, accidentia quodammodo definitionem habent. Passionis autem *esse* et cuiuslibet accidentis est inesse subiecto: quod quidem demonstratione concluditur. Non ergo de passione praecognoscitur *quia est,* sed *quid est* solum.—Subiectum autem et definitionem habet et eius esse a passione non dependet; sed suum esse proprium praeintelligitur ipsi esse passionis in eo. Et ideo de subiecto oportet praecognoscere et *quid est* et *quia est·,* praesertim cum ex definitione subiecti et passionis sumatur medium demonstrationis....

"Alia vero sunt, de quibus oportet praeintelligere *quid est quod dicitur,* idest quid significatur per nomen, scilicet de *passionibus.* Et non dicit *quid est* simpliciter, sed *quid est quod dicitur,* quia antequam sciatur de aliquo an sit, non potest sciri proprie de eo quid est: non entium enim non sunt definitiones. Unde quaestio, *an est,* praecedit quaestionem, *quid est.* Sed non potest ostendi de aliquo an sit, nisi prius intelligatur quid significatur per nomen." *(In I Post. Analyt.,* fect. 2, n. 3, n. 5.)

74 Post. *Analyt.,* Bk. 1, Chap. 13, 78a 22.

75 Cf. the schema of types of demonstration given in the Leonine Edition of the Commentary on the Post. *Analyt.,* p. 239.

754 Cf. *In I Post. Analyt.,* lect. 37 and 38, esp. note *a,* p. 291. See also the opusculum *De Demonstratione.*

of its specific nature, but by reason of its proximate genus. Hence, the particular demonstration partakes of the perfection of *propter quid* demonstration, although not fully. The cause assigned is an actual and proximate cause of the attribute, not a remote or radical cause that needs a specific difference which would assign the reason of the attribute. Such would be the case if we said that an isosceles has three angles equal to two right angles because it is a plane figure. This particular demonstration is of great value, especially when it occurs in conjunction with a universal demonstration as applying the universal conclusion to a less universai case.

A demonstration *propter quid* may be of two kinds from the point of view of what is proved. This division is only implicit in Aristotle, and was explicitly made by Averroes. An effect may be already known, for instance, we may see an eclipse of the moon, and a demonstration of that effect will make known its cause. This Averroes called *demonstratio propter quid tantum.* Or we may deduce the very existence of the effect and then we would have a demonstration of the proper cause and the being of the effect, which Averroes called *propter quid et absoluta.*™

Demonstration *quia,*77 the kind of proof that establishes the existence or truth of a fact without telling the proper reason or cause of the fact, is univocally a type of demonstration, for it gives us certain and evident knowledge. But it imperfectly participates the nature of science, which sees the proper causes of attributes in the essence of their subjects.78 There are degrees of demonstration *quia.* It may be *a posteriori,* through effects that are convertible and adequate with their hidden causes, which are thus made known. Then we can come to a knowledge of the essence of the cause. Or it may be through effects not adequate

78 Schema of demonstration, IIIa (Cf. note 75 supra.) Cf. St. Thomas, *In II Post. Analyt.,* lect. 7, n. 5.

w Cf. *Summa Theol.,* I, q. 2, a. 2.

Cf. John of St. Thomas, *op. cit.,* p. 788.

to their cause, and then we arrive at only the existence of the cause.

> Some things are knowable to us through themselves; and in bringing such things to light the speculative sciences use their definitions to demonstrate their properties, as happens in the sciences which demonstrate *propter quid.* There are other things which are not knowable to us through themselves but through their effects. And if indeed the effect is adequate to the cause, we take the quiddity itself of the effect as our starting point to prove that the cause exists and to investigate its quiddity, from which in turn its properties are made evident. But if the effect is not adequate to the cause, then we take the effect only as the starting point to prove the existence of the cause and some of its conditions, although the quiddity of the cause is always unknown.[79]

Demonstration *quia* occurs also when we have reasoning from cause to effect, but the cause is remote and non-convertible with its effect. Aristotle gives as one example that a wall does not breathe because it is not an animal.[80] This is only a remote cause and is not convertible, or adequately universal, with the effect, because there are some animals, fishes, that do not breathe. The proper cause *of not* breathing is the absence of lungs. Such demonstrations are useful and yield certainty of fact when they are negative. But often, to demonstrate from a non-convertible cause, says Aristotle, is "like far-fetched explanations, which precisely consist in making the cause too remote, as in Anacharsis'

[79] *In De Trin.,* q. 6, a. 4, ad 2. Cf. *In II Post. Analyt.,* lect. 13 . When an a posteriori demonstration has led us to a proper and commensurate cause, we can turn around and demonstrate the effect a *priori.* This does not constitute a circular demonstration. There is a circular demonstration when the conclusion is deduced *a priori* from the premisses, and then the premisses are deduced *a priori* from the conclusion. In such a case, the premisses are more known and less known at the same time. Cf. St. Thomas, *In I Post. Analyt.,* lect. 8, and note b of Card. Zigliara (Leonine ed.)

[80] *Post. Analyt.,* Bk. I, Chap. 13, 78b 15.

account of why the Scythians have no flute-players, namely because they have no vines."[81]

Demonstration can also be indirect, or negative. It can show that it is impossible or absurd that a certain attribute should inhere in a certain subject. Such demonstration can be both *propter quid* or *quia.* This type is not to be contemned, for sometimes we must be satisfied to know what a thing is *not;* at other times, when we are able to set up a complete disjunction, then by showing that a thing is not one member of the disjunction, we by that very fact show that it is the other.

In the beginning of this chapter we spoke of the process of understanding whereby we grasp the principles of demonstration: the definitions and immediate propositions that make up a syllogism. Understanding and scientific demonstration give us true knowledge of a necessary object or fact. But there are also facts that are true, though not necessary; they are contingent. They obviously cannot be the object of science, which by its very nature concerns necessary matters. The act of the mind that apprehends the contingent is called opinion.[82] Aristotle defines it as: "the grasp of a premiss which is immediate but not necessary."[83] It may be an immediate and necessary proposition, but thought to be contingent; or it may be itself contingent.

> If there is some mediate contingent proposition, it has to be reduced to some immediate propositions. But it is not reduced to necessary immediate propositions, because necessary principles are not the proper principles of contingent things, nor can contingent things be concluded from necessary things. Hence there must be some contingent immediate proposition. For instance, *the man is not running* is mediate; it can be proven through this middle: *the man is not moving,* which is a contingent, but immediate proposition. The knowledge of such contingent immediate propositions is opinion: but this does not exclude the acceptance

[81] *Ibid.,* 29-31.

[82] Cf. *In I Post. Analyt.,* lect. 44.

[83] *Post. Analyt.,* Bk. 1, Chap. 33, 89a 4.

of a mediate contingent proposition from being opinion.[84]

Thus we have opinion considered subjectively, or the assent given to any proposition with some fear that it may not be true; and opinion considered objectively, or the assent to a proposition concerning contingent matter, whether the proposition be actually true or false.[85] Opinion can yield us factual certitude regarding contingent things, but as scientific explanation it cannot surpass the status of probability. A syllogism that concludes only an opinion or non-necessary knowledge is called a dialectical syllogism.

It is to be noted that the reason for contingency is matter. It is by reason of form that things have 'the character of necessity, and since form is the determinant of cognition, things are the more knowable the more necessary they are. Matter is the principle of contingency, for matter introduces into a being the potentiality to be otherwise than it is. Thus, the contingent, being more immersed in matter, is by that very fact less knowable, for a thing is knowable in proportion to its immateriality. So we can have science of the necessary, but only opinion of the contingent.[88]

84 "Si igitur sit aliqua propositio contingens mediata, oportet quod reducatur ad aliquas immediatas. Non autem reducitur ad immediatas necessarias, quia necessaria non sunt propria principia contingentium, neque ex necessariis potest concludi contingens. Unde relinquitur quod sit aliqua propositio immediata contingens. Sicut, *homo non currit,* est mediata; potest enim probari per hoc medium, *homo non movetur,* quae etiam est contingens, sed immediata. Existimatio ergo talium propositionum contingentium immediatarum est opinio: sed per hoc non excluditur quin etiam acceptio propositionis contingentis mediatae sit opinio." *(In I Post. Analyt.,* lect. 44, n. 5.)

85 There is a broad and generic use of the word "opinion," meaning any knowledge with assent, e.g., St. Thomas' opinion on the eternity of the world. In this sense, understanding and science can also be called opinion.

88 This is not meant to rule out the certainty of things known by faith or history. The authority of another can give us certain and necessary knowledge of a nature, such as the nature of the sacraments. A trustworthy eye witness gives certitude of the contingent facts of history; this is a certitude of existence or fact, not of essence, and hence is of no concern to us in this discussion of science.

Moreover, since matter is the principle of individuation, we immediately see that singular things are contingent—singular things, the knowledge of which belongs properly to sense, and only indirectly to the intellect.[87] This knowledge of singular contingent things *as* contingent is really not an intellectual knowledge at all. It belongs rather to the sense faculties, especially to the cogitative power. This distinction is so important that it deserves to be corroborated by a pertinent quotation from St. Thomas.

> Contingent things can be known in two ways. In one way, according to their universal reasons; in another way, in their particularity. The universal reasons of contingent things are immutable, and from this aspect there can be demonstrations about them and the knowledge of them pertains to demonstrative sciences. For natural science does not deal only with necessary and incorruptible things, but also with corruptible and contingent things. Hence, contingent things so considered clearly belong to the same part of the intellective soul as do necessary things. This the Philosopher calls scientific. __Contingent things can be considered in another way, in their particularity: thus they are variable and are known by the intellect only through the medium of the sensitive powers. Hence among the sensitive parts of the soul there is a faculty that is called *particular reason* or *vis cogitativa,* which collates particular intentions.[88]

[87] "Est autem unumquodque contingens ex parte materiae, quia contingens est quod potest esse et non esse; potentia autem pertinet ad materiam. Necessitas autem consequitur rationem formae, quia ea quae consequuntur ad formam, ex necessitate insunt. Materia autem est individuationis principium; ratio autem universalis accipitur secundum abstractionem formae a materia particulari. Dictum autem est supra quod per se et directe intellectus est universalium; sensus autem singularium, quorum etiam indirecte quodammodo est intellectus, ut supra dictum est. Sic igitur contingentia, prout sunt contingentia, cognoscuntur directe quidem sensu, indirecte autem ab intellectu; rationes autem universales et necessariae contingentium cognoscuntur per intellectum." *(Summa Theol.,* I, q. 86, a. 3.)

[88] "Contingentia dupliciter cognosci possunt. Uno modo secundum rationes universales; alio modo secundum quod in particulari. Univer-

We wished to emphasize this matter of opinionative knowledge of contingent objects, because positive science deals with contingent objects, at least insofar as it does not arrive at a grasp of their essences whereby necessary knowledge is attained. Hence, *de facto,* positive science, in as far as it is physical rather than mathematical, seems to remain on the level of the cogitative power, and so is not science at all in the Aristotelian sense. Its "concepts" are not true universals, but the quasi-universals or generalized sense images of the cogitative. We will have to come back to this point presently. First, we wish to discuss opinion in the domain of necessary matter, of conclusions which in themselves are scientific, but which are not grasped as such by a particular person—opinion, that is, considered subjectively rather than objectively.

A man may have only opinion of a conclusion that is objectively a scientific and necessary proposition. One may see the proposition as impossible to be otherwise, and thus have science. Another may think it possible to be otherwise. The root of his difficulty is in the understanding of the immediate propositions. The first man sees them as immediate; the other cannot see them as such, so he is barred from scientific knowledge of the conclusion. A corollary to this possibility of a scientific demonstration being known only opinionatively is the need to understand demonstrative theory, and this especially for beginners in philos-

sales quidem igitur rationes contingentium immutabiles sunt, et secundum hoc de his demonstrationes dantur et ad scientias demonstrativas pertinet eorum cognitio. Non enim scientia naturalis solum est de rebus necessariis et incorruptibilibus, sed etiam de rebus corruptibilibus et contingentibus. Unde patet quod contingentia sic considerata ad eamdem partem animae intellectivae pertinent ad quam et necessaria, quam Philosophus vocat hic scientificum.... Alio modo possunt accipi contingentia secundum quod sunt in particulari: et sic variabilia sunt nec cadit supra ea intellectus nisi mediantibus potentiis sensitivis. Unde et inter partes animae sensitavas ponitur una potentia quae dicitur *ratio particularis, sive vis cogitativa,* quae est collativa intentionum particularium." *{In VI Ethicorum,* lect. 1, n. 1123. Cf. *De Anima,* a. 12, c., *De Ver.,* q. 15, a. 2, ad 3.)

ophy. If one does not understand the process of demonstration, he will indeed learn philosophy: he will know the doctrines of Thomism and perhaps even teach them. But if he does not recognize and understand the demonstrations, his knowledge will not be scientific, but opinionative and always vacillating and unstable/9 He will therefore be tempted to look around for novel opinions, or to confine himself to the historical approach to philosophy, or to become a mere cataloguer of opinions.

Opinion, as an inferior type of knowledge, is characterized by uncertainty on the scientific level. St Thomas compares it with natural processes that do not always and of necessity produce their effects.90 Its essential weakness is also apparent from the fact that we do not acquire an opinion ordinarily from a single probable argument, but prefer to multiply arguments and count the authorities favoring the opinion.91 So when philosophy becomes a listing of

89 "To have knowledge, if it be not accidental knowledge of things which are demonstrable, means precisely to have a demonstration of them." (Post. *Analyt.,* Bk. 1, Chap. 2, 71b 28.)—Common sense knowledge can in some cases be certain and necessary, and thus participates the nature of science. Yet, because it is confused and uncritical, it falls short of the perfection of science.

90 "Attendendum est autem quod actus rationis similes sunt, quantum ad aliquid, actibus naturae. Unde et ars imitatur naturam in quantum potest. In actibus autem naturae invenitur triplex diversitas. In quibusdam enim natura ex necessitate agit, ita quod non potest deficere. In quibusdam vero natura ut frequentius operatur, licet quandoque possit deficere a propria actu. Unde in his necesse est esse duplicem actum; unum, qui sit ut in pluribus, sicut cum ex semine generatur animal perfectum; alium vero quando natura deficit ab eo quod est sibi conveniens, sicut cum ex semine generatur aliquod monstrum propter corruptionem alicuius principii. Et haec etiam tria inveniuntur in actibus rationis. Est enim aliquis rationis processus necessitatem inducens, in quo non est possibile esse veritatis defectum; et perhuiusmodi rationis processum scientiae certitudo acquiritur: Est autem alius rationis processus, in quo ut in pluribus verum concluditur, non tamen necessitatem habens. Tertius vero rationis processus est, in quo ratio a vero deficit propter alicuius principii defectum." *(In I Post. Analyt.,* lect. 1, n. 5.)

91 "Quando actio agentis est efficacior, tanto velocius inducit formam;

opinions, it is actually in a weakened and degenerate state.

However, we do not wish to imply that opinion has no place in the genesis of science. To begin with, the essential limitation of our minds does not permit us to have certainty about everything. There are some matters about which we must be content to have only probability. Then, there are many minds that cannot grasp demonstrations, and so find satisfaction on the more superficial level of common opinion. But the most important function of dialectics is its methodological character; it is a preparation for, a clearing of the way for, and the first gropings toward true scientific demonstration. "Dialectic is a process of criticism wherein lies the path to the principles of all inquiries."[92] "Moreover, as contributing to knowledge and to philosophic wisdom the power of discerning and holding in one view the results of either of two hypotheses is no mean instrument, for it then only remains to make a right choice of one of them."[92] As St. Thomas puts it:

> Sometimes the investigation of reason cannot arrive at the ultimate end, but stops in the investigation itself, that is to say, when two possible solutions still remain open to the investigator. And this happens when we proceed by means of probable arguments, which are suited to produce opinion or belief, but not science. In this sense, *rational* method is contradistinguished to *demonstrative* method. And we can proceed rationally in all the sciences in this way, preparing the way for necessary proofs by probable arguments.[94]

It is important to note the difference between demonstration and the so-called "scientific" method. This latter

et ideo videmus in intellectualibus, quod per unam demonstrationem, quae est efficax, causatur in nobis scientia; opinio autem, licet sit minor scientia, non causatur in nobis per unum syllogismum dialecticum; sed requiruntur plures propter eorum debilitatem." *(De Virtutibus in Communi,* a. 9, ad 11.)

92 *Topics,* Bk. 1, Chap. 2, 101b 3-4. On this whole matter of opinion, cf., L.—M. Regis, O.P., *L'Opinion selon Aristote.*

«Ζὸἀι, Bk. 8, Chap. 14, 163b 9-11.

84 *In De Trin.,* q. 6, a. 1, c.

is not a species of demonstration, but rather a process of discovery. It is more closely related to the search for definitions and to induction, than to demonstration. Induction is the progression of the mind from a sufficient enumeration of singular instances to the universal implicit in them. It takes its origin in the experience of the senses through the mediation of the *vis cogitativa,* from whose generalized image the intellect abstracts a universal essence, or in inductive argumentation, infers the universal.[95] It is to be noted that induction does not necessarily give us a knowledge of an essence down to its last specific difference at the outset of our investigation. But it does yield us a general definition; it gives us *some* knowledge of an essence, a knowledge that we can further divide and specify in the course of our sciences.

As we come down to the particular aspects of material beings, we find their specific natures impervious to our intellectual intuition. Their very materiality dims their intellibility. At this level we must often substitute an unknown *x,* a conjecture or a hypothetical construction, especially of a mathematical kind, for the essence.[98] In this we touch upon the core of the experimental method. A large number of facts are carefully observed, ordinarily by measuring instruments, for example, the rectilinear propagation of light, its reflection from a smooth surface, its angle of refraction at the surface of a body of water, and the transmission of energy by light. From the constant recurrence of these phenomena we come to suspect that they are properties of light. But we cannot demonstrate

95 Cf. *In I Post. Analyt.,* lect 30, n. 4-6; II, lect. 20.

98 "Sunt autem quaedam in quibus non est possibile talem resolutionem facere ut perveniatur usque ad quod quid est, et hoc propter incertitudinem sui esse; sicut in contingentibus in quantum contingentia sunt: unde talia non cognoscuntur per quod quid est, quod erat proprium objectum intellectus, sed per alium modum, scilicet per quamdam conjecturam de rebus illis de quibus plena certitudo haberi non potest." *(De Ver.,* q. 15, a. 2, ad 3. Cf. *Summa Theol.,* I, q. 32, a. 1, ad 2.)

them as such, because we do not know the essence of light. Essence is the middle term of a demonstrative syllogism, and is the foundation of the necessity of the scientific conclusion. However, as a *hypothesis,* light was for many centuries considered to be the emission of corpuscules shooting out from a luminous source. Taking such a provisional definition of light as a middle term, scientists thought that the attributes were shown to follow as properties. But naturally, the whole demonstration did not surpass the level of probability.

Thus we have two steps: observation and hypothesis. Now, *if* the hypothesis is true, it will not only explain all the observed facts in question, but it will also serve for the deduction of new facts. Thus, the third step of the experimental method is that of verification: deduction of new facts and the construction of a "crucial" experiment to test the deduction.

Even when a hypothesis is "verified" by deduction of new phenomena, no matter how startling they may be—even then we do not enjoy necessary and scientific knowledge. The fact *could be otherwise,* since we do not have an intellectual intuition of the essence, but know it only by conjecture. Thus, there have been a succession of theories regarding the nature of light: the corpuscular, the wave, the electromagnetic and finally the quantum theory. The atomic theory, the Copernican theory of the heavenly bodies, the Freudian theory of the psyche, in fact, a large part of Newtonian physics—all are merely probable explanations, not in the realm of demonstration, but rather of inductive attempts to reach a definition.[97] In this respect we must

[87] It would be better to say that the theories of experimental science are working hypotheses for the discovery of new facts and practical applications. Scientists are not so much interested in essential as in functional and metrical definitions which will suggest further research. As Vincent E. Smith says: "Discovery, not proof, is the goal of empiriological physics. From Georges Sorel, one may borrow the term *systematic* and some of its meaning. Empiriological physics makes a system or catalogue of facts for the engineers. It

remember St. Thomas' remark regarding the Ptolemaic system of astronomy:

> Reasoning may be brought forward for anything in a twofold way: firstly, for the purpose of furnishing sufficient proof of some principle, as in natural science, where sufficient proof can be brought to show that the movement of the heavens is always of a uniform velocity. Reasoning is employed in another way, not as furnishing a sufficient proof of a principle, but as showing how the remaining effects are in harmony with an already posited principle; as in astronomy the theory of eccentrics and epicycles is considered as established, because thereby the sensible appearances of the heavenly movements can be explained; not however, as if this proof were sufficient, since some other theory might explain them.[98]

This method of the experimental sciences is called by some "systematic explanation" and is merely a substitute for demonstration.[99] It can be used whenever we do not have a definition of our subject. It is used in theology, as for instance in the distinction of the angels into hierarchies and orders.[100] This method consists essentially in using a logical, and very often mathematical, construct in place of an essential definition. In this way congruous premisses can be established from which a certainly known conclusion is seen logically to follow. However, there is no question of a connection of the conclusion with real and necessary

multiplies data by schemes that are not explanations and are not ultimate. The ultimate in the empiriological order is the practical and the factual of experience." *(Philosophical Physics,* p. 174.)

[98] *Summa Theol.,* I, q. 32, a. 1, ad 2; cf. *In II De Coelo,* lect. 17, n. 2.

[99] Cf. tiie excellent treatinent of Owen Bennett, O.M.C., *The Nature of Demonstrative Proof,* Chap. VI, "Systematic Explanation, the Substitute fo Demonstrative Proof" and Chap. VII, "The Use and Interpretation of Systematic Explanation," pp. 68-85. Our description of the experimental method has been confined to the explanatory aspect, the search for causes. There is another aspect to the method, the search for physical laws or relations between phenomena. Cf. P. Coffey, *The Science of Logic, Vol.* II, pp. 120-127.

[100] Cf. *Summa Theol.,* I, q. 108, a. 1-6.

principles. The experimental method cannot directly and immediately yield science in the strict Aristotelian sense of the word.

As a final remark, we may say that where a definition of a subject is available, particularly in the sciences of man, whose specific definition we know, we should use the demonstrative method, otherwise we close the door to a rich harvest of truth and doom ourselves to roam in the stubble-field of uncertainty. We will return to this subject again and again. For the present we may quote a few sentences of Father Bennett, at the conclusion of his valuable study of systematic explanation.

> It would be foolish, indeed, to contemn such an instrument. But it would be more foolish to use it or seek to use it when a more perfect instrument is at hand and can be employed. Let man, rather, prove what he can prove, and explain by system what he cannot prove.[101]

[101] *Op. cit.,* p. 91.

CHAPTER II

THE SUBJECT OF NATURAL PHILOSOPHY

A science is a body of truths about some subject, varying in their degrees of certitude, but all essentially orientated toward and leading to strict *propter quid* demonstrations. We have seen that before we can demonstrate we have to know the existence and nature of our subject, for the definition of the subject is the middle term in a demonstration, and in the light of it we prove the proper attributes. The knowledge of the subject is attained either through sensory experience or is supplied from a higher science, for no science can prove its own subject, but rather proves the attributes by means of the subject.[1]

Sciences are distinguished from one another by reason of their subjects, that is, according to the manner in which the subjects are defined, for the definition of the subject as used for the middle term is the principle of intelligibility of all that is attained in a science.[2] In order, then, to deter-

1 "Ipsum autem quod quid est sui subjecti aliae scientiae faciunt esse manifestum persensum; sicut scientia, quae est de animalibus, accipit quid est animal per id quod 'apparet sensui,' idest per sensum et motum, quibus animal a non animali discernitur. Aliae vero scientiae accipiunt quod quid est sui subjecti, per suppositionem ab aliqua alia scientia, sicut geometria accipit quid est magnitudo a philosopho primo. Et sic ex ipso quod quid est noto per sensum vel per suppositionem, demonstrant scientiae proprias passiones, quae secundum se insunt generi subjecto, circa quod sunt. Nam definitio est medium in demonstratione propter quid." *(In VI Meta.,* lect. 1, n. 1149. Cf. *In II Post. Analyt.,* lect. 8, n. 1.)

2 "Ad cognoscendum differentiam scientiarum speculativarum ad invicem, oportet non latere quidditatem rei, et 'rationem' idest definitionem significantem ipsam, quomodo est assignanda in unaquaque scientia. Quaerere enim differentiam praedictam, 'sine hoc,' idest sine cognitione modi definiendi, nihil facere est. Cum enim definitio sit medium demonstrationis, et per consequens principium sciendi, oportet quod ad diversum modum definiendi, sequatur diversitas in scientiis speculativis." *(Ibid.,* n. 1156.)

mine the nature of natural philosophy, we must first investigate the requirements and characteristics of the subject of a science.

There is a difference of terminology and viewpoint among the scholastics regarding the subject of a science. This can be confusing, especially when we are reading the text of St. Thomas and paralleling his doctrine with that of his commentators. In the following discussion we have adopted the divisions and terminology of John of St. Thomas in his *Cursus Theologicus*[3] as being more in harmony with the usage of St. Thomas. The terminology of Cajetan,[4] which most authors follow, seems deficient in that it does not explicitly distinguish between the subject of a science and the object of the habit of science.

"In each science," says John of St. Thomas, "subject and object differ; and in each we can find something formal and something material."[5]* When St. Thomas speaks of science in the sense of the scientific process, he uses the term: "subject" or "subject-genus" of the science. It is that of which we are seeking knowledge: "A subject in a science is that whose causes and properties we are seeking."*[7] Whereas, when he speaks of science in the sense of an intellectual habit, he refers to the object of science. Subject and object are not identical, though there is an analogy between them.[7] It is to be noted that the object of the habit of science is not a subsisting thing, as the subject is; it is rather the scientific process itself, the demonstrations given

[3] *Cursus Theologicus,* In Q. 1, Primae partis, Disp. 2, Art. 11, Vol. I, p. 402.

[4] *Commentaria* in 1a, q. 1, a. 3.

[5] "In qualibet scientia differunt subjectum et objectum, et in utroque potest invenire id quod est formale, et quod est materiale." *(Ibid.)*

* "Hoc enim est subjectum in scientia, cujus causas et passiones quaerimus." *(In Meta.,* Proem.) Cf. "... genus subjectum, cuius proprias passiones et per se accidentia demonstratio ostendit." *(In I Post. Analyt.,* lect. 15, n. 3.)

[7] "Sic enim se habet subiectum ad scientiam, sicut obiectum ad potentiam vel habitum." *(Summa Theol.,* I, q. 1, a. 7.)

in the science. John of St. Thomas calls it: "something complex, namely that which is made known by the science as inferred and proved."[8] That which specifies the habit of science is not the subject known, but the scientific knowledge of that subject, the scientific conclusions about that subject.

The subject is both material and formal. The material subject (or subject matter) is the thing or things to be studied in the science, apart from the consideration of the mind; for instance, man, animals, vegetables, minerals, etc., as they exist entitatively. It embraces everything that can be the subject of a conclusion in the science. The formal subject is the particular aspect from which the material subject is to be considered, that aspect, namely whereby the material thing is the proper and commensurate subject of the attributes to be demonstrated of it.

The material *object* of the habit of science is all the scientific conclusions about the subject. The formal object is the reason under which and through which the conclusions are made known scientifically.[9] We saw in the preceding chapter that it is the middle term, as the definition of the subject, that is the cause of the scientific intelligibility of the conclusion. This is clear in the following passage of St. Thomas:

> The object of every cognitive habit includes two things: first, that which is known materially, and is the material object, so to speak, and secondly, that whereby it is known, which is the formal

[8] "Objectum scientiae est aliquid complexum, scilicet id quod per scientiam manifestatur tamquam illatum et probatum, scilicet conclusiones, ut docet S. Thomas (II-II, q. 1, a. 1): scientia enim non cognoscit, nisi probando et inferendo. Quod autem infertur et probatur, est conclusio illata: conclusio autem est aliquid complexum, in quo aliquod praedicatum dicitur de aliquo subjecto; et illa propositio seu conclusio illata dicitur objectum scibile, id est, id quod scitur et infertur in aliqua scientia." *{Ibid,* Cf. *Summa Theolo.,* I-II q. 57, a. 2, ad 2.)

[9] "Formale vero est ratio illa sub qua, et per quam illustratur et manifestatur talis conclusio." (John of St. Thomas, *Ibid.)*

> aspect of the object. Thus, in the science of geometry, the conclusions are what is known materially, while the formal aspect of the science consists in the means *(.media)* of demonstration, through which the conclusions are known.[10]

The formal object, then, is the middle term as it is the definition of the formal subject. This middle term is a definition by the first principles or component parts of the formal subject, and in the light of these first principles, the conclusions are deduced.

We must investigate further into the nature and requirements of the object of a science. St. Thomas says:

> Now we must understand that when habits or powers are distinguished according to their objects, they are not distinguished according to just any difference of objects, but according to those which essentially characterize the objects as objects. For instance, to be either animal or plant is accidental to a sensible thing as sensible; and so the distinction of the senses is not taken from this difference, but rather from the difference of color and sound. Consequently, the speculative sciences must be distinguished according to the differences among objects of speculation precisely as objects of speculation.[11]

In other words, although things may be specifically distinct in their entitative being, such as men or brutes, they may be united into one object of speculation, if there is a single knowable aspect in them all, and if they can be made objects of knowledge by being defined with the same first principles. As St. Thomas says in another place:

> In order for a science to be simply one there is required unity of both subject and principles.... It is not to be understood that for the unity of a science it is sufficient to have unity of first principles simply, but rather, unity of first principles in some scientific genus *(genere scibili).* For sci-

[10] *Summa Theol.,* II-II, q. 1, a. 1.

[11] *In De Trim,* q. 5, a. 1. Cf. *Summa Theol.,* I, q. 77, a. 3; I-II, q. 54, a. 2; *In I Post. Analyt.,* lect. 41, n. 11.

> entific genera are distinguished according to the different manner of knowing.[12]

An object of the habit of science (i.e. a scientific demonstration) must have two characteristics, one on the part of the intellect and another on the part of the habit of science. John of St. Thomas remarks:

> To be knowable scientifically adds to mere intelligibility a special manner of knowledge, namely, that something be known not in a simple manner, but in an inferential manner by proceeding from causes, or premisses, to conclusions; for to know scientifically is to know the cause why a thing is.[13]

A thing is intelligible according to its degree of *immate-j riality;* but a thing is scientifically intelligible insofar as j an attribute is seen to inhere *necessarily* in a necessary | subject.[14]

Immateriality and necessity, then, arp^the two notes of' the scientific object. The middle termis the cause of the | necessity of the conclusion and must therefore itself be

12 "Ad hoc autem quod sit una scientia simpliciter utrumque requiritur et unitas subiecti et unitas principiorum.... Nec tamen intelligendum est quod sufficiat ad unitatem scientiae unitas principiorum primorum simpliciter, sed unitas principiorum primorum in aliquo genere scibili. Distinguuntur autem genera scibilium secundum diversum modum cognoscendi." *(In I Post. Analyt.,* lect. 41, n. 12.)

13 "Esse scibile addit supra esse intelligibile talem modum cognoscendi, scilicet quod aliquid intelligatur non simplici modo, sed modo illativo, ex causis seu praemissis procedendo ad conclusiones; scire enim est cognoscere causam, ob quam res est, etc." (John of St. Thomas, *Cursus Phil.,* I, p. 823 a).

14 "Speculabili autem, quod est objectum speculativae potentiae, aliquid competit ex parte intellectivae potentiae et aliquid ex parte habitus scientiae, quo intellectus perficitur. Ex parte siquidem intellectus competit ei quod sit immateriale, quia et ipse intellectus immaterialis est; ex parte vero scientiae competit ei quod sit necessarium, quia scientia de necessariis est.... Omne autem necessarium, in quantum hujusmodi est immobile, quia omne quod movetur in quantum hujusmodi est possibile esse et non esse vel simpliciter vel secundum quid.... Sic ergo speculabili quod est objectum scientiae speculativae per se competit separatio et a materia et a motu, vel applicatio ad ea." *(In De Trin.,* q. 5, a. 1.)

necessary in some way, as we shall see in Chapter III. The intelligibility of the middle term—and therefore also of the conclusion, which must be of commensurate universality—depends on the degree of removal from matter. These two characteristics coalesce, in that the more immaterial a thing is, the more necessary it is, for potentiality is equally the principle of materiality and contingency.

There are some things that are so dependent on matter that they can neither be nor be defined without matter. Such, we shall see, are the objects of natural science, or physics, which are abstracted only from individual matter, but are essentially involved in sensible matter. Other objects of knowledge abstract from sensible matter in their definition, such as straight or curved and other mathematical entities; they depend on matter, however, as to their existence, for they cannot exist apart from matter. At the highest degree, there are objects of knowledge that completely prescind from matter, both as to definition or concept and as to existence, such as substance, actuality, causality and being. These are the objects considered in metaphysics. They are independent of matter in their concept, and though they are jisually found in matter and it is from their material existence that we learn of them, yet they are verified even in immaterial existence, as in God and separated souls. It is according to these three degrees of removal from matter that we have subjects given us of the three sciences of physics, mathematics[15]*and metaphysics.

We can now easily reconcile the apparently different ways in which St. Thomas distinguishes the various sciences. Sometimes he says that sciences differ according to the different degrees in which their objects are abstracted from matter.[10] At other times he seeks the reason in the

[15] There are two distinct mathematical sciences, arithmetic and geometry.

[10] *In De Trin., q.* 5, a. 1; *In I Phys.,* lect. 1, n. 2; *Summa Theol.,* I, q. 85 a. 1, ad 3; *De Sensu.* Prol.

diversity of middle term.[17] Again he appeals to the manner of defining or the difference of first principles.[18] Sciences are distinguished, then, according to the degree of immateriality whereby the formal subject is defined in the middle term: namely, whether it be by physical, mathematical or metaphysical principles. The same real thing may be the subject in all three types of science.

We are now in a position to begin our determination of the subject of natural philosophy. What is to be our procedure? How are we to begin a philosophy of nature, a science of the material universe around us? Aristotle gives us at the beginning a rule that flows from the very nature of our knowledge. This is the supreme principle of procedure throughout natural philosophy; in fact, it covers the whole of philosophy and all other disciplines as well. "We must advance from generalities to particulars."[19]

In our human type of knowledge we must advance from what we know to what we do not know, and from what we know better to what we know less. So we begin with sense knowledge and then proceed on slowly and arduously to the higher realms of intellectual attainment, gradually extending, clarifying and systematizing our knowledge.

In philosophical terms, we say that our knowledge is a development of the intellect from potency to act. On the day of our birth our intellect is in a state of complete potency, a *tabula rasa.* On its first awakening to actuality our mind conceives being: *id quod primo cadit in intellectu est* ens,[20] not indeed being as the metaphysician studies it, but a most confused concept of *something existing,* the most imperfect concept, almost completely enveloped in potency

[17] *Summa Theol.,* II-II, q. 1, a. 1; I-II, q. 54, a. 2, ad 2.

[18] *In I Post. Analyt.,* lect. 41, n. 9-13; *In VI Meta.,* lect 1, n. 1156, 1157.

[19] *Physics,* Bk. 1, Chap. 1, 184a 24.

[20] *Summa Theol.,* I-II, q. 55, a. 4, ad 1. Cf. Owen Bennett, O.F.M. Conv., "Existence and the First Principles According to St. Thomas Aquinas," *Philosophical Studies in honor of the Very Reverend Ignatius Smith, OR.,* J. K. Ryan, editor, pp. 165-178.

and with the minimum of act'. The life-long intellectual adventure consists of adding determinations to the potentialities of the mind, of proceeding from potency to intermediate act, and from that on toward perfect act.

Knowledge that has a large admixture of potentiality is confused knowledge; clarification and distinction move in the direction of actuality. We first know things in a general way, as being, as body, as living; but as we add determinations we clear up the confusion and make our ideas specific and precise. So what we know first is a whole, such as the universal whole, which contains its inferiors in potency: we know animal before we know rational animal, kudu, ferret or brant. Even the integral whole, for exampie a house, whose parts are actual, is first known as a whole, before our attention focusses on the parts to distinguish them. When the intellect knows something only in general, it is still in potency to know that which distinguishes the parts from the whole and from one another.

This progress of knowledge becomes clear in the light of the fundamental principle that the formal constitutive of knowledge is immateriality: a thing is knowable and is cognitive according to the degree of removal from materiality, or potentiality. A thing is more knowable insofar as it has more being; but a thing has more being in proportion as it is removed from potentiality and possesses actuality. Likewise, knowledge is the perfection of being, and the more actual and less material or potential a being is, the more cognitive it is. Thus, God Himself, Pure Act, is at the summit of cognition, and His essence is the most knowable thing there is.[21]

Our knowledge, then, begins in the darkness and materiality of the senses and spirals upward toward the pure dazzling intelligibility of God's Being.

[21] On immateriality as the root of cognition, cf., *Summa Theol.,* I, q. 14, a. 1; *De Ver.,* q. 2, a. 2. On the progress of knowledge from general to particular, cf., *In I Phys.,* lect. 1, n. 6-11 and *Summa Theol.,* q. 85, a. 3.

In accordance with the nature of our intellectual knowledge our first science will be that of the sensible world, of that which is most material and least knowable, of that, namely, which has the most of potentiality and the minimum of actuality whereby it is knowable. The first step of this science will be to consider all sensible things in general, or according to the aspects they have in common, and then to descend to particular sensible beings and to their proper characteristics. We must begin our science with a *subject-genus.* In this way we follow the natural mode of human knowledge even within a science, for the knowledge of things in general is more confused, more potential, than the knowledge of things with their particular determinations

, The material subject of natural philosophy is all sensible 'and material being, thé whole world upon which our senses feed. What will our formal subject be? To establish it we must find some common aspect of all sensible beings, some characteristic in which they all share, which will serve to unify material being and to furnish a key whereby we can penetrate to the general nature of it. For this common characteristic must needs be a property of material being as such, and by this property we will be able to define the nature of the sensible world on the most general level. Whatever common property we find will be a wedge whereby we pry open the shell of physical being and get our first look at the nature crouching within.

What is this common aspect? To find it was no difficulty for Aristotle, nor need it be for us. The one facet of reality that had puzzled philosophers from the beginning is that all things are changing, or are in motion. The mark of change is unmistakeably evident in all sensible things. "We physicists," says Aristotle, "must take for granted that the things that exist by nature are, either all or some of them, in motion—which is indeed made plain by induction."[22] Notice that he does not say absolutely "all of them," but

[22] *Physics,* Bk. 1, Chap. 2, 185a 13-15.

leaves open the possibility that there may be some beings unknown to us that do not change. If we find that to be true, then we will have to devise another science to study them.[23] But for the present it seems that the aspect of motion or change is a universal aspect of sensible being, and in the light of change we can set up a science of nature.

Note that we do not mean any kind of motion without restriction. There are some motions that are the result of violence and others that issue from mere chance conjunctions of causal actions. Moreover, there are motions that are attributable to an artificial arrangement of matter, as in a machine. Such motions are not essential, but only contingent, and as such can in no way lead us to a knowledge of essences and essential attributes. Therefore, they cannot serve as the means of establishing a subject-genus of scientific demonstration. We can take into consideration only motions that flow from an intrinsic principle, motions that we qualify as "natural." So the typical operations of animals, plants and simple elementary bodies are evidently natural, as issuing from a commensurate interior principle. In this they are distinguished from the operation of artificial things whose principle is merely *per accidens* and imposed from without. It is natural motions in which we are interested, those that flow from a nature or intrinsic principle.

Let us pause here for a moment and ask just why we should choose motion as the unifying aspect of all material things. Would it not be possible to find some other aspect of material reality as the basis for natural philoso-

[23] As a matter of fact, the science of physics does lead us to immaterial beings not subject to sensory motion: to the First Unmoved Mover and to the separated human soul. (Aristotle thought also that he found in nature evidences of the causality of "separated substances," which the Scholastics identified with the angels.) At once it becomes evident that the concepts of substance, act, causality, even being itself are not commensurate with material, mobile being, the subject of physics. These concepts extend to immaterial beings also. Hence, we need a new science, a "metaphysics," to study them. Cf. our article, "The Formal Subject of Metaphysics," *The Thomist,* XIX r (1956), pp. 59-74.

phy? Why should we not study the material universe as *being,* rather than as mobile?

We cannot study material things as being, because they are not first presented to our knowledge as being. We become aware of material things through our sensory experience. What the senses testify to is a constant flux: things are ever changing, they come and go, they are here today and gone tomorrow. It was this dynamic aspect of things given in sense knowledge that aroused the wonder of the first philosophers and gave birth to scientific thought. It was this continual flux of sensible things that made Heraclitus proclaim: All things are changing, nothing remains; we cannot bathe in the same river twice! There can be no static universal knowledge of things that are ever changing.

Parmenides tried to grasp nature as being, rather than becoming. His celebrated dilemma forced him to admit only one, eternal, immoblile reality. His grasp of the being of things with its intelligibile stability and necessity was such as could satisfy the intellect in its yearning for its proper formal object, but it was a scandal to the senses; and he could silence their violent protest only by denouncing them as illusory. This was not the right approach. The human mind had to face becoming and reconcile it with being. This is the most basic problem of all natural philosophy: nothing can be more general or more fundamental than the question of being, not-being and becoming.

It may be added that the aspect of being is not a proper formal aspect under which to study material things as such, because being is not commensurate with material things, but transcends matter. One might ask, however, whether from our early contact with material beings we can isolate the transcendental perfection of existence immanent in material things and thus begin philosophy with an ontology. But the goncfiptjrf existence as found in material beings, is proportioned to material essences and extends no further than they. Only when the existence of immata-

rial beings has been demonstrated can our idea of existence and being be scientifically extended beyond material things. Ontology must follow philosophy of nature.[23]*

Sensible change, or becoming, we conclude, is the first unifying aspect of all material beings, for it spontaneously asserts itself to our attention at our first contacts with material beings.

We are now in a position to determine the formal object of natural philosophy. The formal object, it will be remembered, is the definition of the formal subject and is the middle term in demonstration. No science can get started without such a definition. "Now in any science the things that must first be known are its subject and the medium by which it demonstrates."[24] We already have a nominal and descriptive definition of our subject, being that changes, or *mobile being.* There is no hope of getting a definition at this stage through genus and specific difference, as our genus could be nothing but being itself; but being transcends all genera. Therefore, we must try to define our subject through its first or fundamental constituent physical principles. We want to know the first principles, or intrinsic causes, of mobile being as such.[25]

As we well know, these first principles of mobile being are prime matter and substantial form. Mobile being as such is defined as "being composed of prime matter and substantial form." With this definition we have a starting point for the philosophy of nature, for in the light of it we can proceed to demonstrate the properties commensurate with it. The following quotation from St. Thomas

23»Cf. G. Klubertanz, S.J., "The Teaching of Thomistic Metaphysics," *Gregorianum,* XXX (1954), pp. 187-205, for views differing from those we have expressed.

24 "Ea autem quae primo oportet cognoscere in aliqua scientia, sunt *subiectum* ipsius, et *medium* per quod demonstrat" *(In II Phys.,* lect 1, n. 1.)

25 "Quaelibet scientia debet inquirere principia et causas sui subjecti, quae sunt ejus inquantum hujusmodi." *(In VI Meta.,* lect 1, n. 1145.)

is most important, not only as confinning what we have just said, but as giving us a glimpse of the whole process of natural philosophy.

> The subject of any science can have two kinds of parts, namely, the primary component parts, that is, the principles of the subject, and the subjective parts.... In every science there are certain principles of the subject, which we must consider first, for instance, in natural science, matter and form; and in grammar, letters. There is also in every science something ultimate at which the consideration of the science terminates, that is, the manifestation of the properties.[2]

Aristotle's search for the first principles of mobile being occupies the whole first book of the *Physics.* We do not intend to make a detailed analysis of the process. The treatment is given in its historical setting, and it strikingly exhibits the logical acumen and high genius of its author. We may remark that Aristotle first examines the requirements of motion in general, without any distinction as to the various kinds of motion, whether artificial or natural, substantial or accidental. He proceeds from the kind that is more known to us, namely, accidental change, and he gives some easy examples from artificial motions, such as making a statue out of bronze or a bed out of wood. So he is able to establish that change as such requires a subject that is permanent throughout the process of change, the

[2] "Subiectum alicuius scientiae duplices partes habere potest, scilicet partes ex quibus componitur sicut ex primis, ut dictum est, idest ipsa principia subiecti, et partes subiectivas.... In qualibet enim scientia sunt quaedam principia subiecti, de quibus est prima consideratio; sicut in scientia naturali de materia et forma, et in grammatica de literis. Est etiam in qualibet scientia aliquid ultimum ad quod terminatur consideratio scientiae, ut scilicet passiones subiecti manifestentur." *(In I Post. Analyt.,* lect. 41, n. 9.) The principies of the subject also define the *limits of the science*. "Consideratio speculativae scientiae non se extendit ultra virtutem principiorum illius scientiae, quia in principiis scientiae virtualiter tota scientia continetur." *(Summa Theol.,* I-II, q. 3, a. 6. Cf. I, q. 1, a. 7; II-II, q. 4, a. 1.)

privation in the subject of the new status to be acquired, and at the completion of the change, a new determination or form in the subject. The investigation is pursued to the point where it is seen that in the most fundamental sort of change, where one thing becomes simply another thing, as when a living being becomes a dead being, there must be a subject that is entirely devoid of any determinations, a primary substratum, to which is given the name prime matter. Correlative to this is a principle of determination that is called substantial form.

At the beginning of the second book of *Physics* Aristotle returns to the consideration of the principles of mobile being, this time as *nature.* This added treatment can cause us some confusion, and we ask with John of St. Thomas, "Why/does the Philosopher treat the principles of natural things in the first book, and again in this second treat of nature as the principles of natural things?"[27]

St. Thomas says that in the first book Aristotle had treated the principles of natural things, whereas in the second book he determines the principles of natural science.[28] This is certainly true, as the Stagirite goes on to establish the special postulates and the manner of demonstrating in the science in subsequent chapters of this same book. We may add that this discussion of the first principles as nature is a further precision of the subject of our science. It eliminates all artificial changes, and also the changes due to violence, chance and fortune. In this science we are concerned only with things that have natures, that is, intrinsic principles of motion and rest,[29] things whose prime matter!

27 "Cur ergo Philosophus egit de principiis rei naturalis in primo libro, et iterum in hoc secundo agit de natura pro principiis rei naturalis...." *(Cursus Phil.,* II, p. 171. Cf. Celestin Taylor, O.P., "The Relation Between Book I and II of the Physics," *Laval Theologique et Philosophique,* VII (1951), pp. 150-158.)

28 *II Phys.,* lect. 1, n. 1.

29 "Nature is a source or cause of being moved and of being at rest in that to which it belongs primarily, in virtue of itself and not in virtue of a concomitant attribute." (Physics, Bk. 2, Chap. 1, 192b 23.)

and substantial form are the root sources of their typical characteristics and manifestations. Whereas the first book of *Physics* had discussed all types of change as a help to establish the hylemorphic constitution of matter, now there is a further refinement made to exclude certain of those types from natural science.

The concept of prime matter and substantial form as nature adds a dynamic connotation to these first principles of material being.[30] Every particular type of mobile being has its own characteristic properties and operations. These are discovered by the regularity of their occurrence. Whatever happens with a significant frequency, either always or almost always, cannot be the result of chance, but must have some corresponding regular cause. The measurable regularities, whose discovery and formulation allow modern science to bear such fruitful results, reveal that there is a cause of this regularity in the very essence of the thing concerned. The constancy of qualitative manifestations, *such* as typical structure and operations, are effects of something in the heart of a being; they flow from the thing's essence, and the principles of the being are also the principles of its properties and operations.

Matter in a mobile being is the principle of potentiality and receptivity; form is the principle of actuality. Quantity, then, is said to follow upon matter, and quality, upon form.

> Only a thing that is *per se* subsistent can act. So it is neither matter nor form, but the composite, that acts. But it does not act by reason of matter, but by reason of form, which is act and the prin-

30 "Hic autem de principiis rei naturalis seu de natura agit sub habitudine et respectu ad motum. Sic enim induit rationem naturae, in quantum est principium motus, sive active sive passive, atque ita in primo libro considerantur principia ut constituentia ens naturale, sive in fieri sive in facto esse, ibique non tam considerantur principium ut activum et passivum quam ut materiale et formale. In praesenti vero considerantur principia non ut constituentia ens naturale, sed ut principiantia motum, et ita consideratur principium ut activum vel passivum." (John of St. Thomas, *ibid.*)

> ciple of action. And because quantity follows upon matter and quality upon form, therefore quantity does not act except by means of quality, which is of itself a principle of action.[31]

It is not our duty here to study this important concept of nature. It is vital, if we wish to attain an understanding of the material world.[32] For the present, we may well quote a clarification given by John of St. Thomas, which will preclude any misunderstanding. It is the composite that is the subject of accidents, but matter is the subject *quo,* that by which the composite is receptive.

> That matter is the subject *quo,* or the principle of receiving, is certain, for matter is the first root of potentiality and reception in the composite, since it is pure potency and is first in the order of receiving. Hence, whatever is received in the composite has matter as principle *quo* and first root of receiving. Likewise, substantial form is the first root and principle of actuality and being; it is the principle of *esse simpliciter,* or substantial being, which is given by form. If being *simpliciter* comes from substantial form, *a fortiori* being *secundum quid* depends on it. Therefore, matter and form are only principles *quo,* because they are constitutive of the subject on which accident depends: the characteristic of potentiality comes through matter, and of actuality, through form.[33]

31 "Agere non est nisi rei per se subsistentis. Et ideo neque materia agit neque forma, sed compositum: quod tamen non agit ratione materiae, sed ratione formae quae est actus et actionis principium. Et quia quantitas se tenet ex parte materiae et qualitas ex parte formae, ideo quantitas non agit nisi mediante qualitate quae est per se actionis principium." *(In IV Sent.,* d. 12, q. 1, art. 2, resp. ad 1a quaest. Cf. *De Pot.,* q. 9, a. 7; *De Ente et Ess.,* Chap. 6; *De Principiis Naturae,* n. 16; *Summa Theol.,* I, q. 3, a. 4, c; *Contra Gen.,* Bk. 3, Chap. 97.)

32 A recent study of "nature" has been made by James A. Weisheipl, O.P., "The Concept of Nature," *The New Scholasticism, ~KX.N1TL* (October, 1954), pp. 377-408.

33 "Quod materia sit subiectum *quo* seu principium recipiendi, constat, quia materia est prima radix potentialitatis et receptionis in composito, cum sit pura potentia et primum in genere recipiendi.

The starting point of Aristotelian natural science, it must be noted, is the fact of natural motion, which is evident to the senses. There is no need to prove the existence of our formal subject. The physicist is justified in accepting the testimony of the senses. It is not his domain to investigate and defend the validity of sense knowledge: that belongs to the metaphysician. Nor does he, strictly speaking, have to refute Monism, which is also a metaphysical aberration. If incidentally, however, a physicist's audience has been influenced by metaphysical errors that concern the principles of natural science and thus block the very beginning of it, he will have to settle the metaphysical issue before getting started in his own science. Thus, Aristotle was forced as a practical exigency to take up the arguments of Melissus and Parmenides at the beginning of his *Physics;* and likewise, the neo-Thomists at the beginning of this century had to face the epistemological problem posed by Kantianism. But it must always be kept clear that these tracts are borrowed from metaphysics and do not belong *per se* to natural philosophy.[34] They can be treated here only

Unde quidquid in composito recipitur, habet pro principio *quo* et prima radice recipiendi ipsam materiam, similiter forma substantialis est prima radix et principium actualitatis et esse, siquidem est principium ipsius esse simpliciter seu esse substantialis quod datur per formam. Unde autem oritur esse simpliciter a fortiori dependet esse secundum quid. Ergo materia et forma solum se habent ut principium *quo,* quia sunt constitutiva ipsius subiecti, a quo dependet accidens quantum ad rationem potentialitatis per materiam, et actualitatis per formam." (John of St. Thomas, *ibid,* p. 758; cf. 755-764. St. Thomas, *In VII Meta.,* lect. 2, n. 1285, 1286.)

[31] We wish to call attention to the following warning of Father Fernandez-Alonso, O.P.: "Sane modemi in naturali philosophia quaestiones plurimas exponunt quae, sicut creatio, miraculi possibilitas, pantheism! refutatio, obiectiva sensibilis mundi exsistentia, tractatus de causis, de aeternitate, etc., sunt vere metaphysicae vel theologicae. Sed est error absolute reprobandus. Horum enim scibilitas, utpote ab omni materia abstrahens, est omnino distincta a scibilitate eorum, quae, ut ultima corporum constitutio, naturae motus, spatii, temporis, vitae, animae humanae, etc., sunt in primo gradu abstractionis. Haec duo genera quaestionum, ad philosophiam sensu hodierno acceptam pertinentia, nequent sine errore, tanquam partes eiusdem scientiae

dialectically.[35]

The first part of natural philosophy deals with mobile being in general. It formulates a general definition of motion; demonstrates its proper subject; treatsTtsTntrinsic concomitants, action, passion and the infinite; anditsmeasures, place and time.[36] It divides motion into its various species[37] and into its quantitative parts, under which comes the consideration of the continuum.[38] It also investigates the efficient cause of motion[38] and culminates by tracing motion back to a First Unmoved Mover.[40]

With this, general physics has run its course. At this~l point mobile being and the common properties commensurate with it will have been thoroughly investigated. The next step is to divide our subject-genus into its subjective parts or species, and to study each species as determinations of the general principles already established. We divide the subject-genus according to its formal aspect and demonstrate the properties commensurate to the various subjects obtained by division. Then we subdivide and again demonstrate commensurate properties at the lower specific levels.[41] As we proceed toward the mysterious core of ma-

considerari. Et si aliquando de illis in philosophia naturali est agendum proper rationes extrinsecas, hoc explicite notandum est, ut faciunt Aristoteles et S. Albertus ne ulla sit aequivocatio." "Scientiae et philosophia secundum S. Albertum Magnum," *Angelicum,* XII (1936), pp. 30-31.

35 Note that when Aristotle *(Physics,* Bk. 1, Chap. 2, 185a 15-20) decides to "spend a few words" on the opinions of Melissus and Parmenides, he uses the term *&ια\εγθηναι.*

33 Physics, Bks. 1-4.

33 Ibid., Bk. 5.

38 Ibid., Bk. 6.

33 Ibid., Bk. 7.

**3 Ibid.,* Bks. 7 and 8.

41 "Sicut in rebus naturalibus nihil est perfectum dum est in potentia, sed solum tunc simpliciter perfectum est, quando est in ultimo actu; quando,vero medio modo se habens fuerit inter puram potentiam et purum actum, tunc est quidem secundum quid perfectum, non tamen simpliciter; sic et circa scientiam accidit. Scientia autem quae habetur de re tantum in universali, non est scientia completa secundum

terial beings, we have difficulty dividing our subjects into their ultimate species, because we cannot know their specific differences. Hence, at that level we must make use of descriptive definitions or of conjectures and hypotheses in place of definitions.

In making our first divisions, we must note that, contrary to the practice of some modern scholastics, it is not correct to divide mobile being into that which is anorganic and that which is organic; such is to divide the material subject, rather than the formal subject. The formal aspect of the material world that has specified our science is mobility; therefore, the first divisions of our science will be divisions of mobility, the three kinds of motion: locomotion, qualitative motion and quantitative motion.[42] The first two kinds are general and are common to all mobile beings; the third kind is proper only to corporeal living beings:; augmentative^ghange is the one type of motion common to* all organisms and proper only to them.

It is on the level of these first special divisions of natural science that philosophy of nature and experimental science

ultimum actum, sed est medio modo se habens inter puram potentiam et ultimum actum. Nam aliquis sciens aliquid in universali, scit quidem aliquid eorum actu quae sunt in propria ratione eius: alia vero sciens in universali non scit actu, sed solum in potentia. Puta, qui cognoscit hominem solum secundum quod est animal, solum scit sic partem definitionis hominis in actu, scilicet genus eius: differentias autem constitutivas speciei nondum scit actu, sed potentia tantum. Unde manifestum est quod complementum scientiae requirit quod non sistatur in communibus, sed procedatur usque ad species: individua enim non cadunt sub consideratione artis; non enim eorum est intellectus, sed sensus." *(In I Meteor.,* lect. 1, n. 1. Cf. R. J. Nogar, O.P., "Cosmology Without a Cosmos," *From an Abundant Spring,* pp. 363-392.)

42 "Res autem quas considerat Naturalis, sunt motus et mobile: dicit enim Philosophus in *II Physic,* quod quaecumque mota movent, sunt physicae speculationis. Et ideo oportet quod secundum differentiam motuum et mobilium, distinguantur et ordinentur partes scientiae naturalis. Primus autem motuum est motus localis, qui est perfectior ceteris, et communis omnibus corporibus naturalibus." *(In De Gen. et Cor.,* Proem., n. 1. Cf. *In I Phys.,* lect. 1, n. 4.)

can and must be integrated.[43] For these divisions correspond almost exactly to the sciences of Physics (locomotion), Chemistry (qualitative motion), and Biology, (quantitative motion). But it is to be noted that natural philosophy does not absorb these experimental sciences, for insofar as at least Physics and Chemistry are highly mathematized, they constitute autonomous sciences of the type called *medial* by the ancients. Their demonstrations proceed from mathematical principles; they do not give physical explanations. It is for the natural philosopher to take the physical data furnished so abundantly by the experimental sciences and to integrate it into his own explanation of the physical universe. In fact, only the philosopher can raise the factual findings of modem science to the level of true science in the Aristotelian sense. It can be said, then, that even the mathematical-physical sciences belong reductively to philosophy of nature.

At each stage of natural philosophy we first treat our subjects in general and then in particular, in keeping with our natural manner of proceeding from the potential or confused to what is more actual. St. Thomas is acutely aware of these methodological principles and he prefaces each of his commentaries with a review of what has been accomplished so far and of how the same principles are to be applied in the tract in hand.

By this method of proceeding from general to particular through progressive division of mobile being, the formal subject of our science, we not only satisfy the natural manner of our growth in knowledge, but we also provide ourselves at each stage of natural science with a definition of our subject, in the light of which we can demonstrate its commensurate attributes. This is the only way in which we can construct a true science of nature, for with-

43 For an account of the studies made on the possibility of integration by the Albertus Magnus Lyceum for Natural Science, see Kane *et al., Science in Synthesis,* p. 219sq. Cf. also W. H. Kane, O.P., "The Nature and Extent of Philosophy of Nature," *The Thomist,* VII (1944), p. 231.

out a definition of our subject we cannot have demonstration; but "the most convenient way to find definitions is through divisions."[44]

To a modem mind there arises a stubborn difficulty concerning the whole principle of proceeding from the general to the particular. How can we know general things about all mobile being without having first studied the particular types of mobile being? Would it not be more natural to study first the particular beings and on the basis of our findings to form generalizations? Is it not the grossest a *priorism* to form a general concept on the basis of a few common sense observations and to extend it "sight unseen" to all material beings, in fact to make it the principle of interpretation of all material beings? Such an objection is really a veiled attack upon the ability of our minds to know abstract natures. It is the whole epistemological question brought back to us in a particularized form. It involves a basic misunderstanding of the nature of induction, of abstraction and of the formation of definitions. To answer all this is out of the ambit of our present study. But it may be answered indirectly in what we consider the unsurpassed words of a modem Aristotelian, words which focus for us the ultimate difference of the scholastic approach and that of the modem scientist:

> This whole argument toward the primacy of the general in human knowledge and, in the limit, toward the idea of being as the first of man's intellectual achievements can be put in another and perhaps even more forceful form. If intellectual knowledge had to begin by grasping the individual, then it would have to be radically inductive, and if it is radically inductive, it never begins with the individual because it could never begin at all. If a so-called individual is given in experience, how can the knower be sure that it is truly an individual unit? On radically inductive premises, he cannot. Thus he splits the 'individual,' say a

[44] "Via ad inveniendum definitiones convenientïssima est per divisiones." (In *III Phys.,* lect. 1, n. 5.)

> molecule, into atoms. But uncertain whether the atom is an individual, he charges into it with his particle guns and breaks the atom into neutrons, protons, electrons, and other microscopic entities. Radically inductive and compelled to begin with the individual, he cannot logically even accept these subatomic entities as realities that are ultimate and given. So his process of division goes on and on *ad infinitum.* His empiriological physics becomes an eternal quest after premises, a constant effort to begin.[45]

There is one last point to occupy us momentarily in passing. The first divisions of our subject^genus are easy to make, because they are still at the level of generalities and of relatively indistinct knowledge. But as our scientific invasion proceeds into the lush and fertile jungle of specific essences, we find that attainment of distinct knowledge is hindered by the undergrowth of matter, which, is of.itself impervious to scientific investigation. These essences are by nature involved in matter and thus share the obscurity of matter. What is the specific difference between a lamb and wolf, between a rose and a tomato? Our intellectual insight is dimmed in this dusky realm of limited intellibility.[40] Is it possible to make some inroad into the

[45] V. E. Smith, *Philosophical Physics,* p. 24.

[4<] "Under the sensible clarity of phenomena, of the visible and tangible, there is the obscurity of matter, which by its indétermination, its poverty and its instability remains beyond the grasp of the intellect. Thus, there is nothing more clear empirically than the difference which distinguishes the two animal species, the eagle and the lion, or the two vegetable species, the oak and the spruce. But how can these species be defined otherwise than in a descriptive, empirical fashion? How can these species be rendered intelligible? Only their generic characteristics: corporal substance, alive, endowed or not **endowed** with sensation, can be grasped by the intellect. The *specific difference* of oak, of spruce, of eagle or of lion remains hidden from us. It is impossible for us to have a distinct intellectual understanding of these species, from which we can deduce what is proper to their natures, as we may do with regard to triangle or circle. Why is this? Because their *specific* or substantial *form,* remains as if *buried, immerged in matter.* Consequently the human idea of eagle or

interior of material species, to acquire some knowledge of these specific essences, in order thereby to demonstrate the properties commensurate with them?

There are three ways of getting some understanding of particular essences: through descriptive definition, through extrinsic causes, and through systematic explanation or conjecture.

(1) When we do not know the specific difference of a thing, we can often compose a definition from a proximate genus and a property in place of a specific difference. Such is a descriptive definition, that is, one that defines a thing in terms of proper or common accidents, of sensible qualities and operations. "Since we do not know essential differences, sometimes we use accidents and effects in their place."[47]

. Since we do not know the substantial differences

lion is like a cone whose summit is lit up and whose base remains in the shade. Eagle and lion are clearly intelligible for us in that they are beings, substances, corporal substance, endowed with life and sensation, but what formally constitutes the eagle, as eagle, or the lion, as lion, remains intellectually very obscure. We can hardly go beyond a descriptive or empirical definition. Thus St. Thomas notes often that the *specific differences of sensible beings are often left unnamed.* There is a penury of terms because there is a penury of distinct ideas." (R. Garrigou-Lagrange, *Le Sens du Mystere,* pp. 11-13; cited by Owen Bennett, O.M.C., *The Nature of Demonstrative Proof,* p. B9.) As St. Thomas puts it: "Cognitio nostra est adeo debilis quod nullus philosophus potuit unquam perfecte investigare naturam unius muscae: unde legitur, quod unus philosophus fuit trigenta annis in solitudine, ut cognosceret naturam apis." *(In symbol, ap.,* art. 1.)

47 Quia differentiae essentiales sunt nobis ignotae, quandoque utimur accidentibus vel effectis loco earum." *(De Ver.,* q. 4, a. 1, ad 8. Cf. *In I Post. Analyt.,* lect. 4, n. 16: "Quandoque id quod est notius quoad nos non est notius simpliciter, sicut accidit in naturalibus, in quibus essentiae et virtutes rerum, propter hoc quod in materia sunt, sunt occultae, sed innotescunt nobis perea, quae exterius de ipsis apparent. Unde in talibus fiunt demonstrationes ut plurimum per effectus, qui sunt notiores *quoad nos,* et non *simpliciter."* Here St. Thomas is speaking of a demonstration *a posteriori;* from such a demonstration the essence of the cause becomes known and can then be used in a demonstration a *priori.*

> of things, those who make definitions sometimes use accidental differences because they indicate or afford knowledge *of* the essence as the proper effects afford knowledge of a cause. Therefore, when *sensible* is given as the constitutive difference of animal, it is not derived from the sense-power, but the essence of the soul from which that power comes.[48]

The proper qualities and proper motions of natural things must have their proper causes, which are ultimately the specific essence. Hence, from the constancy of proper accidents known inductively we can construct a vague definition of the essence of their subject.[49] Even from the constancy of a certain pattern of common accidents we can get some idea of the nature that is the root of them.

(2) "In the case of natural science, in which demonstration takes place through extrinsic causes, something is proved of one thing through another thing entirely external to it."[50] We may define a thing in terms of its efficient cause, for example that an acorn is a seed produced by an oak tree or that a sun tan is the result of exposure to the sun. It is especially by defining in terms of final cause that we get to know something of natural things, but to discuss this further would bring us into matter that must be reserved for later chapters.

(3) Finally, there are many cases where we have to try a systematic explanation, as discussed in our last chapter. We reason that if such and such is the nature of a thing, then its various manifestations or empirical properties would follow. We are in the realm now of hypothesis, and our knowledge of material things at this lowest frontier of intelligibility scarcely surpasses probability and opinion.

48 *De Ver.,* q. 10, a. 1, ad 6. Cf. In *VII Meta.,* lect. 12, n. 1551-1552; *Summa Theol.,* I, q. 29, a. 1, ad 3; *In I De Gen. et Cor.,* lect. 8, n. 5; In II *Post. Analyt.,* lect 13-16; *De Ente et Ess.,* Chap. 5, n. 25.

49 Cf. V. E. Smith, "Definitions," From *an Abundant Spring,* pp. 343-344; Card. Zigliara, Leonine ed. of Commentary on *Post. Analyt.,* note E, pp. 374-375.

50 *In De Trin.,* q. 6, a. 1, c.

We are here undoubtedly in the field of the positive sciences of nature, those which usually claim to profess no interest in the intrinsic natures of things, but only in their sensible manifestations. Whatever the nature and extent of the positive sciences may be, we can state for certain that they are at the lowest level of the study of nature. However, we can see that they do fit in: insofar as they are physical rather than mathematical, they are at least a continuation (/ at the dialectical level of the philosophy of nature, as is held by one of the Thomist theories of positive science.[61]

The methodological difference between natural philosophy and positive science is that the latter starts from the bottom and tries to work upward; it begins by trying to understand the individual and to generalize on the basis of the individuals known. But *individuum est ineffabile;* the individual escapes the grasp of the intellect and yields itself only to the senses. Thus, positivistic knowledge is restricted to the sensible and the dialectical. On the other hand, true science begins with the general and defines its subjects downward by progressive division,[62] attaining a

51 Cf. C. De Koninck, "Introduction à L'Étude de L'Âme," preface to *Précis de psychologie thomiste,* S. Cantin, Ixxv-lxxxi; Most Rev. J. M. Marling, C.PP.S., "The Dialectical Character of Scientific Knowledge," *Philosophical Studies in Honor of the Very Reverend Ignatius Smith, O.P.,* pp. 3-13. Our own study will make it clear that even more than a dialectical understanding is sometimes possible at the specific level.

52 "Oportet enim definitionum cognitionem, sicut et demonstrationum, ex aliqua praeexistenti cognitione initium sumere." *(In De Trin.,* q. 6, a. 3.) "In scientiis speculativis semper ex aliquo prius noto proceditur tam in demonstrationibus propositionum quam etiam in inventionibus definitionum. Sicut enim ex propositionibus praecognitis aliquis devenit in cognitionem conclusionis, ita ex conceptone generis et differentiae et causarum rei aliquis devenit in cognitionem speciet Hic autem non est possibile in infinitum procedere, quia sic omnis scientia periret et quantum ad demonstrationes et quantum ad definitiones, cum infinita non sit pertransire. Unde omnis consideratio scientiarum speculativarum reducitur in aliqua prima, quae quidem homo non habet necesse addiscere aut invenire, ne oporteat in infinitum procedere, sed eorum notitiam naturaliter habet...et etiam primae

much more perfect knowledge even of the same entities against which the positivistic scientist hurls his forces in vain. The demonstrative approach to nature can reveal nature to the intellect; it can unlock the intelligible reason stored away in the black cellar of matter. The method of doing this is the concern of the present study.

To summarize briefly:—We need a definition of the subject of our science in order to demonstrate, as the subject is the middle term of a demonstrative syllogism. Since we cannot know a thing at once in all its virtuality, we must take it from some particular aspect whereby it is knowable. The science of nature studies material being from the aspect of mutability. It defines its subject in terms of the physical principles of its mobility, first in general and then by division and concretion down to the lowest species. At the lower levels the definitions are in relation to properties and effects, through extrinsic causes, or by the systematic method of conjecture. The last mentioned kind of definition is dialectical and yields us probable knowledge. The other two kinds give us middle terms whereby we can attain certain and necessary truths about things of the material world about us.

conceptiones intellectus, ut entis et unius et hujusmodi, in quae oportet reducere omnes definitiones scientiarum praedictarum." *(In De Trin.,* q. 6, a. 4. Cf. *De Ver.,* q. 1, a. 1.)

CHAPTER III

CERTITUDE AND NECESSITY IN NATURAL PHILOSOPHY

We have claimed that the demonstrative method can yield us certain and necessary truth about things of the material world. But how can this be? The formal subject of natural science and the matter treated in the light of the subject are so involved in sensible matter as to require it in their very definition. Yet matter is the principle of uncertainty and contingency. Where can we find the certainty and necessity that are indispensable if we are to attain to a strict demonstrative and *propter quid* science?

First let us note that the concept of a certain and necessary objective truth about nature is unthinkable to the modern mind.

> The idea that thought is the measure of all things, that there is such a thing as utter logical rigor, that conclusions can be drawn endowed with an inescapable necessity... these are not the ideas of a modest animal.[1]

The proud self-assurance of the nineteenth century scientist has collapsed along with the mechanical theory of nature and in the face of the theoretical dilemmas with which the present-day scientist is faced.

To Aristotle, however, there was no doubt about the matter. He does not hesitate to apply to his physical science that technical term ἐπιστήμη that characterizes the exalted type of demonstrative knowledge outlined in the *Pos-*

1P. W. Bridgman, *The Nature of Physical Theory,* (Princeton: Princeton University Press, 1936), p. 135; cited by Owen Bennett, O.M.C., *The Nature of Demonstrative Proof,* p. 1. Cf. Kane, *et al., Science in Synthesis,* p. 41; W. Agar, *The Dilemma of Science,* p. 101-105; A**J**. Mc Nicholl, O.P., "The Uneasiness of Science," *The New Scholasticism,* XXIV (January, 1950), pp. 57-68.

terior Analytics.[2] Moreover, in the exposition of his theory of science in the *Posterior Analytics* he uses, along with mathematical examples, a notable number of physical examples, which we will study in later chapters.[3] He does not, of course, consider that everything in physical science, nor in any science, for that matter, is strictly demonstrative. There will always be a substantial amount of dialectical material and other matter preparing for *propter quid* demonstrations or proved by lesser types of demonstration. In fact, strict demonstrations are the culmination of knowledge on any particular subject, and we must not be disappointed if they are not as plenteous as we would like them to be.

The question of certitude and necessity in science are closely bound together, for it is the intellectual grasp of necessity that yields the certitude characteristic of science. But for the purpose of analysis we will investigate them separately.

In the *Nicomachean Ethics*[4] Aristotle lays down a general principle, whose capital importance has been well illustrated by the history of philosophy.

> Our discussion will be adequate if it has as much clearness as the subject-matter admits of, for precision is not to be sought for alike in all discussions, any more than in all the products of the crafts.... For it is the mark of an educated man to look for precision in each class of things just so far as the nature of the subject admits; it is evidently equally foolish to accept probable reasoning from a mathematician and to demand from a rhetorician scientific proofs.

2 τηϛ! rrepi φύσΐω επιστήμη . *Physics,* Bk. 1, Chap. 1, 184a 14. Cf. *Ibid.,* Bk. 3, Chap. 4, 202b 30; *On the Heavens,* Bk. 1, Chap. 1, 268a 1; Bk. 3, Chap. 7, 306a 17; *Parts of Animals,* Bk. 1, Chap. 1, 641a 35; *Metaphysics,* Bk. 6, Chap. 1, 1025b 19; Bk. 11, Chap. 7,1064a 17; b 2.

s A list of them is given by A. Mansion, *Introduction a la Physique Aristotélicienne,* p. 214, note 13.

* Bk. 1, Chap. 2,1094b 13-15, 24-28.

St. Thomas adds that a person ought not to require a greater certitude than his subject-matter affords, nor ought he to be content with less.[5]

The same thing is touched upon in the Second Book of the *Metaphysics** from a slightly different angle. St. Thomas' commentary on this is especially interesting and gives us a good insight into the Angelic Doctor's mastery of the art of exegesis, as he elaborates the pithy sentences of the Stagirite. In seeking truth men are impelled by the methods to which they have become accustomed. Those, for instance, who have been brought up in mathematics are unwilling to accept anything as true unless it is presented with mathematical rigor and precision. In this Aristotle and St. Thomas had the example of Plato, but they seem almost to be prophesying about the dreams of Descartes and the myopia of certain modern mathematical-physicists.[7] Other persons who have a strong sensitivity but weak intellects will assent only to what is given in sensible examples, that is, to that which can have some imaginative and emotional appeal. Others must hide behind the authority

[5] "Et ideo auditor bene disciplinatus, non debet majorem certitudinem requirere, nec minori esse contentus, quam sit conveniens rei de qua agitur." *In I Eth.,* lect. 3, n. 36.

[6] Chap. 3, 994b 33—995a 20. Cf. St. Thomas, *In II Meta.,* lect. 5, n. 331-337.

[7] Descartes wrote: "I was especially delighted with the Mathematics, on account of the certitude and evidence of their reasonings: but I had not as yet a precise knowledge of their true use; and thinking that they but contributed to the advancement of the mechanical arts, I was astonished that foundations, so strong and solid, should have had no loftier superstructure reared on them.... I reserved some hours from time to time which I expressly devoted to the employment of the Method in the solution of Mathematical difficulties, or even in the solution likewise of some questions belonging to other Sciences, but which, by my having detached them from such principles of these Sciences as were of inadequate certainty, were rendered almost Mathematical." (Discourse on Method, Harvard Classics, Vol. 34, pp. 9,26.) Cf. F. J. Sheen, *Philosophy of Science,* "The Mathematical Theory," pp. 18-21 for some of the modern opinions on the primacy of the mathematical description of natural phenomena.

of some noted author. Some minds are annoyed by an insistence on certitude, especially when this involves hard reasoning and a certain amount of detailed work, a charge that can be made against many modern philosophers, who have tried to oversimplify philosophy. Actually, however, each discipline has its own method corresponding to its own subject matter. Therefore:

> That method which is without qualification the best ought not to be looked for in every science. "Acribology," that is, the minute accuracy of mathematics is not to be demanded in all cases where there is scientific knowledge, but only as regards those objects that are without matter. For those that have matter are subject to motion and variation, and so we cannot have perfect certitude about them all. Wg.inquire about them not what_ is always and necessarilyZsb.'but what is so .in ^inost instances. Things that are immaterial are of themselves most certain, because unchangeable. However, such things that are immaterial of their own nature, for instance, the separated substances, are not certain to us, because of the imperfection of our intellect, as we have mentioned above. Mathematical entities are abstracted from matter, and yet they do not exceed our intellect; so in them the most certain method is required. Now, because all nature is concerned with matter, this method of greatest certainty does not belong to ' the natural philosopher.§

§ "Hie modus, qui est simpliciter optimus, non debet in omnibus quaeri; dicens quod "acribologia" idest diligens et certa ratio, sicut est in mathematicis, non debet requiri in omnibus rebus, de quibus sunt scientiae; sed debet solum requiri in his, quae non habent materiam. Ea enim quae habent materiam, subjecta sunt motui et variationi: et ideo non potest in eis omnibus omnimoda certitudo haberi. Quaeritur enim in eis non quid semper sit, et ex necessitate; sed quid sit ut in pluribus. Immaterialia vero secundum seipsa sunt certissima, quia sunt immobilia. Sed illa quae in sui natura sunt immaterialis, non sunt certa nobis propter defectum intellectus nostri, ut praedictum est. Hujusmodi autem sunt substantiae separatae. Sed mathematica sunt abstracta a materia, et tamen non sunt excedentia intellectum nostrum: et ideo in eis est requirenda certissima ratio. Et quia tota natura est circa materiam, ideo iste modus certissimae

It is matter that limits the certitude of natural science.® We must state precisely to what extent it does so and how there can be true science of material objects. For since matter is the principle of individuation and no science treats of individuals, but only of universals, it would seem that we cannot have any science of material things. Moreover, the intellect, to which the habit of science belongs, knows only by abstracting from matter and the conditions of matter; and therefore it seems that we cannot have a science of what is not abstracted from matter.10

The answer to these objections must obviously involve an explanation of physical abstraction. Assuredly, we have to abstract from the determined dimensions whereby matter is the principle of individuation. The individual as such is knowable, not to the intellect, but to the senses. Yet we do not abstract from matter entirely when we know a thing with the universality characteristic of intellectual knowledge. We know essences; but the essences of material things contain matter in their concept; it is impossible,

rationis non pertinet ad naturalem philosophum." *(In III Meta.,* lect. 5, n. 336.) Cf. *In I Meteor.,* lect. 11, n. 1, where we are told that in some matters, e.g., the cause of the appearance of comments, we must he satisfied with a mere possible solution.

8 Natural science is also less certain because of the many elements that enter into it. "Ex hoc autem quod consideratio naturalis est circa materiam, eis cognitio a pluribus dependet, scilicet a consideratione materiae ipsius et formae et dispositionum materialium et proprietatum, quae consequuntur formam in materia. Ubicumque autem ad aliquid cognoscendum oportet plura considerare, est difficilior cognitio. Unde in *I Posteriorum* dicitur quod minus certa scientia est, quae est ex additione, ut geometria arithmetica. Ex hoc vero quod eius consideratio est circa res mobiles et quae non uniformiter se habent, eius cognitio est minus firma, quia eius demonstrationes frequenter procedunt ut in maiori parte ex hoc, quod contingit aliquando aliter se habere. Et ideo etiam quanto aliqua scientia magis appropinquat ad singularia, sicut scientiae operativae, ut medicina, alchimia et moralis, minus possunt habere de certitudine propter multitudinem eorum, quae consideranda sunt in talibus scientiis, quorum quodlibet si omittatur, sequetur error, et propter eorum variabilitatem." *(In De Trin.,* q. 6, a. 1, ad q. 2, c.)

10 *In De Trin.,* q. 5, a. 2, obj. 1 & 2.

for instance, to conceive of man without body. However, we include only that matter common to the whole essence, such as flesh and bones, not the particular matter of individuals, this flesh and these bones.[11]

Thus, there is abstraction from matter sufficient to make natural things intelligible in their universal aspects. Yet there is sufficient relation to matter in the abstract, universal concept to make it represent the essence of material beings. That is why "we do not call this simply nn abstraction of form from matter, but of the universal from the particular."[12] However, because science is concerned with universal· natures, it does not follow that it gives us no knowledge of singular existing things. The universal becomes a means through which we know the particular.[12]

In order further to determine the degree of certitude attainable in natural science, we must consider the kind of necessity to be found in material things.[14]

But is there, indeed, anything necessary about natural things? All material beings, by reason of possessing matter, the principle of change, are contingent, whereas the necessary is unchangeable. Is it not a contradiction to expect science, that is, necessary knowledge, about contingent things? This is the difficulty that drove Plato to seek the reason for universal and necessary knowledge outside sensible things in a separate world of ideal substances, and to concede only contingent knowledge, that is, opinion, of material things.[15]

[11] *Ibid.,* a. 2, c and ad 1 & 2; a. 3, c. Cf. *Summa Theol.,* I, q. 85, a. 1, ad 1 & 2; *DeEnte et Ess.,* Chap. 2, n. 6.

[12] "Ideo praedicta abstractio non dicitur formae a materia absolute, sed universalis a particulari." *(In De Trin.,* q. 5, a. 2, c.)

[12] *Ibid.,* ad 4.

[14] Cf. J. Maritata, "Reflections on Necessity and Contingency," *Essays in Thomism,* R. Brennan, editor, pp. 27-37; A. Mansion, *Introduction a la Physique Aristotélicienne,* Chap. 8, n. 1, pp. 282-292; W. H. Kane, O.P., "Comment on Father Nogar's Paper" ("Nature: Deterministic or Indeterministic?"), *Proceedings of the American Catholic Philosophical Association,* XXVII (1953), pp. 104-109.

[15] Cf. *Summa Theol.,* I, q. 84, a. 1.

Following Aristotle, St. Thomas[16] makes a profound metaphysical analysis of the concept that is abstracted from individual matter. A sensible substance existing in reality is a composite whole, including the designated matter that is the principle of individuality. Now the mind can prescind from the individual notes of this material being and consider only what is essential to it. The ensuing concept is a form with respect to the whole individual; for the individual participates in the species, receiving it and limiting it as potency receives act.[17] Yet this is not the substantial form, for substantial form is not the whole essence, but only a part of it. This form abstracted from the determined dimensions of matter includes that matter that is essential to the nature, common matter, and excludes only that matter that is accidental to the nature, the individual determinations of matter. Hence, this form representing the whole essence (substantial form and common matter) is called the form of the whole.[18] It does not change in the process of substantial change; it is the individual that changes. The nature itself, considered in precision from the individual determinations is unchangeable and hence necessary. The constitutive notes of a nature can never be other than what they are.

For further clarity we may quote the words of St. Thomas:

[16] *In De Trin.,* q. 5, a. 2, c.

[17] "In definitione speciei non ponitur materia individualis, sed materia communis; sicut in definitione hominis ponuntur cames et ossa, non autem hae carnes et haec ossa. Natura igitur speciei constituta ex forma et materia communi, se habet ut formalis respectu individui quod participat talem naturam; et pro tanto hic dicitur quod partes quae ponuntur in definitione, pertinent ad causam formalem." (In *II Phys.,* lect. 5, n. 4.)

[18] The substantial form is the *forma partis,* that is, the form of the essence, which is itself the formal part of the whole. Cf. *Summa Theol.,* I, q. 3, a. 3; Suppl., q 79, a. 2, ad 2. There is an inadequate real distinction between the individual and its nature, as betwen the whole and the part. There is an adequate real distinction between the substantial form and prime matter.

> Now, as is shown in the *Metaphysics,* we find in a sensible substance both the whole or the composite itself, and also the nature *{ratio),* that is, its form; and it is the composite which is essentially-generated and corrupted and not the nature or form except accidentally. As the Metaphysics says, "It is not *house* that comes into existence, but *this* house." Now anything can be considered apart from whatever is not essentially related to it. Consequently, *the forms and natures of things, though they be forms and natures of things existing in motion, are without motion according as they are considered in themselves.* Therefore, as the philosopher says, they can be the objects of science and definitions.... Therefore, natures of this sort, by reason of which there can be sciences of mobile things, must be considered without determined matter and everything consequent upon matter, but not without undetermined matter, because the notion of the form which determines matter to itself depends on this notion of undetermined matter.[19]

In investigating this matter of necessity and contingency we must be careful to keep our point of view in mind., A metaphysician will speak differently of necessity than, will ajnatural philosopher. The metaphysician is interested in the necessity and contingency of being and the reasons for such. He speaks of an absolute necessity founded upon essence or the intrinsic causes and made known to us whenever a predicate forms part of the definition of a subject. Essences cannot be otherwise than they are, for any new essential principle would destroy an essence and create a new one. The metaphysician pushes forward his search for the ultimate reason of the necessity and immutability of essences to the mind of God wherein are contained the exemplary ideas of all possible participations of the divine Being.

Furthermore, the metaphysician speaks of a hypothetical

[19] *In De Trin.,* q. 5, a. 2, c. Cf. *De Ente et Ess.,* Chap. 2, n. 11-12; *Contra. Gent.,* Bk. 4, Chap. 80-81; *In VI Ethic.,* lect. 1, n. 1123; *Summa Theol.,* q. 85, a. 1.

necessity, or a necessity following upon existence. This falls short of absolute necessity: only God's existence is absolutely necessary, because it pertains to His essence. But given the existence of other things, it is necessary that they exist *when* they exist, in virtue of the principle of noncontradiction. Likewise, given the fact that Socrates is seated, it is necessary that he be sitting while he is seated.[20] Thus, both *esse simpliciter* and *esse tale* are hypothetically necessary when they are posited.[21] The metaphysician seeks the reason for this necessity of existence and finds it again in God. God wills all things other than Himself inasmuch as He ordains them to His own goodness as to an end, that is, as means of manifesting His goodness. He does this not with any absolute necessity, but freely: His goodness is already perfect without creatures. Creation is an overflow of His goodness. But granting creation and the existence of material things, they are necessary because God wills them and cannot not-will them. His will is immutable.[22] The will of God and final causality are the reason for the hypothetical necessity of the whole physical order of exist-

20 "Omne quod est necesse est esse quando est, et omne quod non est necesse est non esse quando non est. Et haec necessitas fundatur super hoc principium: Impossible est simul esse et non esse: si enim aliquid est, impossible est illud simul non esse; ergo necesse est time illud esse.... Et ideo manifeste verum est quod omne quod est necesse est non esse pro illo tempore quando non est: et haec est necessitas non absoluta, sed ex suppositione. Unde non potest simpliciter et absolute dici quod omne quod est, necesse est esse, et omne quod non est, necesse est non esse: quia non idem significant quod omne ens, quando est, sit ex necessitate, et quod omne ens simpliciter sit ex necessitate; nam primum significat necessitatem ex suppositione, secundum autem necessitatem absolutam." *(In I Periherm.,* lect. 15, n. 2.)

21 St. Thomas also speaks of things whose existence God has made absolutely necessary, insofar as there is no potency in them to nonexistence. Cf. *Contra Gent.,* Bk. 2, Chap. 30.

22 "Unde cum bonitas Dei sit perfecta, et esse possit sine aliis, cum nihil ei perfectionis ex aliis accrescat; sequitur quod alia a se eum velle, non sit necessarium absolute. Et tamen necessarium est ex suppositione; supposito enim quod velit, non potest non velle, quia non potest voluntas eius mutari." *(Summa Theol.,* I, q. 19, a. 3.)

ence, just as the intellect of God and exemplary causality are the reason for the absolute necessity of the metaphysical order of essence.

The natural philosopher, on the other hand, does not worry about the necessity of existence as such. He accepts the existence of the material world as given in experience. Likewise, he does not seek the ultimate reason for the immutability of essences, but takes them for immutable and necessary because they transcend the process of natural change. His problem is different. To begin with, he does not properly speak of essences at all, but rather of natures. Essences are of the static order of being; natures are of the dynamic order of becoming, the proper domain of the physicist. He observes the phenomena of nature, its changes, and inquires about the proper causes without which these changes could not have come about. He begins with a change or motion as already achieved and seeks everything that was ordained to that change, every proper cause without which that motion could not have been produced.[23]

There is true necessity between a natural change and its causes when we view the matter *a posteriori.* The change could not have been produced without the causes. But the change itself is not at all necessary nor is the being or state of being produced by the change. The change and the end of the change, the *terminus ad quern,* the being produced by the change, are posited or supposed: they are given in experience. It is not the end or achievement of a change, the intrinsic final cause of a change, that is necessary, for it is contingent and presupposed. It is rather the connection between this posited end and its causes that is necessary. Such necessity is hypothetical. It binds all the other causes of a thing to the final cause.

Since this matter is so important, let us comment briefly on St. Thomas' Commentary to Book Two, Chapter Nine of Aristotle's *Physics.*[24]

23 *Parts of Animals,* Bk. 1, Chap. 1, 640a 12-18.

24 Leet. 15. This chapter is Aristotle's main treatment of necessity

St. Thomas begins by inquiring whether in natural things there is a simple and absolute necessity, or a conditional and hypothetical necessity. He had defined his meaning of necessity a few lessons back.

> Some have defined the necessary as that which does not have an impediment and the contingent as what happens frequently but which can be impeded in a few cases. But this is irrational, because that is said to be necessary which in its nature cannot not-be; but the contingent which happens frequently is that which can not-be.[25]

In his commentary on the *Perihermeneias*[26] he had shown two erroneous definitions: that the necessary is what will always be and that it is what cannot be kept from being true. The first definition is a *posteriori;* it is an effect of necessity rather than necessity itself. The second is from an extrinsic condition: "A thing is not necessary because it does not have an impediment, but rather because it is necessary it cannot have an impediment."[27] Therefore, he defines the necessary as: "that which in its nature has been determined only to existence."[28] This definition is fully verified only of absolute necessity; for hypothetical necessity is such only in a qualified sense.[29]

Absolute necessity, says St. Thomas,[30] is that which de-

in physics. He comes back to the subject in summary form in his methodological treatise at the beginning of *On the Parts of Animals,* Bk. 1, Chap. 1, 639b 21—640a 10; 642a 1-36. He devotes a chapter to it in his metaphysical lexicon, *Metaphysics,* Bk. 5, Chap. 5, 1015a 20—b 15; St. Thomas' Commentary, lect. 6, n. 827-841.

25 "Quidam definierunt esse necessarium, quod non habet impedimentum; contingens vero sicut frequenter, quod potest impediri in paucioribus. Sed hoc irrationabile est. Necessarium enim dicitur, quod in sui natura habet quod non possit non esse: contingens autem ut frequenter, quod possit non esse." *(In II Phys.,* lect. 8, n. 4.)

26 *In I Periherm.,* lect. 14, n. 8.

27 "Non enim ideo aliquid est necessarium, quia non habet impedimentum, sed quia est necessarium, ideo impedimentum habere non potest." *(Ibid.)*

28 "Quod in sua natura determinatum est solum ad esse." *(Ibid.)*

29 *In V Meta.,* lect. 6, n. 833-834.

30 *In II Phys.,* lect. 15, n. 2. In *De Principiis Naturae,* n. 33, he

pends on prior causes: matter, form and agent. For instance, matter is the necessary cause of corruptibility, and man's rationality and the properties of mathematical figures flow with absolute necessity from formal cause. Likewise, "that which has necessity from the efficient cause is absolutely necessary; for example, because of the motion of the sun it is necessary that day and night alternate."[31] Again, because of the contraction of the lungs it is necessary that the air in them be expelled.

Whatever has necessity from what is posterior in existence, namely end or form insofar as it is the end of generation, is conditionally or hypothetically necessary. "Therefore," St. Thomas says ,"to ask whether there is necessity simply or from supposition in natural things is the same as to ask whether the necessity in natural things is found from the end or from matter."[32]

In the pre-Aristotelian tradition, as well as in the modern mechanist tradition, thinkers tried to explain the generation of natural things from the brute necessity of matter and cosmic agents, without any recourse to design or finality. Things have come into existence simply because of the blind interplay of material and efficient causes." With Aristotle and St. Thomas, however, nature is strictly teleological. The marvelous disposition of matter cannot be accounted for unless all the causes involved are predetermined in the direction of the end to be realized, of the being to be produced. The intricate structures and coordinations of the eye or ear, for instance, cannot be due to the chance interactions of evolving matter; the matter had to be given an intrinsic ordination to the production of eye or ear, and this in view of the function of the eye or ear. This does not deny, but rather implies, the absolute neces-

calls the form necessary by hypothetical necessity, in that it is the end of generation.

31 *In II Phys.,* lect. 15, n. 2.

32 Ibid.

33 Cf. examples given by Aristotle in *Parts of Animals,* Bk. 1, Chap. 1, 640a 18—b 29.

sity *flowing* from the essences of material beings; each nature necessarily has its own specific properties.[34] But these are all ordered and organized in the process of natural generation by the end, or specific nature, to be achieved.

> The parts of a house are so disposed because of the end, which is to shelter and protect men from wind and rain. Also, just as it is with the house, so it is in all other things where there is action for the sake of something: for in all these the dispositions of the things generated or made do not follow without the material principles which have the necessary matter whereby they are naturally designed to be so disposed. But the things made or generated are not so disposed because the material principles are such, except insofar as the *because* means the material cause; rather they are so disposed because of some end, and the material principles are sought that are apt for this disposition that the end requires. This is plain as regards the saw. Because the saw is *such,* i.e. it is of such disposition or form; therefore it should be *of such,* i.e. it should have such matter; and it is *such,* i.e. it is of such disposition or form, *because of this,* i.e. because of some end. However, this end, which is sawing, could not come about unless it were made of iron. Therefore, the saw must necessarily be of iron, if it is going to be a saw and if its end is going to be achieved—that is, its work. It is clear, then, that in natural things there is necessity from supposition, just as in artificial things. But this is not in such a way that what is necessary is the end. What is necessary is posited on the part of matter, but the reason for the necessity is posited on the part of the end. We do not say that it is necessary that there be such an end because matter is such; rather the opposite: because such an end and form is going to exist, it is necessary that such matter exist. Thus the necessity is placed in the matter, but the reason for the necessity is placed in the end.[35]

[34] There are some events that are due to the absolute necessity of matter without the intervention and direction of finality. These are due to chance conjunctions of causes acting for other ends. These events are all per *accidens* and contingent, so that they are outside the scope of science. Cf. A. Mansion, op. *cit.,* "Le hasard," pp. 292-314.

It follows that whenever we can arrive at a formal definition, either of a complete being or of a motion, we know that such a definition is identical with the intrinsic final cause of the production of that being or motion. Therefore, from the point of view of necessity, we can demonstrate the other causes of the subject in question. They are rendered hypothetically necessary by the given end.

The following example given by Aristotle will clarify the place of the two types of necessity in physical demonstration.

> Of the method itself the following is an example. In dealing with respiration we must show that it takes place for such or such a final object; and we must also show that this and that part of the process is necessitated by this and that other stage

[35] "Partes domus sic sunt dispositae propter finem, qui est cooperire et salvare homines a caumate et pluviis. Et sicuti est in domo, similiter est in omnibus aliis, in quibuscumque contingit agere propter aliquid: in omnibus enim huiusmodi non consequuntur dispositiones generatorum aut factorum sine principiis materialibus quae habent necessariam materiam, per quam apta nata sunt sic disponi. Non tamen res factae aut generatae sic disponuntur propter hoc, quod principia materialia sunt talia, nisi sicut ly *propter* dicit causam materialem; sed sic disponuntur propter aliquem finem, et principia materialia quaeruntur ut sint apta huic dispositioni, quam requirit finis, ut patet in serra. Est enim serra *huiusmodi,* idest talis dispositionis aut formae; quare oportet quod sit talis dispositionis aut formae, *propter hoc,* idest proter aliquem finem. Sed tamen iste finis, qui est sectio, non posset provenire nisi esset ferrea: necessarium est ergo serram esse ferream, si debeat esse serra, et si debeat esse eius finis, quod est opus ipsius. Sic igitur patet quod in rebus naturalibus est necessarium ex suppositione, sicut et in rebus artificialibus: sed non ita quod id quod est necessarium, sit sicut finis; quia id quod necessarium est, ponitur ex parte materiae; sed ex parte finis ponitur ratio necessitatis. Non enim dicimus quod necessarum sit esse talem finem, quia materia talis est; sed potius e converso, quia finis et forma talis futura est, necesse est materiam talem esse. Et sic necessitas ponitur ad materiam, sed ratio necessitatis ad finem." *(In II Phys.,* lect. 15, n. 4. [our trans.]).

> of it. By necessity we shall sometimes mean hypothetical necessity, the necessity, that is, that the requisite antecedents shall be there, if the final end is to be reached; and sometimes absolute necessity, such necessity as that which connects substances and their inherent properties and characters. For the alternate discharge and re-entrance of heat and the inflow of air are necessary if we are to live. Here we have at once a necessity in the former of the two senses. But the alteration of heat and refrigeration produces of necessity an alternate admission and discharge of the outer air, and this is a necessity of the second kind.[36]

Therefore, whenever a final cause is influencing a process, the necessity ultimately comes from this final cause, rather than from the absolute necessity of the prior causes. This absolute necessity is indeed present in natural changes, but the reason for the necessity is the end to be realized. This is the case in natural as well as artificial changes. Chance occurrences, on the other hand, are attributable to the necessity of efficient and material causes.

We have seen that there is a special and limited kind of certitude attainable in natural science, because there is a special and limited kind of necessity between natural things and their causes. We cannot expect the rigorous and exact certainty of mathematics in the science of nature. In mathematics there is a perfect intuition of essences and deduction of properties through the medium of formal causality. Hence, mathematics, which does not transcend the realm of formal cause, yields the perfect certitude that flows from absolute necessity.[37] In natural

[36] *Parts of Animals,* Bk. 1, Chap. 1, 642a 31-37.

[37] Mathematical-physical sciences proceed according to middle terms that are mathematical, non physical. These sciences participate in the certainty of mathematics, but it is a certainty of mathematical relation. Mathematical-physical sciences cannot demonstrate physical necessity, but only mathematical necessity. Hence, its laws are physically only *quia* or factual. Physical necessity can be shown only by the connection of properties with essence defined in terms of their physical causes. Mathematical-physics does not attain physical essences as such. Cf. *In De Trin.,* q. 5, a. 3, ad 6 & 7.

science there is not a perfect intuition of essences or causes from which properties and effects are rigorously deduced. Rather, the properties and effects are discovered in contingent matter, and the causes or essences are inferred from their effects. Natural science, unlike mathematics, cannot proceed a *priori* with rigorous certitude. All the effects of natural causes can be impeded, for they are realized in contingent matter which can be indisposed to receive the action of the cause. Once, however, we are given an effect, we can proceed a *posteriori* to the proper causes. There is a hypothetical necessity between a given effect and its causes. But there is no necessity between any natural cause and its future effect, unless we assume the necessity by positing the production of the effect. We can do this by abstracting from the contingent conditions of individual matter and considering the cause-effect relationship in its universal aspect.[38]

Experience apprises us of contingent facts. But among these contingent facts we note a constancy of certain occurrences or phenomena. The judgment of this regularity presupposes, of course, a thorough acquaintance with the case in question and a critical investigation into the phenomena. Some things always happen, such as the succession of day and night. Others occur most of the time, as the genera-

[38] "Est autem considerandum quod de his quidem quae sunt sicut frequenter, continget esse demonstrationem, in quantum in eis est aliquid necessitatis. Necessarium autem, ut dicitur in *II Physicorum,* aliter est in naturalibus, quae sunt vera ut frequenter, et deficiunt in minori parte; et aliter in disciplinis, idest in mathematicis, quae sunt semper vera. Nam in disciplinis est necessitas *a priori;* in naturalibus autem *a posteriori* (quae tamen est prius secundum naturam), scilicet a fine et forma. Unde sic docet ibi Aristoteles ostendere *propter quid,* ut si hoc debeat esse, puta quod oliva generetur, necesse est hoc praeexistere, scilicet semen olivae; non autem ex semine olivae generatur oliva ex necessitate, quia potest impediri generatio per aliquam corruptionem. Unde si fiat demonstratio ex eo quod est prius in generatione, non concludet *ex* necessitate; nisi forte accipiamus hoc ipsum esset necessarium, semen olivae ut frequenter esse generativum olivae, quia hoc facit secundum proprietatem suae naturae, nisi impediatur." *(In I Post. Analyt.,* lect. 42, n. 3.)

tion of an integral human being rather than a monster. When something seldom happens, it can be explained by the contingencies of chance or coincidence. But when a regularity or frequency of occurrence is evident, there must be some cause of the regularity or frequency. A constant effect denotes a corresponding constant cause. When we consider only the constant effect and its proper and proximate cause, abstracting from the contingencies that can hinder the effect in individual cases, then we have a necessary relation: it cannot be otherwise but that such an effect follow from such a proper and proximate cause of it. Universal aspects of contingent things are necessary, for the universal is formed from the regularities noted by sensory experience. Therefore, of the universal we can have science and demonstration.[38] But as soon as we begin to apply our conclusions to individual instances, we are back in contingency; our conclusions will hold only for the most

38 "Ostendit quomodo eorum, quae sunt ut frequenter, possit esse demonstratio, dicens: quod eorum quae saepe fiunt, sunt etiam demonstrationes et scientiae: sicut de defectu lunae, qui tamen non semper est. Non enim luna semper deficit, sed aliquando. Haec autem quae sunt frequenter, secundum quod huiusmodi sunt, idest secundum quod de eis demonstrationes dantur, sunt semper: sed secundum quod non sunt semper, sunt particularia. De particularibus autem non potest esse demonstratio, ut ostensum est, sed solum de universalibus. Unde patet quod huiusmodi, secundum quod de eis est demonstratio, sunt semper. Et sicut est de defectu lunae, ita est de omnibus aliis similibus. Consideranda tamen est differentia inter ea. Quaedam enim non sunt semper secundum tempus, sunt autem semper per comparationem ad causam: quia nunquam deficit, quin posita tali causa, sequatur effectus; sicut est de defectu lunae. Nunquam enim deficit, quin semper sit lunae eclypsis, quandocunque terra diametraliter interponitur inter solem et lunam. In quibusdam vero contingit quod non semper sunt, etiam per comparationem ad causam: quia videlicet causae impediri possunt. Non enim semper ex semine hominis generatur homo habens duas manus; sed quandoque fit defectus vel propter impedimentum causae agentis vel materiae. In utrisque autem sic ordinandae sunt demonstrationes, ut ex universalibus propositionibus inferatur universalis conclusio, removendo illa, in quibus potest esse defectus vel ex parte temporis tantum vel etiam ex parte causae." *(In I Post. Analyt.,* lect. 16, n. 8.)

part, for their necessity is only hypothetical.

It is possible, then, to have true science of natural things, because in their universal aspects there is a sufficient necessity, a necessity discovered along with the universal nature itself in the contingent individuals given in frequent sensory experience.

We are now in a position to study the manner of demonstrating in natural science.

CHAPTER IV

THE MANNER OF DEMONSTRATING IN NATURAL PHILOSOPHY

In our treatment of the kind of certitude and necessity to be found in natural science, we have virtually established the manner of demonstrating in it. There is no necessity of natural things *a priori,* that is, in the downward direction from cause to effect. But there is hypothetical necessity *a posteriori,* in the ascending direction from effect to cause. Therefore, natural science must start with experience and proceed from it to essences and causes. It remains for us to clarify this concept and establish it more firmly.

Perhaps, one of the most persistent calumnies leveled at Aristotle is that his natural science is *a priori,* that it is insufficiently founded in critical experience. As a result, he is said to have come up with a kind of scientific monster purporting to be an explanation of nature. This Aristotelian science is thought to have been unmasked, discredited and definitively repudiated by the renaissance physicists and their successors for all times.

The question is not as simple as that. Modern researches into the nature of the experimental sciences are beginning to show up a decided *a priori* element in them, whereas Aristotelian studies are proving how the peripatetic science is a picture much closer to physical reality.[1] It is not our duty here to delve into the content of Aristotelian science and philosophy. We are at present interested only in the methodology of the Stagirite, and that in principle, rather than in application. In other words, we intend at present to investigate his rules of procedure, abstracting

1Cf. Gavin Ardley, *Aquinas and Kant, the Foundations of the Modern Sciences.*

for the moment from the question whether he sufficiently put them into practice in his own physical studies.

We must begin by showing the fundamental role given by Aristotle to observation and experience.[2]

Aristotle holds that a young man cannot be either a moralist or a physicist, though he can be a mathematician. The reason is that the objects of mathematics are abstract, though not so abstract as not to be imaginable, whereas natural and moral science require a great deal of experience, which takes a long time to acquire.[3] Moreover, the Philosopher shows a great respect for the opinions of elderly people, especially in moral matters, so that "we ought to attend to the undemonstrated sayings, and opinions of experienced and older people or of people of practical wisdom not less than to demonstrations; for because experience has given them an eye they see aright."[4]

According to Aristotelian demonstrative theory, all demonstrations proceed from foreknowledge which ultimately comes from sense perception.

> Now induction is the starting-point which knowledge even of the universal presupposes, while syllogism proceeds *from* universals. There are therefore starting-points from which syllogism proceeds, which are not reached by syllogism; it is therefore by induction that they are acquired.[5]*

Here are a few examples of inductions that Aristotle makes. "We physicists must take for granted that the things that exist by nature are, either all or some of them, in motion—which is indeed made plain by induction."[6] Nothing is contained locally in itself: "Thus if we look at the matter inductively we do not find anything to be 'in' itself in any

[2] Cf. J. M. Le Blond, *Logique et Méthode chez Aristote,* Part 2, Chap. 2, "L'experience," pp. 222-268; A. Mansion, *Introduction a la Physique Aristotélicienne,* Chap. 6, "La méthode aristotélicienne en physique," pp. 206-225.

[3] *Nicomachean Ethics,* Bk. 6, Chap. 8, 1142a 12-20.

[4] *Ibid.,* Chap. 11, 1143b 11-13.

[5] *Ibid.,* Chap 3, 1139b 27-30.

[6] *Physics,* Bk. 1, Chap. 2, 185a 13-14.

of the senses that have been distinguished; and it can be seen by argument that it is impossible."[7] "Change which is not accidental on the other hand is not to be found in everything, but only in contraries, in things intermediate between contraries, and in contradictories, as may be proved by induction."[8]* Frequently throughout his treatises we find an explicit appeal to induction as the source of his data. Other times he uses induction, but does not explicitly inform us of it. "It is clear," he says in the last paragraph of the *Posterior Analytics,* "that we must get to know the primary premisses by induction; for the method by which even sense-perception implants the universal is inductive."*

This induction must be established upon careful observation and experience. There is a capital text which must be kept in mind:

> Lack of experience diminishes our power of taking a comprehensive view of the admitted facts. Hence *those who dwell in intimate association with nature and its phenomena* grow more and more able to formulate, as the foundations of their theories, principles such as to admit of a wide and coherent development: while those whom devotion to abstract discussions has rendered unobservant of the facts are too ready to dogmatize on the basis of a few observations.[10]

Unbiased scholars know well how intimate was Aristotle's association with nature and its phenomena. In his treatise *On the Parts of Animals* he shows how we have scanty enough evidence of the imperishable and eternal things that we desire to know,

> ... whereas respecting perishable plants and animals we have abundant information, living as we do in their midst, and ample data may be collected

[7] *Ibid.,* Bk. 4, Chap. 2, 210b 8-10.

[8] *Ibid.,* Bk. 5, Chap 1, 224b 28-30. Cf. *Parts of Animals,* Bk. 2, Chap. 1, 646a 24-30. References to more specialized physical inductions are given by A. Mansion, *op. cit.,* p. 220.

* *Post. Analyt.,* Bk. 2, Chap. 19, 100b 3-5.

[10] *On Generation,* Bk. 1, Chap. 2, 316a 5-10. (Italics ours.)

> concerning all their various kinds, *if only we are willing to take sufficient pains.*[11]

Faithful to this principle, Aristotle made some rather amazing observations. He established that air has weight, that a vessel breaks from the pressure of expanding vapors, that "that which does not twinkle is near—we must take this truth as having been reached by induction or sense-perception."[12] It is well recognized that the Fourth Book of *Meteors* is characterized by "its extraordinary richness of precise observations,"[13] so much so that scholars find in it "a proof of the progress of Aristotle in precision of research and a confirmation at the same time, if such is needed, of the relatively late date of the *Meteors."*[14]

Aristotle was not satisfied only with observation. He practiced some rudimentary experiments, such as blinding young swallows to see if their eyes would be regenerated.[15] He says: "The following experiment makes the necessity of a medium clear. If what has color is placed in immediate contact with the eye, it cannot be seen."[16] He speaks of a kind of imaginary experiment: "If you planted a bed

[11] *Parts of Animals,* Bk. 1, Chap. 5, 644b 26-31. (Italics ours.)

[12] *On the Heavens,* Bk. 4, Chap. 4, 311b 9-11; *ibid.,* Bk. 3, Chap. 7, 305b 9; *Post. Analyt.,* Bk. 1, Chap. 13, 78a 33-35. Cf. Le Blond, *op. cit.,* pp. 233, 237, 238 and *passim.*

[13] "On a depuis longtemps remarqué son extraordinaire richesse en observations précises." (Le Blond, *op. cit.,* p. 237.)

[14] "Leur richesse d'observation apporte par là une preuve du progrès d'Aristote dans la précision de la recherche et confirmerait en même temps, s'il était nécessaire, la date relativement tardive des Météores." *(Ibid.,* p. 238-239.) It seems to us that this opinion does not take sufficiently into account the Aristotelian methodology of proceeding from general to particular. At the more general levels, which in present times is said to be the realm of philosophy as opposed to science, there is less need of the minute and precise observation required at the lowest specific levels. Therefore, there is no point in saying: "Il est certain par exemple que les traités *sur les Parties des Animaux* et la *Génération des Animaux,* qui sont sûrement tardifs, sont beaucoup plus riches en details que les *Physiques." (Ibid.,* p. 236.)

[15] *Generation of Animals,* Bk. 4, Chap. 6, 774b 31-34.

[16] *On the Soul,* Bk. 2, Chap. 7, 419a 13.

and the rotting wood acquired the power of sending up a shoot, it would not be a bed that would come up, but wood—which shows that the arrangement in accordance with the rules of the art is merely an incidental attribute."[17] We know that he practiced dissection of animals, and some authors think that he refers to a book of his: *On Dissections,* which do not have.[18] He tried blowing into the windpipe of an animal and thought that he saw the air enter the heart.[19] He cut insects in two, in order to learn if the parts lived on.[20] He gives a simple experiment purporting to prove that the cicada has weak eyesight.[21] A mere casual paging through the works of Aristotle will convince us of his esteem for the observation of facts. Only biased scholarship or lack of scholarship could accuse him of *a priorism.*

We should not reproach Aristotle for the mistakes of observation that he made. After all, he was a pioneer scientist, and we would do well to look at his marvelous accomplishments, rather than to harp upon his errors. Likewise, we must not expect the precise observations and experiments of a modern scientific laboratory from Aristotle. He did not have to make such exact measurements, because his science is not quantitative, but qualitative, a distinction that many of his critics do not understand or keep in mind. Aristotle studies the real world from the aspect of essences and essential attributes, not from that of quantitative relations. Finally, it is sometimes noted that the majority of Aristotle's observations appear in the biological treatises, and that the observations of inanimate beings are less spectacular.[22] This is easily explained by the fact that he was

17 *Physics,* Bk. 2, Chap. 1, 193a 13-15.

18 Cf. *On Respiration,* Chap. 14, 474b 9 and footnote in Ross ed.

19 *History of Animals,* Bk. 1, Chap. 16, 495b 14.

20 *Ibid.,* Bk. 4, Chap. 7, 531b 30.

21 *Ibid.,* Bk. 5, Chap. 30, 556b 17-21.

22 Le Blond, *op. cit.,* p. 228, says: "On a remarqué que les exemples précédents sont empruntés aux traités biologiques: la physique des inanimés manifeste moins vivement cette curiosité exigeante et cet esprit d'observation scientifique: Aristote n'y fait était que d'un

a specialist in biology and because living beings were more numerous and accessible and more stimulating to scientific curiosity.[23] Living beings, moreover, because of their manifest typical operations, are easier to study in a qualitative manner. Even if it is true, however, that his observations are relatively meager in the study of inanimate beings, yet we must admit his inexorable demands that all natural science take its origin in experience.

He found the Platonic theory of elements in the *Timaeus* untenable because it broke against experience. "Anyone who insists upon an exact statement of this kind of theory, instead of assenting after a passing glance at it, will see that it removes generation from the world,"[24] which, of course, is evident to experience. He finds Atomism unacceptable because it cannot explain alteration, growth and diminution, which also are evident to sensory experience.[25] He asserts his principle vigorously against those who come with a pre-conceived theory to the study of the generation of elements one from the other.

nombre assez restreint de faits et c'est sur cette base un peu étroite qu'il s'efforce d'édifier ses théories."

23 It is interesting to note the reaction of Charles Darwin to Aristotle's biological studies. He wrote the following letter to Wm. Ogle, upon receiving a copy of the latter's translation of *Parts of Animals;* ""You must let me thank you for the pleasure which the introduction to the Aristotle book has given me. I have rarely read anything which has interested me more, though I have not read as yet more than a quarter of the book proper. From the quotations which I have seen, I had a high notion of Aristotle's merits, but I had not the most remote notion what a wonderful man he was. Linnaeus and Cuvier have been my two gods, though in very different ways, but they were mere schoolboys to old Aristotle. How very curious, also, his ignorance on some points, as on muscles as the means of movement. I am glad that you have explained in so probable a manner some of the grossest mistakes attributed to him. I never realized, before reading your book, to what an enormous summation of labour we owe even our common knowledge." Charles Darwin to W. Ogle, Feb. 22, 1882. *Lafe and Letters of Charles Darwin,* ed. by his son Francis Darwin, Vol. I, p. 371.

24 *On the Heavens,* Bk. 3, Chap. 8, 306b 27-29.

25 *On Generation and Corruption,* Bk. 1, Chap. 9, 327a 16-25.

> It is absurd, because it is unreasonable that one element alone should have no part in the transformations, and also *contrary to the observed data of sense,* according to which all alike change into one another. In fact their explanation of the observations *is not consistent with the observations.* And the reason is that their ultimate principles are wrongly assumed: they had certain predetermined views, and were resolved to bring everything into line with them. It seems that perceptible things require perceptible principles, eternal things eternal principles, corruptible things corruptible principles; and, in general, every subject matter principles homogeneous with itself. But they, owing to their love for their principles, fall into the attitude of men who undertake the defence of a position in argument. In the confidence that the principles are true they are ready to accept any consequence of their application. As though some principles did not require to be judged from their results, and particularly from their final issue! And that issue, which in the case of productive knowledge is the product, *in the knowledge of nature is the unimpeachable evidence of the senses as to each fact.*[28]*

It is quite significant that Aristotle did not limit the amassing of experience to his personal activity. He looks to the experience of others. He examines the writings and uses many of the facts observed by others, sometimes naming his sources,[27] more often not.[28] He never accepts data blindly and without criticism, even though his sources did occasionally lead him into error. He knows and reports the interpretations that his predecessors put upon their facts. He shows deference for authorities, especially for the common accord of all philosophers. He was the first to study the history of thought, its development and vicissitudes at the hands of philosophers who had gone before. "Let us

28 *On the Heavens,* Bk. 3, Chap. 7, 306a 4-18. (Italics outs.)

27 Cf. T. W. Organ, *An Index to Aristotle,* "Anaxagoras," "Democritus," "Diogenes of Apollonia," "Empedocles," "Heraclitus," "Parmenides," "Pythagoreans."

28 Cf. Le Blond, *op. cit.,* p. 253; W. D. Ross, *Aristotle,* p. 113.

remember," he wrote in regard to political wisdom, "that we should not disregard the experience of ages; in the multitude of years these things, if they were good, would certainly not have been unknown."[29] Again, "We should therefore make the best use of what has been already discovered, and try to supply defects."[30] He is looking for the perennial stream of truth, contributed to in greater or lesser degree, by his predecessors: "the experience of the eternal man, more complete and more imposing still than that of the elderly individual man."[31]

Aristotle showed an extraordinary reverence toward the simultaneous experience of the multitude of people, as trusting the judgment of the many more than of the individual.[32] He does not disdain to study myths, common beliefs and superstitions, proverbs, poetry and dreams as indications of common experience.[33] In all this he endeavored to extend his personal experience in time as well as in space by recourse to the experience of others.

After the physicist has completed his observation of **facts**, he is ready to proceed to theory, to an understanding and unification of his facts by means of the demonstrative process. "The course of exposition must be first to state the attributes common to whole groups of animals, and then to attempt to give their explanation."[34] In the treatise *On the Parts of Animals,* in which Aristotle is so thoroughly conscious of methodological principles, he says:

> The nature and the numbers of the parts of which 'animals are severally composed are matters which have already been set forth in detail in the books of Researches about Animals. We have now to

29 *Politics,* Bk. 2, Chap. 5, 1264a 1-3.

30 *Ibid.,* Bk. 7, Chap. 10, 1329b 35. Cf. *On the Soul,* Bk. 1, Chap. 2, 403b 20-25; *Metaphysics,* Bk. 1, Chap. 3, 983b 1-6.

31 "... expérience de l'homme éternel, plus complète encore et plus imposante que celle du vieillard." (Le Blond, *op. cit., p.* 262.)

32 Cf. *Polities,* Bk. 3, Chap. 11,1281a 40—b 10.

33 Cf. *Metaphysics,* Bk. 12, Chap. 8, 1074b 1-15; Organ, *op. cit.,* "Proverbs"; *On Prophesying by Dreams,* Ch. 1, 462b 13-20.

34 *On the Parts of Animals,* Bk. 1, Chap. 5, 645b 1-3.

SUM!

> inquire what are the causes that in each case have determined this composition, a subject quite distinct from that dealt with in the Researches.[35]

The whole process of proof in natural science is well summarized in the following passage from the *Prior Analytics.*

> It is the business of experience to give the principles which belong to each subject. I mean for example that astronomical experience supplies the principles of astronomical science; for once the phenomena were adequately apprehended, the demonstrations of astronomy were discovered. Similarly with any other art or science. Consequently, if the attributes of the thing are apprehended, our business will then be to exhibit readily the demonstrations. For if none of the true attributes of things had been omitted in the historical survey, we should be able to discover the proof and demonstrate everything which admitted of proof, and to make that clear, whose nature does not admit of proof.[36]

St. Thomas is no less demanding of sensory experience in the philosophy of nature. All our intellectual knowledge takes its origin in the senses. The experience of the senses is prior in our knowledge, and it is more known as regards us. From this sensory experience we can abstract mathematical entities, and because we know the whole essence of these, we can rigorously deduce a perfect science from them. The knowledge of these mathematical essences is prior in us to the knowledge of their properties. Therefore, we proceed from these principles to demonstrate. We have seen in the .last chapter how St. Thomas excludes this procedure in natural science, because we do not have a perfect intuition of material essences. Therefore, the direction of our demonstrations at the outset cannot be *from* them, but must rather be *toward* them.

> Some things are knowable to us through themselves; and in bringing such things to light the speculative sciences use their definitions to demon-

[35] *Ibid.,* Bk. 2, Chap. 1, 646a 8-12.
[36] *Prior Analytics,* Bk. 1, Chap. 30, 46a 17-29.

> strate their properties, as happens in the sciences which demonstrate *propter quid.* There are other things which are not knowable to us through themselves but through their effects. And if indeed the effect is adequate to the cause, we take the quiddity itself of the effect as our starting point to prove that the cause exists and to investigate its quiddity, from which in turn its properties are made evident.[37]

Again and again St. Thomas emphasizes that natural science must start with the senses. "Physics gets its data from the senses." "As a starting-point for natural science, we must take what appears sensibly." "Natural principles are taken from the experience of sensible things." "We should learn natural science after mathematics because the extensive data it is grounded upon require experience."[38] He sees this fidelity to sensory experience as the distinctive feature of Aristotle's philosophy.[39] He willingly concurs in Aristotle's criticism of Platonic procedure[40] and even elaborates it:

> He assigns the reason why Plato was more in error than Democritus was on this matter (i.e. whether bodies are ultimately composed of indivisible planes: Plato). He says that the reason why Plato was less able to see admitted facts, that is, things that were manifest to everyone, was inexperience. He was so intent on intelligible

37 *In De Trin.,* q. 6, a. 4, ad. 2. Cf. *In I Ethic.,* lect. 4, n. 51-52; *In II De Anima,* lect. 3, n. 245.

38 "Modus physicae... secundum quod a sensu accipit." *(In De Trin.,* q. 6, a. 1, ad q. 2, ad 4.) "Oportet autem id quod sensibiliter apparet, accipere ut principium in scientia naturali." *(In l De Gen.* et *Cor.,* lect. 12, n. 3.) "... in principiis naturalibus quae ex sensibilium experimento accipiuntur." *(In VIII Phys.* lect. 3, n. 4.) "Naturalis post mathematicam addiscenda occurat, eo quod universalia ipsius documenta indigent experimento et tempore." *(In De Trin.,* q. 5, a. 1, ad 10.)

39 "Quidam ad inquirendam veritatem de natura rerum, processerunt ex rationibus intelligibilibus; et hoc fuit proprium Platonicorum; quidam vero ex rebus sensibilibus; et hoc fuit proprium Philosophiae Aristotelis." *(De Spir. Creaturis,* a. 3.)

40 The passage from Aristotle is quoted above, Chap. IV, note 10.

> things that he paid no attention to sensible things with which experience deals. So those philosophers who cared more for sensible and natural things were more able to find the kind of principles to which they could adapt many sensible facts. But the Platonists, who were unobservant of existing things, that is, of natural and sensory beings, regarded only a few sensory objects that presented themselves; and then, by many abstract discussions and reasons, that is from many things considered by the mind on a universal level, they dogmatised, that is, they formed an opinion about sensible matters without careful observation.[41]

In his well known tract on the division and methods of the sciences, St. Thomas gives ample statement of the principles of procedure whereby the science of nature is unfolded. There are two passages that are of special interest to us at present.

In question six, article one of his commentary on the *De Trinitate* of Boethius, St. Thomas is inquiring whether the mode of procedure in natural science can be characterized as rational *(rationabiliter),* as distinguished from the mode of learning *(disciplinabiliter)* in mathematics and the mode of intellect *(intellectualiter)* in metaphysics. He answers that a method can be called rational in three ways. In the first two ways a method is called rational because it belongs to rational science, or logic, either by using logical intentions as principles or by proceeding with probable argu-

41 "Assignat rationem quare circa hoc magis defecit Plato quam Democritus. Et dicit quod causa huius quod Plato minus potuit videre confessa, idest ea quae sunt omnibus manifesta, fuit inexperientia: quia scilicet, circa intelligibilia intentus, sensibilibus non intendebat, circa quae est experientia. Et ideo illi philosophi qui magis studuerunt circa res sensibiles et naturales, magis potuerunt adinvenire talia principia, quibus possent multa sensibilia adaptare. Sed Platonici, qui erant indocti existentium, idest circa entia naturalia et sensibilia, respicientes ad pauca sensibilium quae eis occurrebant, ex multis sermonibus vel rationibus, idest ex multis quae in universali rationaliter considerabant, de facili enuntiant, idest absque diligenti perscrutatione sententiam proferunt de rebus sensibilibus." *(In I De Gen. et Cor.,* lect. 3, n. 8.)

ments; in these two ways the rational method belongs to the dialectician, not to the scientist.[42]

In a third way, the way proper to natural science, a method is called rational because it corresponds to the typical manner in which the rational soul operates. "For in its procedures natural science keeps the characteristic method of the rational soul."[43] Just as the rational soul receives its intelligible species from sensible things, so also does natural science, which "proceeds from what is more known relatively to us and less known in its own nature,"[43] and which makes use of "demonstration by means of a sign or an effect."[43] The method of natural science has, like reason itself, the characteristic of moving from knowledge of one thing to knowledge of another thing really distinct from the first: "In the case of natural science, in which demonstration takes place through extrinsic causes, something is proved of one thing through another thing entirely external to it."[43] Therefore, the method used by natural science especially (though not only by natural science) is most in conformity with the natural operation of the human mind, which derives its data from the senses and then elaborates it by judgment and reasoning.

In the next article St. Thomas shows explicitly that natural science begins in the sense and terminates in the sense. It begins in sensory experience as does all intellectual knowledge. It terminates in the sense, that is, it verifies its conclusions in the light of sensory experience. "Sometimes the properties and accidents of a thing revealed by the sense adequately manifest its nature,"[44] as for instance the manifestations of nourishment, growth, reproduction and cognition point to the nature of a living being. If we try to demonstrate attributes of such a being merely in terms of physics and chemistry, we would be doing violence to the facts. "The intellect's judgment of the thing's nature must

42 Cf. *In I Post. Analyt.,* lect, 20, n. 5; *In IV Meta.,* lect 4, n. 572-574.

^*In De Trin.,* q. 6, a. 1, c.

44 *In De Trin,,* q. 6, a. 2.

conform to what the sense reveals about it."[44] "The unimpeachable evidence of the senses as to each fact,"[45][46] as Aristotle says in a passage to which St. Thomas alludes, is the ultimate judge of our philosophical theories. *"The person who neglects the senses in regard to natural things falls into error."*[**]

We see, then, that according to both Aristotle and St. Thomas the method to be followed in the science of natural things is the careful observation of natural phenomena, even to the point of omitting none of the attributes of our subject,[45] then the demonstration of these attributes by discovering their causes and understanding the necessary relation between cause and attributes—but ever with an eye to sensory experience, which is the final arbiter of our philosophical explanations. In other words, in natural science we begin by observing sensory phenomena, then proceed by demonstration *quia* to discover the cause, from which, by demonstration *propter quid* we can proceed to a^more perfect knowledge of the observed properties.

There is no question in this Aristotelian-Thomistic natural science of deducing new facts. That is an achievement that becomes possible when an *a priori* discipline such as mathematics is applied to natural things; this is the glory of mathematical physics. But a purely physical science of nature, such as Aristotle envisioned, must start with the facts already gathered. The method of demonstration ^s n°t a method of discovery, but of explanation. The work of a qualitative natural science is not to deduce the properties of a being, but rather to understand a being and its observed properties by seeing them in .the. light of their first^nnm^^j^'jpropei^cajmjes. The philosophical sciencehf nature is strictly an experimental science, a science of observation of material beings and their properties from the most general down to the most specific. At the most general level, the observations will be those of ordinary,

45 *On the Heavens,* Bk. 3, Chap. 7, 306a 16. Quoted above, note 26.
46 Cf. text quoted above, note 36.

though not uncritical, common sense and consequently easily accessible. At the level of the ultimate species we must make use of the most refined instruments of observation and of facts borrowed from the higher mathematical-physical sciences. At every stage natural science must keep itself solidly anchored in the unimpeachable evidence of sensory experience.·"

It was this healthy empiricism of peripatetic philosophy that St. Thomas, under the inspiration of St. Albert, found so convincing and attractive. Because of this he was willing to champion that philosophy and fight for it in a cultural milieu that was aggressively Augustinian and that looked upon Aristotle as an Averroist heresiarch. As an illustrious religious brother of St. Thomas has remarked:

> In his rallying to the doctrine of Aristotle, St. Thomas was led less by the contested authority of the Master than by the *incontestable value of his experimental method....* In this *constant fidelity to a rational method based upon experience* consists the true originality of St. Thomas in philosophy—an originality more uncommon than is generally thought—which consists less in producing truth than in discovering it; less in constructing an abstract system out of all its fragments than in finding solid and stable bases for it in living and concrete reality. It is for having followed this method, for having been constantly faithful to it even in theology when he had to treat purely philosophical problems that St. Thomas merits the name of a philosopher. Accordingly, we have no right to assert that he approached philosophy only as a theologian and with a method proper to theology.[48][47]

47 Cf. W. H. Kane, O.P., "Comment on Dr. Foley's Paper," *Proceedings of the American Catholic Philosophical Association,* XXVI (1952), pp. 140-146.

48 "C'est que, dans ce ralliement à la doctrine d'Aristote, St, Thomas fut moins séduit par l'autorité contestée du Maître, que par la *valeur incontestable de sa méthode expérimentale....* En celà, c'est *à dire dans sa fidélité constanteà une méthode rationelle baseé sur ^expérience,* consiste la véritable originalité de St. Thomas en philo-

The method of natural science, we have seen, is that typically human process of seeing facts and asking the reason why. There remains a further question: in what sense does the physicist ask the question why; by what causes, in other words, does the physicist demonstrate? Our answer can be given in a proposition taken verbatim from Aristotle.

> Now, the causes being four, it is the business of the physicist to know about them all, and if he refers his problems back to all of them, he will assign the 'why' in the way proper to his science—the matter, the form, the mover, 'that for the sake of which.'[49]

The natural scientist must answer the question *propter quid* in terms of all four causes, for his science is that of natural motion. He studies subjects that are intrinsically mobile. It is impossible for him to understand his subject until he assigns all the causes that in any way contribute to the changes he observes in natural being.

Obviously, the physicist is concerned with the intrinsic causes, matter and form, for they are "nature"; they are the first principles of his science, without which he could know nothing scientifically about his subject. But no motion can come about without an efficient cause, and no efficient cause can operate except for some end. So natural science must consider also the extrinsic causes, agent and end. The physicist is also interested in these extrinsic causes

Sophie, originalité plus rare qu'on ne le pense généralement, et qui consiste moins à inventer la vérité qu'à la découvrir; à construire de toutes pièces une système, dans l'abstrait, qu'à lui trouver des bases solides et stables dans la réalité vivante et concrète. C'est donc pour avoir suivi cette method; c'est pour y avoir été constamment fidèle même en théologie, lorsqu'il eut à y traiter des problèmes proprement philosophiques, que St. Thomas mérite le nom de philosophe, et qu'on n'a pas le doit de soutenir qu'il n'a abordé la philosophie qu'on théologien et avec un méthode propre a la théologie." F. M. S. Gillet, O.P., "La méthode philosophique de SL Thomas et l'expérience," *Angelicum, Nil* (1930), pp. 150-151.

[49] *Physics,* Bk. 2, Chap. 7, 198a 23-25.

because he is not satisfied to see changeable beings in isolation, but wants to know their relation to all other beings: what initiated their changes and to what goal are they moving?

It will be our task in the remaining chapters to show how natural science demonstrates from each of the causes. For the present, we must delimit the application of two of the causes, the form and the agent. The natural philosopher is not interested in form as such, but in form as it is a principle of motion in matter, for his science is restricted to beings that are defined with sensible matter. He considers the forms of all material beings, including the human soul as existing in the body. But this is the limit of his science. When it comes to the question of the soul's existence apart from the body, the first principles of motion are of no more use for demonstrating. The physicist yields the problem to the metaphysician, whose domain is that of immaterial existents.[50] The questions, therefore, of the manner of existence and operation of souls after death belongs to metaphysics.[51] They can at best be treated only dialectically in natural science. Such things cannot be known through the principles of natural motion. They are rather a part of the science of being as such.

As regards efficient causes, natural philosophy extends to all mobile efficient causes, to all those which, though they move others, are yet moved themselves by another. In studying natural movers, the physicist discovers that there has to be a First Mover that transcends the whole order of mobility: one that moves others, but is in no way moved itself. Again physics has reached the end of its vision. It cannot investigate immobile being with princi-

[50] Cf. *In II Phys.,* lect 4, η. 10; *In VI Meta.,* lect. 1, n. 1159. In the first lesson of *De Sensu et Sensato,* St Thomas says: "Praeter librum *De anima* Aristoteles non fecit librum de intellectu et intelligibili: vel si fecisset, non pertineret ad scientiam Naturalem, sed magis ad Metaphysician, cujus est considerare de substantiis separatis."

[51] Note that the question of the origin of the human soul also belongs to metaphysics: creation is not motion.

pies of mobility. There is need of a higher science to study the first efficient cause of all natural motions.[52] The physicist merely retires at this point in order to study in greater detail the effects of the First Mover in nature.

There will hardly be any objection to the Aristotelian principles of demonstration at the general level of what is currently called philosophy of nature. It seems unanimously admitted among Thomists that natural philosophy derives its data from sensory experience and elaborates this data by causal explanation. But many will disagree with the attempt to extend this method to the level of the ultimâtë~~speciës. Aristotle, St. Thomas and thé scholastics thought that we could get a certain amount of strict scientitle knowledge of specific essences and their properties. In fact, they held that science lacked its full perfection if it remained in generalities.[53] There is no doubt that the human mind seeks a knowledge of specific essences, and many experimental scientists are attempting to learn the natures of material things. Moreover, in at least one case philosophy of nature does extend down to the ultimate species, namely, in the case of man, whose nature we know and whose properties we can demonstrate through the definition of his nature.

Many who object to the integral Aristotelian concept of natural science as starting with general principles and extending to the ultimate differences, may be thinking in terms of mathematicized science. In passing, we may remark that the exact nature and noetic value of mathematical physics is one of the thorniest epistemological problems

52 "Sunt enim principia moventia dupliciter, scilicet mota et non mota: quorum id quod non movetur non est naturale, quia non habet in se principium motus. Et taie est principium movens quod est penitus immobile et primum omnium.... Rerum enim quaedam sunt immobilia, et circa hoc est unum studium philosophiae; aliud vero studium eius est circa ea quae sunt mobilia.... Et primum quidem negotium pertinet ad metaphysicam; alia vero... ad scientiam naturalem." *(In II Phys.,* lect. 11, n. 5, n. 3.)

53 *In I Meteor.,* lect. 1, n. 1. Quoted above, Chap. II, note 41.

being discussed at the present time. The pendulumhas gone full swing from the claim that this type of metrical science gives an exact picture of nature Lo.the.,charge that^_ it in no way depicts reality, but is rather an *a priori* constructionthat deforms reality.

The Aristotelian natural science is strictly qualitative and causal. It claims that the specific stratum of nature is scientifically knowable only in the light of the general principles and causes of mobile being. A property cannot be known as such unless the definition of the subject is known. Aristotelian science defines subjects, not by quantitative principles, but by purely physical or qualitative principles. In the light of these, it proceeds to give causal demonstrations of natural phenomena at every level.

> The most serious hurdle which the modern physical theorist has when he is confronted with Aristotelian cosmology is understanding that the physical theory of matter-form and its entire elaboration in organizing the several branches of science is a purely physical theory.[54]

A qualitative physical science proceeding according to Aristotelian demonstrative method would in no way supplant or absorb the mathematicized sciences. They would remain specifically different, as being at different levels of abstraction. But the Aristotelian natural science would supplement its mathematical counterpart and submit the discoveries of the latter to the demonstrative process whereby they would attain the full status of scientific truth.

An integral natural science such as Aristotle envisioned has yet to be developed. Gavin Ardly writes:

> The new physics of Galileo and his contemporaries ousted the real physics of the ancient and medieval period. The latter has made no progress since the close of the Middle Ages. Let us hope that now the situation has become clearer the pursuit of a

[54] R. J. Nogar, O.P., "Toward a Physical Theory," *The New Scholasticism,* XXV (October, 1951), pp. 397-438. This article gives an excellent survey of attempts to achieve a satisfactory theory of science and of the need for a truly physical theory.

neo-Aristotelian physics will be resumed parallel to the pursuit of Galilean physics.[85]

It is well to observe that the method of demonstrating in natural science is not proper to just one particular part, as though Aristotle extended the method of biology to all of natural science. The methodological principles are established at the generic level of the science, in fact, immediately after the subject-genus is determined and according to the exigencies of the subject. The method is commensurate with the subject-genus, and therefore applies to all the divisions of the subject. For the subject-genus is univocal *in ratione scibilitatis;* the divisions, though different essentially in their real existence, are united by the same first principles and are thereby knowable in the same way.

The Aristotelian demonstrative method, we have seen, is solidly rooted in sensory experience, which must be varied and sure. From observation of constantly recurring phenomena we are led to discover their proper and adequate cause, whose essence is made known to us through its effects. In the light of this essence, defined in terms of all four causes, we can demonstrate and understand the properties and their necessary connection with their subject With this method we can develop a qualitative science, a philosophical physics, that extends down to the lowest specific difference.

It remains for us to see this method at work.

[85] *Aquinas and Kant,* p. 156.

CHAPTER V

DEMONSTRATION THROUGH FORMAL CAUSE

The most difficult feature of the demonstrative theory is to put it into practice. Aristotle and St. Thomas have the theory constantly in mind and use it implicitly, without always casting their demonstrations into strict syllogistic form.[1] But their successors have not been faithful to this method in natural philosophy, with the result that it is hard to find strict *propter quid* demonstrations given in modern manuals of philosophy. Still more, it is hopeless to find them developed at the level of the ultimate species, as the philosophers have abandoned that sphere to the positive sciences.

We will give a few random examples of demonstrations, using each of the causes in turn as middle terms. Most of our examples will be taken from the *Posterior Analytics,* because Aristotle cites them precisely as instances illustrating his demonstrative theory. Many of these examples are outmoded as science. They depend on defective observations or incorrect theories, such as the ancient theory of the elements. The conclusion of a demonstration shares the noetic status of the premisses, for the premisses cause the conclusion and can produce no more certainty than they have themselves. Yet these examples from the *Posterior Analytics* are valuable: they indicate how Aristotle intended his demonstrative theory to be applied. The task

[1] "Si quis recte consideret, omnia ex quibus fides potest definiri in praedicta descriptione tanguntur, licet verba non ordinentur sub forma definitionis; sicut etiam apud philosophos praetermissa syllogistica forma syllogismorum principia tanguntur." *(Summa Theol.,* II-II, q. 4, a. 1.) "Quandoque enim ipsis philosophis sufficit tangere principia syllogismorum et definitionum, quibus habitis, non est difficile in formas reducere secundum artis doctrinam." (De *Ver.,* q. 14, a. 2.)

lies ahead of modern natural philosophers to organize their science according to the exigencies of this method of demonstration and to present demonstrations of those matters that are susceptible of demonstration.

We must first consider demonstration through formal cause. For St. Thomas himself tells us:

> Whatever must be considered about generation must be considered by the philosopher of nature. But in generation we must consider form, matter and the mover, because whoever wants to consider generation as to its causes considers it in this way: first what is that which comes to be after something, for example fire comes to be after air when fire is generated from air, and in this one considers the form through which what is generated is what it is. Likewise one considers what it is that first did this, i.e. what first moved this to generation, and this is the mover. Again one considers what it is that sustains this, and this is the subject and matter.__The philosopher of nature also considers the end.[2]

It must be remembered that the formal cause is the end of generation; it is that which the process of generation is ordained to produce in a given matter. Therefore, in generation formal and final cause coincide.[3] Hie process of demonstration is simple in this case:

> We should proceed in demonstration as follows: If this is to come to be, this and this are required; for example, if man is to be generated, it is necessary that there be human seed acting in generation. ... But that which should come to be, i.e. that in which generation is terminated, wag. that which was to be, i.e. the form, according to-what was said before. Thus it is clear that when we demonstrate according to this mode, *if this is to* come to be, we demonstrate by the formal cause.[4]

2 *In II Phys.,* lect. 11, n. 5 and 6.

3 "In generatione autem, forma non habet causalitatem, nisi per modum finis. Finis enim et forma in generatione incidunt in idem numero." *(In VI Meta.,* lect. 3, n. 1202. Cf. *In II Phys.,* lect 4, n. 8.)

4 *In II Phys.,* lect. 11, n. 8.

The formal cause—as final cause of generation—is not demonstrated, but must be attained by intellectual intuition through experience and the process of definition. But once given, it necessitates the other causes and the properties and can be the medium of demonstrating them.

We must call attention to the fact that the whole definition of a nature, that is, the essential definition, when taken in abstraction from the individuals in which it is realized, pertains to formal cause. St. Thomas says:

> To this mode of cause all the parts which are placed in the definition are reduced because the parts of the species and not the parts of matter are placed in the definition, as is said in the seventh book of the *Metaphysics.* Nor is this contrary to the statement above that matter is placed in the definition of natural things, because it is not individual matter which is placed in the definition of the species but common matter; for example in the definition of man we posit flesh and bones, but not this flesh and these bones. Therefore the nature of the species constituted of form and common matter is formal with respect to the individual which participates in such nature; to this extent we say here that the parts which are placed in the definition pertain to the formal cause.[8]

The most fertile field for demonstration through formal cause is at the generic levels of natural science, that which modem scholastics regard as natural philosophy. For at the generic level formal definitions are relatively easy to obtain. Thus, the logic texts dole out such stock examples as: "Every rational animal is capable of science; man is a rational animal. Therefore man is capable of science." Such examples are easy and obvious. The use of the demonstrative method in natural philosophy takes us into more complicated cases.

There is one demonstration of natural science which we feel ought to be incorporated into this study, the demonstration, namely, of motion, the first property of mobile being.

8 *In II Phys.,* lec. 5, n. 4.

We will use St. Thomas' *ex professo* treatment of the subject, the fourth lesson on the third book of *Physics.*

He introduces the subject as follows:

> After the Philosopher has defined motion, he here shows whose act motion is, namely, whether it belongs to the mobile or to the mover. It can be said that here he lays down another definition of motion, which is related to the foregoing as material to formal and as conclusion to principle. This is the definition: motion is the act of the mobile insofar as it is mobile: *motus est actus mobilis inquantum est mobile.*[6]

This definition of motion through its material cause, or proper subject, is the conclusion of a demonstration which, as we shall see, is *a posteriori.* In the three lessons preceding the one we are now considering St. Thomas, following Aristotle, has gone through the process of finding the formal definition of motion, which serves as the principle and middle term for demonstrating the further definition. Motion is, namely, the act of a being in potency as such: *actus existentis in potentia secundum quod huiusmodi.*[7] St. Thomas gives the demonstration in the following words:

> Motion is the act of what exists in potency as such; but what exists in potency as such is the mobile, not the mover, for the mover as such is a being in act. It follows that motion is the act of the mobile as such?

The reason for this demonstration centers about the major premiss: "what exists in potency as such is the mobile, not the mover." A doubt could arise about the

[6] "Postquam Philosophus definivit motum, hic ostendit cuius actus sit motus, utrum scilicet mobilis vel moventis. Et potest dici quod hic ponit aliam definitionem motus, quae se habet ad praemissam ut materialis ad formalem, et conclusio ad principium. Et haec est definitio: *motus est actus mobilis inquantum est mobile.*" *(Ibid.,* n. 1.)

[7] *Ibid.,* lect 2, n. 3.

[8] "Motus est actus existentis in potentia inquantum huiusmodi; existons autem in potentia inquantum huiusmodi, est mobile, non autem movens, quia movens inquantum huiusmodi est ens in actu; sequitur quod motus sit actus mobilis inquantum huiusmodi." *(Ibid.,* lect 4, n. 1.)

proper subject of motion, since we see that the mover itself passes from potency to act, and thus is moved. The doubt is solved by observing that the mover is itself moved insofar as it passes from potency to act; but precisely as mover, it is in act and communicates act to the thing being moved. Another consideration is the following:

> Every agent moves according to its form. Since every agent acts insofar as it is in act,... and since each thing is in act through a form, it follows that form is the moving principle. And so a thing moves insofar as it has a form through which it is in act. Hence, since motion is the act of a being in potency, it follows that motion does not belong to anything precisely as moving, but as mobile. Therefore, it is laid down in the definition of motion that it is the act of the mobile insofar as it is mobile: *inquantum est mobile.*[9]

We have in the above proof a demonstration *quia,* or certitude of *fact,* which proceeds *a posteriori,* since the middle term is the definition of the effect or property, and through this definition the proper subject is predicated of the property in the conclusion. At this stage we ought to construct a *propter quid* demonstration linking up motion with the definition of mobile being and thereby showing the proper reason why motion is a property of the mobile. "For it is manifest," says St. Thomas, "that the properties are caused by the principles *(ex principiis)* of the subject, which are matter and form."[10]

Actually, the demonstration given above can be under-

9 "Omne agens moveat secundum formam. Omne enim agens agit inquantum est actu,... unde, cum unumquodque sit actu per formam, sequitur quod forma sit principium movens. Et sic movere competit alicui inquantum habet formam, per quam est in actu. Unde, cum motus sit actus existentis in potentia, sequitur quod motus non sit alicuius inquantum est movens, sed inquantum est mobile: et ideo in definitione motus positum est quod est actus mobilis inquantum est mobile. *(In III Phys.,* lect. 4, n. 6.)

10 "Manifestum est enim quod propriae passiones causantur ex principiis subiecti, quae sunt materia et forma." *(In V Phys.,* lect. 3, n. 4.)

stood as *a priori* and *propter quid* by inverting the terms. The syllogism then reads:

A being in potency as such is the subject of motion.
But the mobile is a being in potency as such.
Therefore, the mobile is the subject of motion.

In the minor premiss when we speak of the mobile, we mean mobile being only potentially moved. If it were actually moved or moving another, it would have to have some form whereby it was moved or moving, for the substance of mobile being is not immediately operative, but must have some proximate principle of operation." Since the first principles of mobile being are established at the beginning of the science, mobile being, or a being in potency as such, means a being composed of prime matter and substantial form.

The major premiss is already evident from the hunt which Aristotle and St. Thomas had made for the definition of motion, for motion has thereby been defined as the act of a being in potency as such. But a deeper insight can be gained by taking each part of the definition of motion and showing that it flows from the first principles of mobile being, taken either together or separately.

Motion is an *act.* We find in the heart of mobile being a first principle of act, substantial form. This is the source of the substantial actuality of material beings, and thus also of all the actuality of the derived properties.

Motion is the act of a being *(existentis).* The proper subject of motion is something existing, that is, a substance. It must be a material substance, because the motion we are considering is sensory motion. Prime matter[11]

11 Cf. *Summa Theol.,* I, q. 77, a. 1, c. "Actio est compositi, sicut et esse; existentis enim est agere. Compositum autem per formam substantialem habet esse substantialiter; per virtutem autem quae consequitur formam substantialem, operatur. Unde sic se habet forma accidentalis activa ad formam substantialem agentis,... sicut *se* habet potentia animae ad animam." *(Ibid.,* ad 3.) "Dicendum quod hoc ipsum quod forma accidentalis est actionis principium, habet a forma substantiali. Et ideo forma substantialis est primum actionis principium, sed non proximum." *(Ibid.,* ad 4.)

and substantial form compose such a substance. It is to be noted that motion differs from *mutatio,* or substantial change, whose subject is a being only potentially existing, prime matter.[12]

The proper subject of motion is a being *in potency.* The mobile substance, composed of prime matter and substantial form, is in potency to all its properties, for accidents are distinct from substance and related to it as act to potency. The potency included in the definition of motion is a passive, not an active potency.[13] Hereby the subject of motion is distinguished from the subject of operations, which is an active potency, namely, some form in addition to prime matter and substantial form.[14]

Finally, motion is the act of a being in potency as such *(in quantum huiusmodi).* This particle designates the specific difference of motion. It does not seem necessary

12 "Quandoque ergo contingit quod utrique mutationis termino est unum commune subiectum actu existens; et tunc proprie est motus; sicut accidit in alteratione et augmento et diminutione et loci mutatione. Nam in omnibus his motibus subiectum unum et idem actu existens, de opposito in oppositum mutatur. Quandoque vero est idem commune subiectum utrique termino, non quidem ens actu, sed ens in potentia tantum, sicut accidit in generatione et corruptione simpliciter. Formae enim substantialis et privationis subiectum est materia prima, quae non est ens actu: unde nec generatio nec corruptio proprie dicuntur motus, sed mutationes quaedam." *(De Pot.,* q. 3, a. 2. Cf. *In V Phys.,* lect. 2, n. 8-11; lect. 3, n. 5.)

13 "Potentia igitur, secundum quod est principium motus in eo in quo est, non comprehenditur sub potentia activa, sed magis sub passiva." *(In V Metaph.,* lect. 14, n. 955.) "Potentia enim passiva est in patiente, quia patiens patitur propter aliquod principium in ipso existens, et huiusmodi est materia." *(In IX Metaph.,* lect 1, n. 1782.)

14 "Licet motus sit actus imperfecti, scilicet existentis in potentia ... actio est actus perfecti, idest existentis in actu." *(Summa Theol.,* I, q. 18, a. 3, ad 1.) "Si largo modo accipiamus motum pro qualibet operatione, sicut Philosophus accipit in III de Anima ubi dicitur, quod sentire et intelligere sunt motus quidam, non quidem motus qui est actus imperfecti, ut definitur III Phys., sed motus qui est actus perfecti, sic proprium videtur esse viventis, et in hoc ratio videtur consistere, quod aliquid sit movens se ipsum." *(De Pot.,* q. 10, a. 1.)

to correlate this particle with the definition of mobile being, for the purpose of this is to differentiate motion from the other properties of mobile being, such as extension, which would share in the characteristic of an act of a being in potency. However, even this particle points up the depths of potentiality in material being by reason of prime matter and thereby links up motion even more closely as the fundamental property of the mobile. Nothing else, not even sensation in animals, shows such deep roots in prime matter, for sensation proceeds from an active principle, and so follows more upon substantial form as the act of a being in first act.

Thus we have a *propter quid* demonstration of the first property of mobile being. Because motion is a property following so closely on prime matter, it is well to quote in clarification one of those valuable physical *obiter dicta* of St. Thomas from the *Summa Theologiae,* in which he shows in what sense motion is a property of material things.

> In the case of natural things, that which is natural, as a result of form only, is always in them actually, as heat is in fire. But that which is natural as a result of matter, is not always in them actually, but sometimes only in potentiality: because form is act, whereas matter is potentiality. Now movement is the act of that which is in potentiality. Wherefore that which belongs to, or results from movement, in regard to natural things, is not always in them. Thus fire does not always move upwards, but only when it is outside its own place.[15]

Let us consider another example, this time one from psychology.

All motions and operations are defined by their terminations. In the case of physical things, we speak of definition by the intrinsic final cause of motion.[15] As regards the

[15] *Summa Theol.,* I-II, q. 10, a. 1, ad 2.

[15] Cf. B. Ashley, O.P., "Research into the Intrinsic Final Causes of Physical Things," *Proceedings of the American Catholic Philosophical Association,* XXVI (1952), pp. 185-194.

potencies of the soul we say that they are specified by their acts and ultimately by their formal objects. Thus, by reference to its object, we find that man has a kind of knowledge that is independent of matter in varying degrees. Therefore, by *a posteriori* reasoning we can demonstrate:

A being that performs immaterial cognitive acts is a being that has a corresponding immaterial cognitive faculty or potency.
But man performs immaterial cognitive acts.
Therefore, man has an immaterial cognitive faculty.

Moreover, whatever has an immaterial cognitive faculty has a correspondingly immaterial substance in which the faculty is subjected.
But man has an immaterial cognitive faculty, his intellect.
Therefore, man has an immaterial substance which is the subject of his intellect. This obviously is not his body, therefore it is the other co-principle of his being, his soul.
The soul, then, is a spiritual substance.

These two demonstrations are *a posteriori.* They go from effect to proper and commensurate cause. Given the commensurate cause, intellect, as made known in the first demonstration, we can proceed deductively to demonstrate the property known from experience, i.e. immaterial cognition. This demonstration will be of the cause of the effect, but not of our knowledge of the existence of the effect, which is known by experience.[37] Likewise, because the cause was made known *a posteriori,* there will be no circle in demonstration.

Whatever being has an immaterial cognitive faculty can perform immaterial acts of knowledge.
But man has an immaterial cognitive faculty, or intellect.
Therefore, man can perform immaterial acts of knowledge.

37 Cf. Card. Zigliara, note t, IIIa in the Leonine edition of the Commentary on the *Post. Analyt.,* p. 239. See our summary of this point, Chap. I, p. 28.

The middle term is a formal cause. In passing, we should note that this demonstration can be accepted as strictly *propter quid* by the natural philosopher, even though actually the predicate is more extensive than the subject, for God and the angels have intellectual knowledge. But the natural philosopher as such knows nothing about the nature of God, only His existence and immateriality. And it remains for the theologian to consider the angels. The demonstration would be strictly applicable to man if it were in terms of rational operations and a rational cognitive faculty.

We have established the spirituality of the soul *a posteriori,* as the subject of the intellect. As we attain a deeper understanding of intellectual cognition, we find that its formal reason is immateriality and that consequently anything immaterial is by that very fact intellective. Therefore, we can set out the following demonstration:

Every spiritual substance is intellective.
But man's soul is a spiritual substance.
Therefore, man's soul is intellective.

This demonstration proceeds through formal cause. The major premiss is in the fourth mode of essential predication, because the spirituality of a substance is the cause of the attribute, for all properties emanate from the nature of their proper subject. The minor premiss contains a definition. However, as we pointed out above, this definition is not fully commensurate, as there are other spiritual substances besides man's soul. Of itself, this demonstration lacks the perfection of *propter quid* knowledge. It is rather the next best thing, a *demonstratio particularis.*

The proof for the freedom of the will gives us a good example of the demonstrative method. St. Thomas gives the proof in various places;[18] for our purpose we can take the treatment of the *Summa Theologiae.* In one sentence he shows how the existence of the fact is established by the universal experience of the human race. "Man has free

[18] *Swnma Theol.,* I, q. 83, a. 1; *De Malo,* q. 6, a. 1; *De Ver.* q. 24, a. 2.

choice, or otherwise counsels, exhortations, commands, prohibitions, rewards and punishments would be vain."[18] It was not necessary for St. Thomas to defend this common experience of freedom from philosophical prejudices, as we are forced to do. He proceeds immediately to establish the *propter quid* reason for man's freedom. He finds it in the indifference or indetermination of our judgment in the face of particular and contingent goods.

> In order to make this evident, we must observe that some things act without judgment, as a stone moves downwards; and in like manner all things which lack knowledge. And some act from judgment, but not a free judgment; as brute animals. For the sheep, seeing the wolf, judges it a thing to be shunned from a natural, and not a free judgment; because it judges, not from deliberation, but from natural instinct. And the same thing is to be said of any judgment in brute animals. But man acts from judgment, because by his apprehensive power he judges that something should be avoided or sought. But because this judgment, in the case of some particular act, is not from a natural instinct, but from some act of comparison in the reason, therefore he acts from free judgment and retains the power of being inclined to various things. For reason in contingent matters may follow opposite courses, as we see in dialectical syllogisms and rhetorical arguments. Now particular operations are contingent, and therefore in such matters the judgment of reason may follow opposite courses, and is not determinate to one. And in that man is rational, it is necessary that he have free choice.[20]

As usual, the demonstration contained in the above paragraph is not put into strict form. The medieval mind was so well trained in logic that it could see the syllogisms implicit in a discursive exposition. For us it is desirable that the demonstrations be given in form.

> An appetitive faculty that follows a judgment not determined by nature is a faculty that has free

[18] *Summa Theol.,* I, q. 83, a. 1.

dominion over the judgment whereby it is specified.
But the will is a faculty that follows a judgment not determined by nature.
Therefore, the will is free, that is, it has dominion over the practical judgment whereby it is specified.

The middle term in the major premiss is a definition of the will through a property and is a formal definition. This puts the premiss in the fourth mode of essential predication. The minor premiss is in the first mode of essential predication (i.e. definition), and the conclusion is in the second mode (i.e. property). The premisses are *per se* evident after an explanation of the terms. Therefore, we have fulfilled all the requirements of a strict, *propter quid* demonstration.

We may take a couple of examples from the science of acoustics. Two of the properties of musical tones are intensity and pitch. Both can be demonstrated *propter quid* as properties.

We know through experiment that sound is the vibration of air and that a tone, as distinguished from mere noise, is a regular vibration or wave. The intensity of sound is due to the energy of the sound. This is determined experimentally, hence, a *posteriori.* The intensity of sound diminishes when the distance from the source is increased and also when the density of the air diminishes. The intensity can also be measured by a sound-level meter. Hence it can be easily seen that intensity or loudness is a property of sound because the definition of sound is included in the definition of loudness. It will be well to formalize the demonstration.

The energy of sound produces intensity of sounds as is evident from experimentation.
But sound is the vibration of air, i.e. air in motion or energized.
Therefore, sound has the property of intensity.

The definition of sound, air waves, air in motion or ener-

gized, is through both material and formal causes, but the present demonstration flows from the formal cause.

The demonstration of pitch is similar to that of intensity. It can be shown *a posteriori* through experiment that the pitch of a note depends on the frequency of vibrations per second. If we hold a card against the teeth of a revolving gear, we find that the pitch of the sound produced rises as the revolution of the wheel is accelerated. This is also verified by using a siren disk, a metal disk with evenly spaced holes around the edge, and able to be rotated at varying speeds. When a current of air is directed through a tube against the row of holes, there is a regular succession of puffs, and a musical tone is produced. As the velocity of the wheel is increased, the tone becomes higher. The frequency of the tone can thus be measured by multiplying the number of holes by the number of revolutions of the wheel per second. Given this definition of pitch, determined *a posteriori,* we easily link it up with the nature of sound and get a *propter quid* demonstration. In form, it would read:

> Frequency of vibrations produces the phenomen of pitch, as determined *a posteriori* by experiment.
> But a musical tone is a regular vibration of air. Implicit in the idea of vibration is a number or frequency of vibrations.
> Therefore, a musical tone has the property of pitch.

One of Aristotle's own examples of his demonstrative theory is that of the non-twinkling of the planets. He gives it to illustrate the difference between knowledge of the fact *(quia)* and knowledge of the reasoned fact *(propter quid).* When a cause and effect are convertible, or commensurate, we usually find that the effect is more known to us because it is closer to sense. From this effect we can demonstrate the nature of the cause.[21] For instance:

> You might prove as follows that the planets are

[21] Cf. St. Thomas' comment, ***In I Post.,*** lect. 23, n. 4.

> near because they do not twinkle: let C be the planets, B not-twinkling, A proximity. Then B is predicable of C; for the planets do not twinkle. But A is also predicable of B, since that which does not twinkle is near—we must take this truth as having been reached by induction, or sense-perception. Therefore A is a necessary predicate of C; so that we have demonstrated that the planets are near.[22]

In form, the demonstration reads:

B, Any heavenly body that does not twinkle is A, near.
C, The planets are B, heavenly bodies that do not twinkle.
Therefore, the planets are near.

Regarding the major, it is taken as being evident by induction from sense perception that the near stars do not twinkle. Aristotle's reason for saying this was that our vision trembles at looking such a great distance, as it similarly trembles when looking at the sun, because of its great brilliance.[23] The minor premiss contains a descriptive definition of the minor term. It is to be noted that the middle term in the major premiss is not a cause of the major extreme, but rather an effect of it. Therefore, the demonstration is *a posteriori and quia.* "This syllogism, then, proves not the reasoned fact but only the fact; since they are not near because they do not twinkle, but, because they are near, do not twinkle."[24] The middle term is a cause *in cognoscendo,* not *in essendo.*

Since the cause and effect are convertible, we can change around the major and middle terms of the proof and get a demonstration *propter quid.*

22 *Post. Analyt.,* Bk. 1, Chap. 13, 78a 30-36.

23 "Our sight, when used at long range, becomes weak and unsteady. This is possibly the reason also why the fixed stars appear to twinkle but the planets do not. The planets are near, so that our vision reaches them with its powers unimpaired; but in reaching to the fixed stars it is extended too far, and the distance causes it to waver." (On *the Heavens,* Bk. 2, Chap. 8, 290a 18-23.)

24 *Post. Analyt., ibid.,* 36-38.

> Thus: let C be the planets, B proximity, A not twinkling. Then B is an attribute of C, and A—not twinkling—of B. Consequently A is predicable of C, and the syllogism proves the reasoned fact, since the middle term is the proximate cause.[25]

In syllogistic form we have:

> B, whatever heavenly body is near, is A, does not twinkle.
> C, The planets are B, heavenly bodies that are near.
> Therefore, the planets do not twinkle.

The major premiss is just reversed from that of the preceding demonstration; it is in the fourth mode of essential predication: B is the cause of A. What kind of cause is B in relation to A? It is a formal definition given in terms of the property of nearness. It does not make any difference that A is negative, since non-twinkling is equivalent to "steady light." In the minor premiss we have a descriptive definition of planets, through their property of nearness. The example, then, fulfills all the theoretical requirements of a demonstration.

Another interesting example is the demonstration that ice is water in a solid state.

> Take a second example: assuming that the definition of ice is solidified water, let C be water, solidified, B the middle, which is the cause, namely total failure of heat. Then B is attributed to C, and A, solidification, to B: ice forms when B is occurring, has formed when B has occurred, and will form when B shall occur.[26]

Let us put this demonstration into form, before we discuss it.

> A liquid that loses the heat required for its liquid state becomes solidified.
> But water is a liquid that loses the heat required for its liquid state.
> Therefore, water solidifies, or becomes ice.

The major premiss is immediately evident by induction, for

25 *Ibid.,* 78b 1-3.

26 *Ibid.,* Bk. 2, Chap. 12, 95a 17-21.

we know that at temperatures proportioned to their specific densities, fluids become solid. Aristotle's understanding of the cause of solidification was incorrect, because it was linked up with his concept of the elements.[27] But his demonstration as given above is valid when we understand the major according to our own scientific information. The middle term is a formal definition through a property. Hence, the major premiss is in the fourth mode of essential predication, the minor in the first mode, and the conclusion in the second. The demonstration is *propter quid,* but since water and liquid are not commensurately universal, the proof is a *demonstratio particularis.*

[27] Cf. *Meteorologies,* Bk. 4, Chap. 7-8, 383b 17—385b 6.

CHAPTER VI

DEMONSTRATION THROUGH EFFICIENT CAUSE

Demonstration through efficient cause is characteristic of natural science. The physicist is interested in efficient causes, because they enter into the process of natural generation.[1] But his use of them is somewhat circumscribed. The cause that, serves as middle term in demonstration must necessitate the effect. However, "not from every agent cause does the effect follow of necessity."[2] Therefore, we must investigate under what conditions we can demonstrate through this cause.

It will be well to consider first Aristotle's treatment of the question in the Second Book of the *Posterior Analytics,* where he is treating it *ex professo.* He mentions all four causes and concludes that "each of these can be the middle term of a proof."[3] Then he gives the following example:

> "Why did the Athenians become involved in the Persian war?" means "What cause originated the waging of war against the Athenians?" and the answer is, "Because they raided Sardis with the Eretrians," since this originated the war. Let A be the war, B unprovoked raiding, C the Athenians. Then B, unprovoked raiding, is true of C, the Athenians, and A is true of B, since men make war on the unjust aggressor. So A, having war waged upon them, is true of B, the initial aggressors. Hence here too the cause—in this case the efficient cause—is the middle term.[4]

This is not a perfect example from the aspect of scientific knowledge, because it deals with a particular instance,

1 Cf. *In II Phys.,* lect. 11, n. 5; *In De Trin.,* q. 6, a. 1.

2 "Non enim ex omni causa agente sequitur ex necessitate effectus." *(In II Post. Analyt.,* lect. 7, n. 2.)

3 *Post. Analyt.,* Bk. 2, Chap. 11, 94a 20-24.

4 *Ibid.,* 94a 36—b 8.

rather than with the universal, and because the necessary bond between cause (raid) and effect (war) is a moral necessity. The conclusion, however, is true and valid with a moral necessity.

A few lines later[5] Aristotle adds in his characteristic pithy style that in nature some things come about for an end and some by necessity. St. Thomas' remarks on this will bring out its significance.

> Many things of this kind, those namely that are of necessity and come about for an end, are found especially in things that subsist by nature and are constructed by nature. For nature does some things for an end, but others from the necessity of prior causes. This latter can be of two kinds: one according to nature, that is, according to the condition of matter; the other according to the moving cause: for instance, a rock is sometimes moved upward by necessity and sometimes downward, but not because of the same kind of necessity; it is moved downward because of the necessity of nature, but upward because of the necessity of the mover or projector.[6]

Since in natural science we wish to demonstrate natural motions and their causes, it is obvious that we will exclude proof through coercive efficient causality, or violence. It is to be noted, however, that in generation the action of the efficient cause, though natural as regards the form to be acquired, is coercive in respect to the form that is lost.

In the second Book of *Physics* the problem of demon-

[5] *Ibid.,* 94b 35—95a 3.

[6] "Plurima huiusmodi, quae scilicet sunt ex necessitate et fiunt propter finem, maxime inveniuntur in his quae subsistunt a natura, et in his quae sunt per naturam constructa. Natura enim quaedam facit propter finem, quaedam vero facit ex necessitate priorum causarum. Quae quidem est duplex: una secundum naturam, quae est secundum conditionem materiae; alia secundum causam moventem: sicut lapis movetur quidem ex necessitate quandoque sursum, quandoque deorsum, sed non propter idem genus necessitatis; sed deorsum movetur propter necessitatem naturae, sursum autem propter necessitatem moventis, idest proiicientis." *(In II Post. Analyt.,* lect. 9, n. 12.)

strating by efficient causality is taken up again, this time explicitly in reference to natural science. We are told there[7] that the efficient cause of generation is often specifically identical with the form and the end. St. Thomas asserts that

> This is true chiefly in univocal agents in which the agent makes something like himself in species, as man generates man. In these the form of the generator which is the principle of generation is the same in species as the form of what is generated which is the end of generation. But in non-univocal agents it is different because in these the things which come to be cannot extend so far that they follow the form of the generator according to the same reason of species, rather they participate in a similitude of it according as they can, as is plain in those which are generated by the sun. Therefore not every agent is the same in species as the form which is the end of generation, nor again is every end the form.[8]

When he comes to show how we actually demonstrate from the prior causes, matter and agent, Aristotle puts it concisely: "We must explain the 'why* in all the senses of the term, namely, (1) that from this that will necessarily result ('from this' either without qualification or in most cases) ; (2) that 'this must be so if that is to be so.'.. When placing the prior causes necessitates the effect, there can be a demonstration by means of them; for instance, the movement of the earth with respect to the sun necessarily determines the length of our daylight. However, effects do not always follow with necessity from efficient causes; in fact, most efficient causes produce their effects only for the most part or frequently.[10] This places a limitation upon the use of efficient causes as middle terms.

> It should be noted that when something follows necessarily from causes prior in generation, name-

[7] *Physics,* Bk. 2, Chap. 7, 198a 27.
[8] *In II Phys.,* lect. 11, n. 2.
[9] *Physics, ibid.,* 198b 5-8.
[10] Cf. *In II Phys.,* lect. 11, n. 7.

> ly from matter and the mover, the demonstration can be taken from these, as was said above; but not when something frequently follows. In the latter case the demonstration should be taken from that which is posterior in generation because something necessarily follows from this just as the conclusion follows from the propositions of the demonstration. Thus we should proceed in demonstration as follows: If this is to come to be, this and this are required; for example, if man is to be generated, it is necessary that there be human seed acting in generation. But, if we were to proceed conversely, from the proposition, *there is human seed acting in generation,* the proposition, *therefore man will be generated,* does not follow as the conclusion follows from the premisses.[11]

Demonstration, then, through final cause is more conatural to physical science; but there are cases where efficient causes can be used as middle terms. At the level of ultimate species, where formal definitions are hard to come by, demonstration takes place frequently through efficient cause.[12] For if we cannot know what a thing is, at least knowledge of its proper and proximate efficient cause gives us some insight into its nature. Things are what their causes make them to be. And efficient causes produce effects like to themselves: *omnes agens agit sibi simile.* Many of the examples that Aristotle gives to clarify the theory of the *Posterior Analytics* are demonstrations having efficient causes for middle terms.

A good example of the demonstrative method is that of the waxing of the moon.

> Another example is the inference that the moon is spherical from its manner of waxing. Thus: since that which so waxes is spherical, and since the moon so waxes, clearly the moon is spherical. Put in this form, the syllogism turns out to be proof of the fact.[13]

The middle term of this syllogism is an effect: "so wax-

Wbid., n. 8.

12 Cf. *In De Trin.,* q. 6, a. 1.

is *Post. Analyt.,* Bk. 1, Chap. 13, 78b 3-7.

es," and it concludes to the cause, "spherical." The basis of this argument is the observation that the moon waxes and wanes in a crescent shape. Only a spherical body could present this phenomenon, by reason of the sun's light striking only a part of it.[14] This is, therefore, a demonstration *quia,* proceeding *a posteriori.* Once the cause is discovered, we can demonstrate the attribute *propter quid.* As Aristotle says:

> Put in this form, the syllogism turns out to be proof of the fact, but if the middle and major be reversed it is proof of the reasoned fact; since the moon is not spherical because it waxes in a certain manner, but waxes in such a manner because it is spherical. (Let C be the moon, B spherical, and A waxing.)[15]

We must construct a syllogism in which B will be the middle term.

> B, A body of spherical shape is A, a body that waxes in such a manner.
> C, the moon is B, a body of spherical shape.
> Therefore, the moon so waxes.

In the major premiss A is a proper effect of B. The proposition is in the fourth mode of essential predication (i.e. contains a cause). B, the spherical shape, is the efficient cause of the manner of waxing and waning in crescent shape, a kind of instrument for so reflecting the sun light as to produce the phenomenon we observe. As efficient cause it acts in accord with its form, and so the effect is specifically identical with the cause in that aspect whereby it is cause; thus we could also consider this middle term a formal cause. From another point of view we may consider the spherical shape as a material cause receptive, according to its own dispositions, of the sun's light. In the minor premiss the moon is defined by a formal cause, its spherical shape, and hence the^premissjsjnJhejfirstjmode of essential predication. The conclusion of the demonstra-

[14] Aristotle's *ex professo* treatment of this is in *On the Heavens,* Bk. 2, Chap. 10, 291b 19-24. St. Thomas' Commentary, lect. 16, n. 6-7.
[15] Post. *Analyt., ibid.*

tion enables us to understand the moon's characteristic way of waxing and waning in view of its spherical shape, the cause of the phenomenon.

The eclipse of the moon is one of Aristotle's favorite examples. He returns to it repeatedly in the *Posterior Analytics,* as exemplifying the various stages of the demonstrative process. If we put these texts together, we will have a quite complete demonstration, from start to finish.

We may wonder if strict demonstrative proof is possible of such an occasional thing as an eclipse. Aristotle reassures us that, although "no attribute can be demonstrated nor known by strictly scientific knowledge to inhere in perishable things," nevertheless, "demonstration and science of merely frequent occurrences—e.g. of eclipse as happening to the moon—are, as such, clearly eternal."[10] The meaning is made clear by St. Thomas in his commentary.[11] The moon is not always in eclipse, but sometimes. Now something that happens frequently or regularly can be demonstrated from the aspect of the frequency or regularity, because there has to be an enduring cause of the regularity, to which the attribute in question has a constant relation.

A demonstration, therefore, could not be given of an isolated particular occurrence. Demonstration must deal with universal aspects and commensurately universal causes. Even if a cause should be clearly evident to sense perception, we do not thereby have scientific knowledge of the effect.

> So if we were on the moon, and saw the earth shutting out the sun's light, we should not know the cause of the eclipse; we should perceive the present fact of the eclipse, but not the reasoned fact at all, since the act of perception is not of the commensurate universal.[18]

We would not know the cause of the eclipse *as* proper and

[10] *Ibid.,* Bk. 1, Chap. 8, 75b 24, 33-36.
[11] Leet. 16, n. 8. Cf. Chap. III *supra,* note 39.
Post. Anaiyt., Bk. 1, Chap. 31, 87b 39—88a 2.

commensurate cause; as far as sense perception goes, the interposition of the earth between the sun and moon might well be an accident or freak of nature, rather than a universal and necessary cause. Aristotle continues:

> I do not, of course, deny that by watching the frequent recurrence of this event we might, after tracking the commensurate universal, possess a demonstration, for the commensurate universal is elicited from the several groups of singulars.[18]

The essential cause of eclipse must be universally the cause of eclipse. Therefore, it cannot be known by a single act of sense perception, but must be abstracted by the mind from many sense perceptions.

The first stage in the demonstrative process in natural science is to establish the existence of facts. These facts are usually learned from sensory experience, but there is no reason why facts should not be supplied by another science, such as by the mathematical sciences. Aristotle describes the beginning of the process, shifting us, however, from the eclipse of the moon to that of the sun.

> When our question concerns a complex of thing and attribute and we ask whether the thing is thus or otherwise qualified—whether, e.g., the sun suffers eclipse or not—then we are asking as to the fact of a connexion. That our inquiry ceases with the discovery that the sun does suffer eclipse is an indication of this; and if we know from the start that the sun suffers eclipse, we do not inquire whether it does so or not. On the other hand, when we know the fact we ask the reason; as, for example, when we know that the sun is being eclipsed[19]

[19] *Ibid.,* a. 3-4. St. Thomas says about this: "Ponamus ergo quod aliquis esset in. ipsa luna, et sensu perciperet interpositionem terrae per umbram ipsius: sensu quidem perciperet quod luna tunc deficeret ex umbra terrae, sed non propter hoc sciret totaliter causam eclipsis. Ulud enim est per se causa eclipsis, quod causât universaliter eclipsim. Universale autem non cognoscitur sensu; sed ex pluribus singularibus visis, in quibus multoties consideratis invenitur idem accidere, accipimus universalem cognitionem. Et sic per causam universalem demonstramus aliquid in universali, de quo est scientia." (In *I Post. Analyt.,* lect. 42, n. 7.)

> and that an earthquake is in progress, it is the reason of eclipse or earthquake into which we inquire.[20]

Sometimes the existence of the fact has to be proved. Thus, we can give an *a posteriori* demonstration that the moon suffers eclipse.

> Let C be the moon, A eclipse, B the fact that the moon fails to produce shadows though she is full and though no visible body intervenes between us and her. Then if B, failure to produce shadows in spite of the absence of an intervening body, is attributable to C, and A, eclipse, is attributable to B, it is clear that the moon is eclipsed, but the reason why is not yet clear, and we know that eclipse exists, but we do not know what its essential nature is.[21]

Put in syllogistic form, the argument reads:

> B,That which fails to produce shadows is A, eclipsed.
> But C, the moon, is B, that which fails to produce shadows.
> Therefore, C, the moon, is A, eclipsed.

The middle term, B, is an effect, rather than a cause of eclipse, so the syllogism is *a posteriori.* But it gives us a fact whose cause we search for in order to demonstrate the fact.

To ask the reason or cause of a thing is equivalent to asking about the middle term, for the middle term is the cause according to its position and function in the demonstrative syllogism.

> In all our inquiries we are asking either whether there is a 'middle' or what the 'middle' is: for the 'middle' here is precisely the cause, and it is the cause that we seek in all our inquiries. Thus, 'Does the moon suffer eclipse?' means 'Is there or is there not a cause producing eclipse of the moon?', and when we have learnt that there is, our next question is, 'What, then, is this cause?'[22]

«° *Post. Analyt.,* Bk. 2, Chap. 1, 89b 26-31.
nlbid., Chap. 8, 93a 37—b 3.
Ibid., Chap. 2, 90a 5-9.

In order to find the cause which is to be our middle term, we have to define the attribute in question, for the definition of the attribute will point out its cause, which will be one with the subject of the attribute.

> The middle term is the cause of the unqualified substance (as distinguished from this or that attribute of it) and of an essential attribute or accident (as distinguished from the substance). I call the unqualified substance the subject, such as moon, earth, sun or triangle. By the latter (i.e. the attributes) I mean eclipse, equality, inequality, interposition or non-interposition. In all these it is clear that the *quid est* is the same as the *propter quid.*[13]

In other words, once we learn that a subject has a certain attribute (e.g. the moon suffers eclipse) we know that there is a cause of this fact. To ask what is the cause is equivalent to asking why the attribute belongs to the subject. To find the answer to both these questions, we seek a definition of the attribute. This definition will manifest the cause; but since the subject is in some way the cause of its essential attributes, the causal definition of the attribute will be at least a descriptive definition of the subject. Thus:

> The quesion 'What is eclipse?' and its answer, 'The privation of the moon's light by the interposition of the earth' are identical with the question, 'What is the reason of the eclipse?' or 'Why does the moon suffer eclipse?' and the reply, 'Because of the failure of light through the earth's shutting it out.'[24]

23 Ibid., 90a 9-15. Because of the difficulties of the Oxford translation of this cumbersome passage, the above is our own translation. We include here the Greek text.

Το <γάρ *αίτιον* τοΰ *είναι μη* τοδι τοδι ἀλλ* *απλώ την ουσίαν,* ή τό *μη απλώ αΚλά τι των καθ' αυτό ή κατά συμβεβηκό , το μέσον εστίν. Χεηω* Sὲ *το μέν απλώ το υποκείμενον, οίον σελήνην ή γην ή ήλιον ή τρίγωνον, το* δ« τὶ *εκλειφ·ιν, Ισότητα, ανισότητα, εἴ εν μέσω ή μη.* Ἐκ *απασι γάρ ταύτοι φανερόν εστιν οτι το αυτό εστι το τί εστι κα\ Ζιά τίεστιν.*

24 Ibid., 15-19.

In a later chapter Aristotle sets forth the demonstration:

> When it is clear that A (eclipse) is attributable to C (moon) and we proceed to ask the reason of this fact, we are inquiring what is the nature of B (the cause): is it the earth's acting as a screen, or the moon's rotation or her extinction? But B is the definition of the other term, viz., in these examples, of the major term A; for eclipse is constituted by the earth acting as a screen.[25][26]

The essence of the cause, B, is made known, then, when we find the definition of the major extreme, A. Put in syllogistic form, the demonstration reads:

> B, A heavenly body whose light is screened off by the earth is a body in eclipse.
> But C, the moon, is B, a heavenly body that has its light screened off by the earth.
> Therefore, the moon suffers eclipse.

In the major premiss B is the efficient cause of A.[2e] In the minor premiss the moon is defined in terms of the property of suffering loss of its light when the earth comes between it and the sun.

Aristotle gives an easy example of the demonstrative process in the case of thunder. The first prerequisite for a demonstration is to establish the existence of some fact. "We are aware whether a thing exists or not sometimes through apprehending an element in its character, and sometimes accidentally, as for example, when we are aware of thunder as a noise in the clouds."[22] We have, therefore,

[25] *Ibid.,* Chap. 8, 93b 3-8.

[26] "What is the cause of eclipse? What is its matter? There is none; the *moon is* that which suffers eclipse. What is the moving cause which extinguished the light? The earth. The final cause perhaps does not exist. The formal principle is the definitory formula, but this is obscure if it does not include the cause. E.g., what is eclipse? Deprivation of light. But if we add 'by the earth's coming in between,' this is the formula which includes the cause." *(Metaphysics,* Bk. 8, Chap. 4, 1044b 10-15.)

[21] *Post. Analyt.,* Bk. 2, Chap. 8, 93a 21-23. St. Thomas comments: "Oportet autem quod qui cognoscit aliquam rem esse, per aliquid rei illud cognoscat: et hoc vel est aliquid praeter essentiam rei, vel aliquid de essentia ipsius. Et de hoc ponit exemplum, puta si cognos-

a certain knowledge of the existence of thunder when we apprehend something of its essence, namely, a noise in the clouds.

We know the fact, now, that there is such a phenomenon as thunder. But our knowledge is not perfect until we have demonstrated the fact, that is, until we have found the reason of the fact. The reason for the fact will be the essential nature of thunder, its definition.

> Thus, (1) 'What is thunder?' 'The quenching of fire in cloud,' and (2) 'Why does it thunder?' 'Because fire is quenched in the clouds,' are equivalent. Let C be cloud, A thunder, B the quenching of fire. Then B is attributable to C, cloud, since fire is quenched in it; and A, noise, is attributable to B ; and B is assuredly the definition of the major term A. If there be a further mediating cause of B, it will be one of the remaining partial definitions of A.[28]

Let us put this argument into syllogistic form:

> Every extinction of fire produces a sound.
> But in the clouds there is extinction of fire.
> Therefore, in the clouds there is the sound that we call thunder.[29]

The major premiss is immediately evident from experience. The middle term, extinction of fire, is efficient cause of the production of sound, hence the premiss is in the fourth mode of essential predication. The act of extinguishing is an efficient cause, specified by its term or object, fire. In the minor premiss the extinction of fire is given as a property of clouds, and hence it is a descriptive defini-

camus tonitruum esse, propter hoc quia percipimus quemdam sonum in nubibus: quod quidem pertinet ad essentiam tonitrui; non tamen est tota tonitrui essentia, quia non omnis sonus nubium est tonitruum." *(In II Post. Analyt.,* lect. 7, n. 6.)

28 *Post. Analyt., ibid.,* 93b 7-14.

29 The syllogism is set out for us by St. Thomas: "In C est B, idest in nube est extinctio ignis; sed omnis extinctio ignis est sonus; ergo in nube est sonus tonitrui. Et sic patet quod accipiendo propter quid, per demonstrationem accipimus quid est, quia ipsum medium ostendens propter quid, est ratio definitiva primi termini, idest maioris extremitatis." *(Ibid.,* n. 8.)

tion. It is well to note here that this theory of thunder is not Aristotle's own, but that of Empedocles and Anaxagoras. Aristotle himself held that thunder is the sound of the impact resulting when a dry exhalation from the earth (wind) is projected into a moist exhalation (cloud).[30] St Thomas remarks: "He often uses the opinions of others in his examples."[31] This gives us a good precedent for using Aristotle's examples in studying his demonstrative theory, even though at our present stage of physical knowledge we know that many of them are incorrect.

We have, therefore, demonstrated that there is thunder in the clouds. As a result of this demonstration we have a richer definition of thunder, namely, the noise of fire being quenched in the clouds. Such a definition is called a "qwasi-demonstration of essential nature, differing from demonstration in the arrangement of its terms."[32] This is the richer and more perfect sort of definition that is acquired at the end of a science, as compared with the imperfect definition that is a principle of demonstration.

It is not at all difficult to adapt this demonstration of thunder to what we know now of this phenomenon.

> Every violent disturbance of the air produces noise.
> But lightning causes a violent disturbance of the air by the discharge of static electricity.
> Therefore, lightning produces the noise that we call thunder.

A more difficult case of demonstration is given in the example of the falling of leaves. It is proposed as follows:

> "Every broad-leaved plant is deciduous;
> Every vine possesses broad leaves;
> Every vine is deciduous."[33]

The conclusion is in the second mode of essential predication (property), and the minor premiss in the first mode,

[30] Cf. Meteor., Bk. 2, Chap. 9, 369a 10—370a 32.

[31] "Utitur autem multoties in exemplis opinionibus aliorum." *(Ibid.)*

[32] *Post. Analyt.,* Bk. 2, Chap. 10, 94a 2-3; cf. *ibid.,* 1-13. St Thomas, lect 8, nn. 8-9.

[33] *Ibid.,* Bk. 2, Chap. 16, 98b 5-10.

since its predicate is a descriptive definition. In order that we may have a true demonstration, the major premiss must be in the fourth mode of essential predication, in which the middle term is shown to be the cause of the attribute. Whether it is so or not in this case depends on the proof which we give of the major; for since it is not immediately evident, it must itself be demonstrated.

As Aristotle says, "Deciduous is a universal attribute of vine, and is at the same time of wider extent than vine; and of fig, and is of wider extent than fig: but it is not wider than but coextensive with the totality of the species."[34] The question is: how are we to define the species, or proper subject, to which deciduous belongs *per se primo?* We approach our solution by noting a common characteristic of all plants that are deciduous; we find that they all have broad leaves. Therefore, we give a descriptive definition of the commensurate subject of deciduous, in terms of the other characteristic of having broad leaves. This common subject, thus vaguely defined, is the proximate genus, of which all the types of deciduous plants are species.

We do not as yet have a cause as middle term and as the subject of the major extreme. But in proving the major premiss we can hope to find a cause. It will be a definition mediating between broad-leaved plant and deciduous. As broad-leaved plant is a descriptive definition, we must look to the definition of deciduous to discover a cause. It is to be noted that the full definition of a property must include its proper subject, for a property can neither be nor be understood without its subject. Aristotle defines deciduous in terms of efficient causality: "It is the coagu-

3**Ibid.,* Chap. 17, 99a 23-25. Aristotle continues: "Then if you take the middle which is proximate, it is a definition of deciduous. *I* say that, because you will first reach a middle, next the subject, and a premiss asserting it of the whole subject, and after that a middle—the coagulation of sap or something of the sort—proving the connexion of the first middle with the major: but it is the coagulation of sap at the junction of leaf-stalk and stem which defines deciduous." (find., 25-30.)

lation of sap at the junction of leaf-stalk and stem -which defines deciduous."[35] Thus we have found our cause, and our demonstration is thereby achieved.

We can now put the syllogism into form:

Every broad-leaved plant is deciduous.
But, every vine possesses broad leaves.
Therefore, every vine is deciduous.

The minor is a descriptive definition arrived at through sensory experience. The major must be proved.

Every plant that exhibits coagulation of sap at the junction of leaf-stalk and stem is deciduous.
But, every broad-leaved plant exhibits coagulation of sap, etc.
Therefore, every broad-leaved plant is deciduous.

The middle term in the major premiss is the efficient cause of the attribute and is therefore in the fourth mode of essential predication. The minor premiss shows the middle term as a further descriptive definition of broad-leaved plant.

Since the first middle term—coagulation—is the proper cause of the attribute, we have a strict demonstration. It proceeds through efficient causality: a proper activity of the broad-leaved plant, i.e. coagulation of sap, causes its leaves to dry up and fall. When the demonstration is brought down to the level of the particular subject, vine, it is of the type called particular demonstration, where the predicate is not commensurate with the subject.

35 Cf. note 34. St. Thomas' comment is: "Hoc enim quod est folio fluere, consequitur ad vitem et excedit ipsam, quia est in pluribus; consequitur etiam ad ficum et excedit eam: non tamen est excessivum omnium quibus convenit, sed est eorum sicut aequalium. Si ergo aliquis velit accipere id quod est primum medium respectu omnium, erit haec definitio eius quod est folio fluere; quae quidem definitio erit primum medium ad alia, eo quod omnia talia-sunt. Et iterum huius accipietur aliquod aliud medium, puta quod succus densatur per desiccationem, vel aliquod aliud huiusmodi. Unde si quaeratur quid est folio fluere, dicemus quod nihil aliud est quam *condensari succum seminis in contactu,* scilicet folii ad ramum." *{In II Post. Analyt.,* lect. 19, n. 4.)

A chapter of the *Posterior Analytics*[26] shows how one generic middle term may prove attributes of different specific subjects and how, on the other hand, several middle terms may be subordinate one to the other.

As instances of the former, Aristotle says:

> This class may be exemplified by the questions as to the causes respectively of echo, of reflection, and of the rainbow: the connexions to be proved which these questions embody are identical generically, because all three are forms of repercussion; but specifically they are different.[37]

Before we consider this demonstration, it will be helpful to examine its premisses and to learn what Aristotle thought of the phenomena in question. He conceived of echo and reflection of light not as waves moving through the medium, but as the medium moving and rebounding "like a ball from a wall."[38]

Regarding the rainbow, he has a lengthy account of it running through the third book of the *Meteorologica.* A few remarks on Aristotle's procedure there will be of value. He prefaces the second chapter with: "Let us now explain the nature and cause of halo, rainbow, mock suns, and rods, since the same account applies to them all. We must first describe the phenomena and the circumstances in which each of them occurs."[39] When he has given the data of observation, which, we again insist, is the prerequisite and beginning of the demonstrative process, he continues:

> These are the facts about each of these phenomena: the cause of them all is the same, for they are all reflections. But they are different varieties, and are distinguished by the surface from which and the way in which the reflection to the sun or some other bright object takes place.·*[9]

Causal explanation, or demonstration proper, follows upon observation of facts.

[26] *Post. Analyt.,* Bk. 2, Chap. 15, 98a 23-34.
[37] *Ibid.,* 27-29.
[38] *On the Soul,* Bk. 2, Chap. 8, 419b 28; cf. 25-33.
[39] *Meteorologica,,* Bk. 3, Chap. 2, 371b 19-21.
[40] *Ibid.,* 372a 18-21.

"We have already stated," he says in Chapter Four, "that the rainbow is a reflection: we have now to explain what sort of reflection it is, to describe its various concomitants, and to assign their cause."[41] The investigation, accordingly, has reached the stage of determining the specific cause of rainbow and of demonstrating its properties. By *a posteriori* reasoning he establishes that "the rainbow is a reflection of sight to the sun" by some substance in the sky.[42]

Now that he has a definition of rainbow,[43] he can go on to demonstrate its properties. It always appears opposite the sun.[44] Its colors are red, green and purple: "The colors of the rainbow are those we described, and how the other colors come to appear in it will be clear from the following considerations... ."[45] In other words, he is now assigning the cause, or demonstrating the facts that previously he had observed: not only *that* there are such colors, but *why* it should be so. "The same cause," he goes on, "explains the double rainbow and the faintness of the colors in the outer one and their inverted order."[44] Next, by a

41 Z5«Z., Chap. 4, 373a 33-34.

K Ibid., Chap. 4, 373b 33. "Alexander observes that the language in which Aristotle speaks of vision in this book is not that of his theory in the *De Anima."* (Note 4, 372a 29 of the Oxford translator of the *Meteorologica.)*

43 For Aristotle the definition would be in terms of efficient cause. The vapor, or other substance, acting in accord with its particular nature, would be the agent cause of the phenomenon. *We* would define a rainbow as a multicolored arc in the heavens (formal cause) formed by the sun (efficient cause) whose rays are received into moisture (material cause) in a diffracted condition (formal *cause).*

"■Ibid., Chap. 4, 373b 34ff.

43 Ibid., 374b 7-10. Aristotle's reasons for the different colors are of no concern to us. A sample of the following: "The rainbow is distinguished by the variety of its colours. The reflection in the one case is from water which is dark and from a distance; in the other from air which is nearer and lighter in colour. While light through a dark medium or on a dark surface (it makes no difference) looks red...." (373b 34—374a 4.)

44 Ibid., 375a 30-35.

mathematical demonstration he shows why the rainbow can never be a circle nor a segment of a circle greater than a semicircle.[47] He completes his investigation by other mathematical deductions relative to the time of day when there can be a rainbow at the different seasons of the year.

Although much of Aristotle's treatment of the rainbow is outmoded, yet his method and procedure are noteworthy as being able to provide us a means of systematizing and understanding the immense body of factual knowledge we have accumulated during the last few centuries.

Let us note that Aristotle has started, in accord with his method, from the generic consideration, common to the echo, reflection and luminous phenomena connected with sunlight. Then he differentiated the latter by division to halo, rainbow, mock suns, and rods. We followed him in brief outline as he broke down rainbow to its nature and attributes, even borrowing mathematical reasoning to complete the picture.

Returning now to the demonstration at the begining of this section, we can summarize it by a schema of subjects and predicates, together with the generic middle term that proves them all.[45]

Repercussion—echoes	Repercussion—reflection	Repercussion—rainbow
Sound—repercussion	Light—repercussion	Sun-light—repercussion
Sound—echoes	Light—reflection	Sun-light—rainbow.

In each instance the middle term is an efficient cause in the major premiss. The middle term may seem to be not commensurate with the attributes. But this is a case of a remote cause being convertible with its effect because the specification of the cause to its different subjects comes

[47] *Ibid.,* Chap. 5, 375b 16 ff.

[48] For the generic middle term, translated "repercussion" in the *Posterior Analytics* (cf. *supra,* p. 133), Aristotle uses the word *ἀντιπερίστασις*. The attribute "reflection" attributed to light in the second example is *διὰ τί ἴμφαίνεται,* translated in the Latin text as "propter quid apparet," to which St Thomas adds "in speculo." *(In II Post. Ancdyt.,* lect 17, n. 5.) When he speaks of the cause of the rainbow in the *Meteorologica,* Aristotle uses the term *ανάκλασις* which is translated "reflection."

about through a material condition, and not strictly through a specific difference: the effect is formally attributable to the generic aspect (repercussion)?[49] In the minor premiss the middle term defines sound, light and sun rays as that which undergoes repercussion; it is a descriptive definition.

Besides having a generic middle term for several demonstrations, as in the examples we have just discussed, we can have instances where the middle term of one demonstration is subordinate to the middle term of a preceding. Aristotle gives this example:

> Why does the Nile rise towards the end of the month? Because towards its close the month is more stormy. Why is the month more stormy towards its close? Because the moon is waning.[50]

If we put this demonstration in form, it will read:

The waning of the moon causes the end of the lunar month.
But stormy weather follows upon the waning of the moon.
Therefore, stormy weather comes toward the end of the month.
But the rising of rivers follows upon stormy weather.
Therefore, the rising of rivers occurs toward the end of the month.

Rivers have the property of rising toward the end of the month.
But the Nile is a river.
Therefore, the Nile rises toward the end of the month.

In the first major premiss we show the waning of the moon as the efficient cause of the end of the month, because the lunar month is determined by the motion of the moon. In the first minor the stormy weather is defined in terms of its efficient cause. The reason why stormy weather follows upon the waning of the moon, according to St. Thom-

[49] Cf. Zigliara, note T, p. 239 of the Leonine ed. of the Commentary on *Post Analyt.* Cf. *supra,* Chap. 1, note 67.
[50] *Post. Analyt.,* Bk. 2, Chap. 15, 98a 31-34.

as,[51] is that the moon has dominion over the vapors of the air, and when it is on the wane, they are more agitated, so as to cause storms. The conclusion of the first syllogism becomes the major of the second; and the subject of the first, the middle term of the second. Consequently, the proposition: "Stormy weather comes toward the end of the month" is in the second mode of essential predication (property) when considered as the conclusion of the first syllogism, and in the fourth mode (cause), when considered as the major of the second syllogism; it is not immediately in the fourth mode, because it does not immediately exhibit the cause, but only by means of the demonstration of which it is the conclusion. The second minor gives us a definition of the rising of the rivers by reason of its efficient cause, stormy weather. Therefore, the conclusion: that the rising of rivers occurs toward the end of the month.

It remains merely to bring the demonstration down to the particular instance of the Nile river. Since we have connected the rising of rivers and the end of the month, and since the rising of rivers is itself a property of rivers (which the property contains in its own definition as proper subject), we need only predicate the property "rising towards the end of the month" with the universal notion of river. Therefore, since the Nile too is a river, the Nile then rises toward the end of the month. Note, however, that in the last syllogism the premiss "Rivers have the property of rising toward the end of the month" does not immediately exhibit the cause, but we have it from the preceding demonstration: rivers are bodies of water affected by the stormy weather at the end of the month. However, since in the conclusion Nile and rising at the end of the month are not commensurate, but are proved through the proper subject of the attribute as middle term, this is not the perfect type of *propter quid* demonstration, but rather a particular demonstration. It is of great value, however, in showing that the attribute belongs to Nile, not

[51] *In II Post. Analyt.,* lect. 17, n. 6.

by reason of anything proper to itself, but by reason of its being a river.

We have in the above example two subordinate middle terms, the waning of the moon and stormy weather. Although the whole example is not true, because of the faulty data of the first minor premiss, yet it gives us a good idea of the kind of science Aristotle envisioned as attainable by the demonstrative method.

CHAPTER VII

DEMONSTRATION THROUGH MATERIAL CAUSE

Intrinsic causes have absolute necessity.[1] But this absolute necessity is in the order of essence. From this aspect the material cause has scientific value and can be the middle term of a demonstration.

It will be helpful first to determine just what we mean by material cause, for the term is broader than we may suspect at first sight. Aristotle, speaking of material cause, says: "That out of which a thing comes to be and which persists, is called 'cause,' e.g. the bronze of the statue, the silver of the bowl, and the genera of which the bronze and the silver are species," i.e. metal.[2] Later on in the same chapter he adds:

> The letters are the causes of the syllables, the material of artificial products, fire, etc., of bodies, the parts of the whole, and the premisses of the conclusion, in the sense of 'that from which.' Of these pairs the one set are causes in the sense of substratum, e.g. the parts, the other set in the sense of essence—the whole and the combination and the form.[3]

With the help of St. Thomas' Commentary we must clarify and amplify the statements of the Stagirite. Aristotle does not mention prime matter when speaking of material cause in science. Prime matter must be properly disposed in order to receive a form. This comes about—keeping

*"Alia autem est causa, qua posita necesse est causatum poni; et haec est causa materialis, quia ea quae sequuntur ex necessitate materiae sunt necessaria absolute." *(In II Post. Analyt.,* lect. 9, n. 2.)

3 *Physics,* Bk. 2, Chap. 3, 194b 23-25.

3 *Ibid.,* 195a 15-21. Cf. St. Thomas' Commentary, lect. 5, n. 3. In another place Aristotle says: "The material of animals is their parts—of the whole animal the non-homogeneous parts, of these again the homogeneous, and of these last the so-called elements of all matter." *(Generation of Animals,* Bk. 1, Chap. 1, 715a 8-11.)

in the same genus of cause—through the combination of the elements and parts. To know the elements and parts of anything is to know its material cause. Aristotle's examples are of artificial things. He makes it clear that in treating natural bodies, with which natural science is concerned, we look for the natural elements.

The parts are in the order of material cause with respect to the nature and definition. The parts of the definition are formal with respect to the subsisting individual whole,[4] but they are material in relation to the essential whole. All the integral parts, such as the eyes and the limbs, are material causes of the whole. As St. Thomas comments:

> He says that the parts are the material cause of the whole while above he reduced the parts of the definition to the formal cause. However, we can say that he was speaking of the parts of the species which fall in the definition of the whole, while here he is speaking of the parts of matter in whose definition the whole falls, just as the circle falls in the definition of the semicircle. But it would be better to say that although the parts of the species which are posited in the definition are compared to the suppositum of the nature in the manner of a formal cause, still they are compared to the nature itself of which they are parts, as matter because all parts are compared to the whole as the imperfect to the perfect which is a comparison of matter to form.[5]

In another sense, the subject of an attribute is related to it as material cause, for substance is a material cause in respect of the accidents that inhere in it. Therefore, if the precise aspect of the middle term upon which we concentrate in any demonstration is its causality as proper subject, then we would be demonstrating through a mate-

4 "Natura igitur species constituta ex forma et materia communi, se habet ut formalis respectu individui quod participat talem naturam; et pro tanto hic dicitur quod partes quae ponuntur in definitione, pertinent ad causam formalem." *(In II Phys.,* lect. 5, n. 4.)

5 *In II Phys.,* lect. 5, n. 9.

rial cause. The middle term always implicitly has this function of subject, but most of the time we are more interested in its definition through other causes?

Regarding the limitations on material cause as the middle term in a demonstration, we must quote St. Thomas' expression verbatim:

> He says first that an antecedent which necessitates a consequent, namely, a material cause, cannot be taken in such a way that of necessity something follows from it if there is only one proposition. There must be at least two propositions so constructed that they communicate in one middle term. If therefore, there is one middle (a material cause) in two propositions, the conclusion will necessarily follow. For instance, if we say: Whatever is composed of contraries is corruptible; a rock is such; therefore, etc. There must be two propositions, not only because the syllogistic form demands them, but also because not all that is from matter has necessity from matter, as is proved in the Second Book of *Physics.* Therefore, besides the proposition in which something is said to have such a matter, there must be another proposition, which declares that from such matter something necessarily follows.[7]

e In the *Summa Theologiae* (I-II, q. 55, a. 4) St. Thomas distinguishes *materia ex qua,* namely, the intrinsic constituent matter; *materia in qua,* the subject; and *materia circa quam,* which corresponds to the proper object, for instance, of a virtue or of a science.

7 "Dicit ergo primo quod illud, quo existente necesse est aliud esse, scilicet causa materialis, non contingit accipi sic, ut ex necessitate aliquid sequatur, si accipiatur una sola propositio; sed oportet accipere ad minus duas hoc modo se habentes, quod communicent in uno medio. Si ergo accipiatur in duabus propositionibus unum medium, quod est causa materialis, ex necessitate sequitur conclusio: puta si dicamus: *omne compositum ex contrariis est corruptibile: lapis est huiusmodi; ergo* etc. Oportet autem accipere duas propositiones, non solum propter exigentiam formae syllogisticae, sed etiam quia non omnia quae sunt ex materia, habent exmateria necessitatem, ut probatur in *II Physic.* Et ideo praeter propositionem in qua sumitur hoc habere talem materiam, oportet quod sumatur alia propositio, quae declaret quod ex tali materia aliquid ex necessitate sequatur." (In *II Post. Analyt.,* lect. 9, n. 4.)

When Aristotle is treating *ex professo* the manner of demonstrating by the various causes,[8] he gives, as an example of demonstration through material cause, an argument from mathematics. We have so far avoided the mathematical examples, because our interest is in physical demonstrations. But this one is too important and enlightening to pass over. St. Thomas' introductory comment must be given in full:

> He then proposes a mathematical example. Nor is this contrary to what he said in the third book of *Metaphysics,* namely, that the mathematical sciences do not demonstrate through material cause. Mathematics, indeed, abstracts from sensible matter, but not from intelligible matter, as is said in the sixth book of *Metaphysics.* Intelligible matter is considered as something divisible, whether in regard to numbers or continua. Accordingly, whenever in mathematics something is demonstrated of the whole through its parts, it seems to be a demonstration through material cause: for the parts are as matter in relation to the whole, according to the second book of *Physics.* However, because matter is more properly spoken of in relation to sensible things, he does not want to call it material cause, but the cause of necessity.[9]

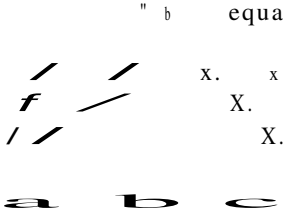
St. Thomas now follows Aristotle[10] as he developes a

[8] *Post. Analyt.,* Bk. 2, Chap. 11, 94a 20ff.

[9] "Deinde... proponit exemplum in mathematicis. Nec est contra id quod dicitur in *III Metaphys.,* quod mathematicae scientiae non demonstrant per causam materialem. Mathematica enim abstrahit quidem a materia sensibili, non autem a materia intelligibili, ut dictur in *VI Metaphys.:* quae quidem materia intelligibilis consideratur secundum quod aliquid divisibile accipitur vel in numeris vel in continuis. Et ideo quandocunque in mathematicis aliquid demonstratur de toto per partes, videtur esse demonstratio per causam materialem: partes enim se habent ad totum secundum rationem materiae, ut habetur in *II Physic.* Et quia materia magis proprie dicitur in sensibilibus, propter hoc noluit eam nominare causam materialem, sed causam necessitatis." *(In II Post. Analyt.,* lect, 9, n. 5. Cf. *In De Trin.,* q. 5, a. 3, ad 4.)

[10] Aristotle puts it tersely as follows: "Thus, let A be right angle, B the half of two right angles, C the angle in the semicircle. Then

demonstration of the proposition that the angle in a semicircle is a right angle. We must construct a semicircle upon chord A C, which is the diameter of the full circle. Upon point D, the center of the diameter and of the circle, we erect a perpendicular line to point B on the circumference. Then two lines are drawn from this point, one to point A and another to point C. We have, therefore, two right triangles ADB and CDB, because line DB is perpendicular to line AC. Now, angles DCB and DBC are equal to one right angle, because the angle at point D is a right angle, and all three angles of a triangle total up to two right angles. Moreover, the two angles DCB and DBC are equal to one another, since DB and DC are equal, both being radii of the circle. Therefore, angle DBC is half of a right angle. By the same process we find that angle ABD is half of a right angle. Therefore, the whole angle ABC is half of two right angles, that is, one right angle.



This demonstration, at the point where it interests us, may be put into syllogistic form, using as middle term: the half of two right angles.

The half of two right angles is a right angle.
But the angle in a semi-circle is the half of two right angles..
Therefore, the angle in a semicircle is a right angle.

In this way we can easily see that in the major premiss the middle term expresses parts of the whole, that is, the two halves. Therefore, it is a material cause. However, Aristotle and St. Thomas note that this middle term can also pertain to formal cause, since it can be taken as a definition of a right angle; but this must be in relation to a particular angle, as the parts of the definition are formal as regards the supposit or individual participating the nature, not as regards the nature itself. So we can say that the

angle ABC shown in the drawing above can be defined as the half of the two right angles, and this definition will be formal: it will tell the *whatness of* that angle.[11]

It should be easier now for us to understand another example that Aristotle gives. "Light shines through a lantern because that which consists of relatively small particles necessarily passes through pores larger than those particles —assuming that light does issue by penetration."[12] Let us put this into form:

> What consists of relatively small particles is that which will pass through the pores of a lantern glass.
> But light consists of relatively small particles.
> Therefore, light shines through the lantern glass.

The middle term here exhibits the parts of which light is composed. The property demonstrated of light belongs to it precisely because of its material composition. Actually, this definition of light is a hypothetical definition; it is not Aristotle's own opinion of the nature of light.[13] The demonstration has no more validity than does the definition in the middle term; for that definition is a principle and cause of the demonstration. This shows us the essential function of demonstration as a supplementation

[11] The failure to grasp this distinction has led Le Blond, *Logique et Methode chez Aristote,* pp. 94-95, to reject the above example as a demonstration through material cause. He says it is really through formal cause.

B is the cause in virtue of which A, right angle, is attributable to C, the angle in a semicircle, since B = A and the other, viz., C, = B, for C is half of two right angles. Therefore it is the assumption of B, the half of two right angles, from which it follows that A is attributable to C, i.e., that the angle in a semicircle is a right angle." (Z6id., 29-34.)

[12] *Post. Analyt., ibid.,* 94b 28-31.

[13] "Light is neither fire nor any kind whatsoever of body nor an efflux from any kind of body (if it were, it would again itself be a kind of body)—it is the presence of fire or something resembling fire in what is transparent. It is certainly not a body, for two bodies cannot be present in the same place." *(On the Sold,* Bk. 2, Chap. 7, 418b 14-17.)

of the act of understanding and of defining. But the example serves its purpose of illustrating the manner of demonstrating through material cause.

While we are on the subject of light, it will be well to mention a modern demonstration about the same. Newton, experimenting with the refraction of light through a prism, discovered the existence and shape of the spectrum. By admitting the various bands of the spectrum to a second refraction through another prism, he found that each color has its proper degree of refractibility and that the pure colors of the band could not be further refracted. Moreover, he found that the colors of the spectrum can, when passed through a large lens, be again combined into white light. The conclusion was inescapable that white light consists of a composition of colored rays in a definite proportion. The cause for the phenomenon of the spectrum is precisely the composition of white light from heterogeneous rays, each with its proper color and index of refractibility. Given this cause, the phenomenon of the spectrum can be demonstrated to be a property of white light.

> A light composed of various colored rays each with a different index of refractibility will produce a band of colors when passed through a prism.
> But, white light is so composed.
> Therefore, a white light produces a band of colors when passed through a prism.

In the major premiss the middle term is seen as the material cause of that which causes the phenomenon of the spectrum : i.e. because white light is so composed, it can be broken up into a band of its component parts. In the minor premiss white light is defined by its material cause, and this definition, it should be noted, has been acquired through the *a posteriori* demonstration whereby Newton discovered the composition. Therefore, the conclusion follows through the medium of material cause.

Chemistry is that part of natural science *par excellence* which makes use of definitions through material cause. Chemical definitions, or formulae, quite evidently show the

parts of which any given substance is composed such as H_2SO_4, H_2O, etc. All properties that can be found to flow from the material composition of a substance, e.g. molecular weight, can be given *propter quid* demonstrations in chemistry.[14]

A simple example can be given. Everyone knows from ordinary experience that water extinguishes fire. But mere knowledge of this fact is not scientific knowledge. Knowledge of a fact is imperfect until we can assign the proper reason Or cause why the fact is so and cannot be otherwise. In the present example we assign incombustibility as a property of water through the definitions of both the property and of water. Combustion is defined as the process of oxydation. Water is by definition an oxide of hydrogen. Its chemical definition, H_2O, a definition through material cause or component parts. Water, then, is not combustible, it cannot be oxydized, because by its very nature it is already oxydized. As it stands, this is what we call a particular demonstration. It lacks the full perfection of science, because the property—incombustibility—is more extensive than the subject water. The proper subject of incombustibility is: any substance that cannot combine chemically with oxygen. By an easy deduction we add: water is such a substance; therefore, water is incombustible. Such a particular demonstration is but one easy step removed from perfect demonstration and participates intimately in its scientific. character.

At the beginning of the seventh book of *Physics* Aristotle gives an interesting demonstration by material cause of the principle: "Everything that is in motion must be moved by something."[15] The argument here is quite difficult, but we wish to discuss it because it is a valuable example for our present concern and because St. Thomas, as against

[14] Cf. Kane, *et al., Science in Synthesis,* p. 67ff. See *ibid.,* p. *935* and 103ff for a famous demonstration through material causality in biology, namely, Harvey's demonstration of the circulation of the blood.

[15] *Physics,* Bk. 7, Chap. 1, 241b 24.

Averroes, explicitly contends that this is a *propter quid* demonstration.16

There is no difficulty in seeing how there must be an extrinsic mover to impart violent motion, such as to move a stone upward through the air. The study, then, is limited to those mobile beings that have an intrinsic source of motion, such as living beings and other natural beings. Now, if something is moved of itself and not by another, that thing must have motion essential to itself and in virtue of its very self: *per se et primo.* If the mobile whole does not have motion essential to it in virtue of itself, but in virtue of its parts, it could not be moved *per se primo:* motion could not be of its essence, and would thus have to come from something outside its essence.

Aristotle first gives an indirect argument. Just because we can perceive no external mover, he says, does not mean that a thing has its motion essential to it; for one part of the thing can be moving another part, as the soul moves the body.

We have simplified the direct demonstration as much as possible and put it into strict form. A deeper and more complex consideration can be found in the treatment of St. Thomas.

Whatever is in motion is divisible into parts on which depends the motion of the whole.
But whatever is divisible into parts on which depends the motion of the whole is something moved, not *per se primo,* but by another.
Therefore, whatever is in motion is moved, not *per se primo,* but by another.

Minor:
1. (Whatever is in motion is divisible into parts.)
Whatever is in motion passes from one state to another, and so is partly in the *terminus a quo* and partly in the *terminus ad quern.*
But whatever so passes from one state to another is divisible.

16 *In VII Phys.,* lect. 1, n. 6. St. Thomas gives the same demonstration in shorter form in *Contra Gent.,* Bk. 1, Chap. 13.

Minor: This is evident, for if something mobile is in the *terminus ad quern,* then the motion has ceased. If it is in the *terminus a quo,* then the motion has not commenced. Therefore, while it is moving, it must be partly in both.

Major: To be partly in one terminus and partly in another is to be divisible: an indivisible would be wholly in either terminus.

2. (... into parts on which depends the motion of the whole.)

If the motion of the whole would cease by reason of a part coming to rest, then the motion of the whole depends on the motion of the part.

But the motion of the whole would truly cease if a part came to rest.

Therefore, the motion of the whole depends on the motion of the part.

The *minor* is evident, since the whole as such cannot move unless the parts all move.

Major: When one thing cannot be without another, then it depends on that other. But if the motion of the whole cannot be without the motion of the parts, then it depends on them.

Major:

Every mobile being that comes to rest from its motion by reason of the rest of something else is moved not *per se primo,* but by another.

But whatever is divisible into parts on which depends the motion of the whole is something that comes to rest from its motion by reason of the rest of something else, namely, the parts.

Therefore, whatever is divisible into parts on which depends the motion of the whole is something moved, not *per se primo, but* by another.

Major: It is *per se* evident that such a mobile being would not be moved *per se primo,* for to be moved *per se primo* means that motion would be of the essence of that being, and so it could not come to rest. Therefore, if it is not moved *per se primo,* it must, by complete disjunction, be moved by another. Whatever is not of the essence of a being comes to it from another.

The *minor* is evident.

The middle term of this demonstration (whatever is divisible into parts on which depends the motion of the whole) is a material cause.· Therefore, as St. Thomas says, "it seems we must say that this is not a demonstration *quia,* but *propter quid; for* it contains the cause why it is impossible that anything mobile move itself."[17]

There is a fascinating chapter in the *Posterior Analytics*[18] that will show us something of the building up of a demonstration from material cause in biology. Suppose that we have an attribute to demonstrate of a particular subject, without, however, knowing the commensurate subject. We ask why this attribute inheres in this particular subject. The answer will evidently be the definition of the proper subject of the attribute. How do we go about identifying that proper subject?

First, according to Aristotle, we must consider the various divisions and subdivisions of a common genus, in an attempt to find the subject that is commensurate with the attribute in question. Suppose that we want to demonstrate sleep of man. We note that sleep is an attribute also of bird and horse. We select the genus common to all the particular subjects in which we find the attribute of sleep, namely, animal, and we also lay down the common properties of animal as such. Then we proceed to the subdivisions with their properties, in order to find out which sub-genus is coextensive with sleep. In this case it is easy to see that sleep belongs to man, bird and horse in virtue of their being animals.[18]

Let us take a difficult example. Suppose we should ask why certain animals, such as the cow and the stag, have more than one stomach and have just a few or no teeth in the upper jaw? Aristotle observes that there is no existing classification that will easily point out the proper sub-

[17] "Videtur dicendum quod non sit demonstratio quia, sed propter quid; continet enim causam quare impossibile est aliquod mobile movere seipsum." *(Ibid.)*

[18] *Post. Analyt.,* Bk. 2, Chap. 14, 98a 1-23.

[18] Cf. *In II Post. Analyt.,* lect. 17, n. 2.

ject of such qualities, but that we can hit upon a common characteristic that will help us work toward a *propter quid* demonstration. That characteristic is that all or most animals without teeth and with more than one stomach have horns. Of course, it takes a goodly amount of observation to establish this characteristic as being common to the animals with the attributes in question.

A descriptive definition of an unnamed and unclassified proper subject will be our starting point. We will say that the attributes of possessing more than one stomach and only one row of teeth belong to cow and stag in virtue of their being homed animals. Can we find in this descriptive definition some cause of the attributes? We have an indication, at least, in that the definition points to a material cause: to prove something of the whole by one of the material parts is to prove by material cause.

Aristotle at once thought that he saw a cause. According to him, larger animals have more earthy matter in their composition. This matter is that from which bone is formed; from the same matter tusk and teeth and horns are formed.

> Thus it is that no animal that has horns has also front teeth in both jaws, those in the upper jaw being deficient. For nature by subtracting from the teeth adds to the horns; the nutriment which in most animals goes to the former being here spent on the augmentation of the latter.[20]

Therefore, the reason for the lack of upper teeth is the possession of horns, as the matter that would have nourished the growth of teeth has been used for horns. Aristotle sees this verified in that

> ... in other animals, where this material is not secreted from the body in the shape of horns, it is used to increase the size of the teeth; in some cases of all the teeth, in others merely of the tusks, which thus become so long as to resemble horns projecting from the jaws.[21]

[20] *Parts of Animals,* Bk. 3, Chap. 2, 663b 36—664a 3.
[21] *Ibid.,* 8-12.

Accordingly, a demonstration can be made:

Animals in whom a limited amount of nutriment that would have gone toward the formation of teeth has been used for some other purpose are animals that have few or no upper teeth.
But horned animals are such.
Therefore, horned animals have few or no upper teeth.
But cows and stags are homed animals.
Therefore, cows and stags have no upper teeth.

The first major contains a material cause in the fourth mode of essential predication. The first minor is a definition of homed animals by material cause. The second minor is a definition of cows and stags through material cause, that is, a descriptive definition through one of the integral parts. It is material cause also from another aspect, that of proper subject. The first demonstration is fully commensurate; the second is a particular demonstration, which uses the proper subject as middle term.

It is quite easy to see now how Aristotle can demonstrate the possession of more than one stomach of horned animals.

> A... multiplicity of stomachs exists also in the horned animals; the reason being that horn-bearing animals have no front teeth in the upper jaw.... For since the mouth, owing to its lack of teeth, only imperfectly performs its office as regards the food, this multiplicity of stomachs is intended to make up for its shortcomings.... For those horned animals that have no front teeth in the upper jaw also ruminate.[22]

The demonstration reads as follows:

Animals that lack upper teeth must ruminate their food.
But horned animals are animals that lack upper teeth.
Therefore horned animals must ruminate their food.
Whatever must ruminate its food needs several stomachs for storage of food.
But horned animals must ruminate their food.

Bk. 3, Chap. 14, 674a 31-33; b 8-11; 675a 5-6.

Therefore homed animals must have several stomachs.

In the major premiss of the first syllogism the middle term is the cause of the rumination of food. It appears to be a material cause, i.e. something is said of the whole because of a part, in this case, the lack of a part. The minor is a definition of homed animals, again in terms of a material part. The major of the second demonstration shows the final cause of having several stomachs. The minor is a definition of homed animals in terms of final cause. Therefore, we have demonstrated that horned animals have several stomachs because they must ruminate their food; they must ruminate their food because they lack upper teeth; they lack upper teeth because the nutriment that would have formed teeth has gone into the formation of horns. They have these properties, then, precisely because they are horned animals.

This example shows us how high Aristotle aimed in finding an intelligible explanation of the world of nature by assigning the causes of each natural thing. Aristotle's ideal and method may well be a guide to us in achieving true scientific knowledge of nature.

CHAPTER VIII

DEMONSTRATION THROUGH FINAL CAUSE

"In natural, moral and artificial matters," says St. Thomas, "demonstrations are taken especially from the end."[1] We have discussed the reason for this at some length in Chapter Three. We do not start out natural science with a perfect intuition of essences, from which we can deduce their properties. The process is just the reverse: to observe the properties of natures through sensory experience and to let them lead us back to the natures that cause them, from the knowledge of which we can demonstrate and understand all the properties.

Not only does the final cause help us to demonstrate properties, but it also enables us to demonstrate the other causes. For final cause is first in intention: it moves the efficient cause to unite the form and matter. Furthermore, matter is ordained to form and form to operation, as is evident in the case of a saw, which is made of steel according to a certain form for the purpose of cutting wood.

> It is evident in things that have four causes that one cause is in some way the cause of another. Matter is because of form, and not the other way around; so the definition that is taken from formal cause is the cause of the definition taken from the material cause of the same thing. Likewise, because the thing generated attains its form through the action of the generator, it follows that the agent is in some way the cause of the form, and is the definition of the definition. Furthermore, every agent acts because of the end; hence the definition taken from the end is somehow the cause of the definition taken from the agent cause. We cannot

[1] "In naturalibus enim, et moralibus et artificialibus, praecipue demonstrationes ex fine sumuntur." *(In V Meta.,* lect 1, n. 762,)

> proceed further in kinds of causes: hence it is said that the end is the cause of causes.[2]

By final cause we mean that for the sake of which something is done: the goal or purpose of a being or an operation. Aristotle's lively consciousness of teleology in nature is well known; we need not discuss it here at length.[3] The main reason he finds for finality in nature is the regularity and intelligent design with which things come about Such a regularity could not be due to chance, for chance happenings occur only infrequently. Moreover, the fittingness and purposiveness whereby all things are patterned and ordered with such obvious perfection precludes an origin from mere mechanical interactions of matter. Things are and act in regular and typical pattern because they are so determined by their natures. This determination of natural agencies to produce constant effects is what we mean by finality in nature.

The existence of finality in nature is known to the physicist from his wide experience of physical reality. He does not demonstrate teleology: he sees it. All beings exhibit to him a natural inclination to what is good for them: to their conservation, their operations, their perfection. More-

[2] "Manifestum est enim in rebus habentibus quatuor causas, quod una causa est quodammodo causa alterius. Quia enim materia est propter formam et non e converso, ut probatur in II *Physic.,* definitio quae sumitur ex causa formali, est causa definitionis, quae sumitur ex causa materiali eiusdem rei. Et quia generatum consequitur formam per actionem generantis, consequens est quod agens sit quodammodo causa formae et definitio definitionis. Ulterius autem omne agens agit propter finem; unde et definitio quae a fine sumitur, est quodammodo causa definitionis quae sumitur a causa agente. Ulterius autem non est procedere in generibus causarum: unde dicitur quod finis est causa causarum." (In *II Post. Analyt.,* lect. 8, n. 3. Cf. *In V. Meta., lect.* 3, n. 782; In *II Phys.,* lect. 5, n. 11; *De Principiis Naturae,* n. 10; etc.)

[3] Aristotle's best treatment of final cause in nature is given in *Physics,* Bk. 2, Chap. 8, 198b 10—199b 33. St. Thomas' Commentary, lessons 12-14, should be consulted. St. Thomas often returns to this subject; he gives a good summary of it in *De Veritate,* q. 5, a. 2; q. 22, a. 2.

over, typical structures and organs are constructed not only with a view to their function, but rather that their function may be accomplished in a better and more fitting way. For instance, the front teeth are sharp for the sake of biting off our food, and the back teeth are broad for the sake of better chewing the food. What a contrast are natural parts and functions to their man-made substitutes, such as artificial limbs and hearing aids.

The main thing that is of concern to us at present is the various aspects of final causality that the natural philosopher uses in demonstrating. We have already seen that the form of a thing generated is identical with the final cause of the whole generative process. But the being_generated_ Js ordained to a further end, which is^peration or the thing attained by bperation^ The thing attained by operation is callëd'thé bbjective end, in distinction to the perfection acquired by the agent in attaining it; this latter is the subjective end. Not only the ultimate end, subjective or objective, has the nature of final cause, but all the intermediate ends ordained as means to it.[5] Likewise, all the individual parts of the agent, its organs and faculties and operations, are mutually coordinated, one being ordained to the other.

The whole physical universe itself has an intrinsic final cause, the perfect correlation of its parts, a *bonum ordinis.*

* "Natura rei, quae est finis generationis, ulterius etiam ordinatur ad alium finem, qui vel est operatio, vel aliquod operatum, ad quod quis pervenit per operationem." *(Summa Theol.,* I-II, q. 49, a. 3.) "Sic igitur causam finalem per tria notificat; scilicet quia est terminus motus, et per hoc opponitur principio motus, quod est causa efficiens: et quia est primum in intentione, ratione cujus dicitur cujus causa: et quia est per se appetibile, ratione cujus dicitur bonum. Nam bonum est quod omni appetunt. Unde exponens quo modo causa finalis efficienti opponatur, dicit quod est finis generationis et motus, quorum principium est causa efficiens. Per quae duo videtur duplicem finem insinuare." *(In I Meta.,* lect 4, n. 71.)

5 "Per formam perficitur natura rei.... Ipsa tamen forma ordinatur ulterius ad operationem, quae est vel finis, vel via in finem." *(Summa Theol.,* I-II, q. 49, a. 4, ad 1.)

It has also an extrinsic final cause, which is the glory of God. The final chapter of St. Thomas' Commentary on the *Metaphysics* of Aristotle is a magnificent *Weltansicht,* a view of the universal teleological order of reality. The doctrine there is summarized with equal beauty in the *Summa Theologiae.* It will be to our advantage to quote this latter passage.

> The entire universe is constituted by all creatures, as a whole consists of its parts. Now if we wish to assign an end to any whole, and to the parts of that whole, we shall find, first, that each and every part exists for the sake of its proper act, as the eye for the act of seeing; secondly, that less honorable parts exist for the more honorable, as the senses for the intellect, the lungs for the heart; and thirdly, that all parts are for the perfection of the whole, just as matter is for form, since the parts are, as it were, the matter of the whole. Furthermore, the whole man is for the sake of an extrinsic end, namely, the fruition of God.
>
> So, even in the parts of the universe every creature exists for its own proper act and perfection, and the less noble for the nobler, as those creatures that are less noble than man exist for the sake of man. Furthermore, each and every creature exists for the perfection of the entire universe. Further still, the entire universe, with all its parts, is ordained towards God as its end, inasmuch as it imitates, as it were, and shows forth the divine goodness to the glory of God. Reasonable creatures, however, have in some special and higher manner God as their end, since they can attain to Him by their own operations, by knowing and loving Him. Thus it is plain that the divine goodness is the end of all corporeal things.[4]

It is the duty of the natural philosopher to specify this plan of the universal order. He has to determine the purpose of every material being, from that of the lowest part and function of the lowest natural unit up to the order of the cosmos itself. He must link up all mobile beings into a

[4] *Summa Theol.,* I, q. 65, a. 2.

teleological pattern by demonstrating of each one and of each part their proper and proximate intrinsic and extrinsic final causes. A momentous assignment and one not likely ever to be fully accomplished—but it is imposed upon the physicist by his own natural desire to understand the world in which he lives.

There is one point at which the investigation of the natural philosopher must stop. He cannot, as a natural philosopher and in virtue of the principles of his science, discover the extrinsic final cause of the universe. He is capable of detecting finality in the structure and operations of mobile being. He can demonstrate the causal interrelations of mobile beings. But the proper principles of his science are inadequate to explain the ultimate reason for finality in nature and the ultimate extrinsic final cause of mobile being. For the principles of mobility[7] can take him no further than to the existence of the First Unmoved Mover. There is need of a science that treats of being as being to give the definitive reason for the existence of finality and of the natural inclinations of all beings. That answer is the Creator, Who has called all things into existence for His own *glory* and has planted in the natures of all a spontaneous tendency toward Himself, the Infinite Good.[8]

A demonstration of the active intellect can be made

[7] "Consideratio speculativae scientiae non se extendit ultra virtutem principiorum illius scientiae, quia in principiis scientiae virtualiter tota scientia continetur." *(Ibid., I-II,* q. 3, a. 6,. Cf. I, q. 1, a. 7.) "Substanta enim solet dici prima inchoatio cuiuscumque rei, et maxime quando tota res sequens continetur virtute in primo principio; puta si dicamus quod prima principia indemonstrabilia sunt subiecta scientiae, quia scilicet primum quod in nobis est de scientia sunt huiusmodi principia, et in eis virtute continetur tota scientia." *(Ibid.,* Π-Π, *q. 4,* a. 1.)

[8] Metaphysics treats of all things under the aspect of being, namely, of essence having existence. The proper cause of esse as such is God, the Creator and Subsistent Being. The ultimate final cause of esse is the glory of God. This is commensurate with being as such, and not with mobile being; hence, it cannot be attained through the principles of mobile being.

through final cause. St. Thomas treats this subject in a number of places,[9] and he developes proofs of it in various ways. The proof in the *Summa Theologiae,* for instance, seems to be *quia,* because it proceeds from the general principle that the potential must be reduced to act by something already in act.

> Since Aristotle did not allow that, the forms of natural things exist apart from matter, and since forms existing in matter are not actually intelligible, it follows that the natures or forms of the sensible things which we understand are not actually intelligible. Now nothing is reduced from potentiality to act except by something in act; as the senses are made actual by what is actually sensible. We must therefore assign on the part of the intellect some power to make things actually intelligible, by the abstraction of the species from material conditions. And such is the necessity for positing an agent intellect.[10]

Here, as well as in other places, St. Thomas gives us the matter for a strict demonstration, although he does not put it into syllogistic form. He gives us a definition of the active intellect in terms of its function, namely, a power or agent that abstracts species from material conditions. A definition through function is a definition through final cause, for beings are ordained to operation as to an end. With this definition, we can demonstrate the active intellect. In skeletal form, it may be expressed as follows:

> An intelligent being who receives intelligible species from the phantasms of sense powers, whereby the intellect is put into act, is a being endowed with an active intellect.
> But, man is such.
> Therefore, man is a being endowed with an active intellect.

[9] *Summa Theol.,* I, q. 79, a. 3; *Sent.,* II, d. 17, q. 2,a. 1; *Contra Gent.,* Bk. 2, Chap. 76 & 78; *In HI De Anima,* lect. 10, n. 728-739; *De Spir. Creat.,* a. 9; *De Anima,* a. 4; *Compendium Theol.,* Chap. 83. Cf. Gredt., *Elementa Philosophiae Aristotelico-Thomisticae,* I, n. 572, who gives a good demonstration of the thesis.

[10] Summa Theol., I, q. 79, a. 3.

The minor premiss is established by experience. For man realizes that his abstract intellectual knowledge takes its rise from sensation, and this is verified by the fact that the intellect's function is impaired by weariness and by injury to the organs of internal sensation. A rich *status quaestionis* must show how this mode of operation follows from the composite nature of man, who is both material and spiritual, with his body being ordained to serve his soul. In the major premiss the middle term is final cause, or goal of operation. This premiss is made known by an *a posteriori* demonstration, for since the senses of themselves cannot produce an intelligible species, there must be an immaterial power to do it. In St. Thomas' day it was necessary to bolster this premiss with indirect demonstrations proving, against the Arabian philosophers, that the active intellect is a faculty in each individual soul, and not a separated intellect. The premisses are all commensurately universal, so it seems that we have here a true *propter quid* demonstration.

In the chapter of the *Posterior Analytics* where Aristotle is discussing the principle that we can demonstrate with any of the four causes as middle terms, he gives this example of a demonstration from final cause.

> Why does one take a walk after supper? For the sake of one's health.... The end in view is... health. To ask the reason why one must walk after supper is precisely to ask to what end one must do it. Let C be walking after supper, B the non-regurgitation of food, A health. Then let walking after supper possess the property of preventing food from rising to the orifice of the stomach, and let this condition be healthy; since it seems that B, the non-regurgitation of food, is attributable to C, taking a walk, and that A, health, is attributable to B. What, then, is the cause through which A, the final cause, inheres in C? It is B, the non-regurgitation of food; but B is a kind of definition of A, for A will be explained by it. Why is B the cause of A's

belonging to C? Because to be in a condition such as B is to be in health.[11]

The example at first sight presents considerable difficulty. As a help to understanding it, we must warn that as it stands, it seems to be a demonstration through formal causality. We will have to transpose the terms to make it a demonstration through final causality, as Aristotle himself informs us: "The definitions must be transposed, and then the detail will become clearer."[12] When the data given above are put into form, the demonstration goes:

B, Good digestion of food is A, a healthy condition.
C, Walking after supper is that which causes B, good digestion.
Therefore, walking after supper causes a healthy condition.

In the major premiss B is a formal cause or definition of A, which is the final cause. In the minor, C is the efficient cause of B, which is also a final cause of C. In this premiss we have a definition of C through its end, B. In the conclusion we see that since B is a formal cause of A and C is for the sake of B and is an efficient cause of B, so then C, walking after supper, is the efficient cause of A, good health, and is for the sake of A, its end. B, the medium of demonstration, is both an end and an effect of C and a definition of A.

The syllogism proceeds according to the order of execution, and hence through what is first in becoming. If we transpose the terms, we can make it prove through final cause, or what is first in intention.

A, Health requires B, good digestion.
But C, walking after supper is A, for the sake of health.
Therefore, C, walking after supper is for B, good digestion.

In the major premiss A, the middle term, is the final cause of B, good digestion. The minor premiss contains a definition of C by reason of its final cause, health. Therefore, C

[11] *Post. Analyt.,* Bk. 2, Chap. 11, 94b 8-21.
[12] *Ibid.,* 22.

is the subject and cause of B through the medium of the final cause, A.[13]

Let us turn our attention to the field of biology where finality and hence the ability to demonstrate are plentifully evident.

In the first chapter of the little treatise *De Sensu et Sensibili* Aristotle demonstrates the possession of the various senses. "Touch and taste," he says, "necessarily appertain to all animals, touch for the reason given in the *De Anima,* and taste, because of nutrition."[14] It is by taste that an animal distinguishes savory substances, which are suitable for food, from unsavory ones, which are not good. But what is the proper reason for the higher senses of smelling, hearing, and seeing? First of all, their proper subject must be assigned. They are found in all animals that have locomotion. Therefore, we may give a descriptive definition of the proper subject: animals that have the faculty of locomotion. This definition of the commensurate subject gives a clew to the final cause of these three senses:

> The senses which operate through external media, viz. *smelling, hearing, seeing,* are found in all animals which possess the faculty of locomotion. To all that possess them they are a means of preservation; their final cause being that such creatures may, guided by *antecedent* perception, both pursue their food, and shun things that are bad or destructive.[15]

If we wish to put this into syllogistic form, it would read:

> Animals endowed with locomotion are animals that must pursue their food and shun things that are bad or destructive.
> But in order to do so these animals must be able to smell, hear, and see.
> Therefore, animals endowed with locomotion are animals that are able to smell, hear and see.

The connection between these faculties and their final

13 Cf. St. Thomas' Commentary (Leonine ed.), lect. 9, n. 9 and footnote k, where Card. Zigliara works out the above syllogisms.

14 *De Sensu et Sensibili,* Chap. 1, 436b 13-14.

33 *Ibid.,* 18-22.

cause is quite evident. An animal that moves around to find its food must have some means of detecting that food from a distance. The same applies to the avoidance of dangers. The sense of smell, at least, is simply necessary; the other senses are necessary for the more perfect attainment of the end.

Aristotle adds that in animals with intelligence these faculties serve a higher purpose. "They bring in tidings of many distinctive qualities of things, from which the knowledge of truth, speculative and practical, is generated in the soul."[16] This constitutes another demonstration from final cause, which can easily be put into form:

> Animals with intelligence are animals that need sensory data from which to abstract speculative and practical truth.
> But animals that need such sensory data are animals that have it supplied especially by the senses of smelling, hearing and sight.
> Therefore, animals with intelligence have the senses of smelling, hearing and sight.

The need for sensory data from which to abstract intelligible species is thus seen to be the final cause of man's having the higher senses.

Aristotle's treatment of the eye is characteristic of his method of demonstration by final cause. The eye is to be defined in relation to its function.

> What a thing is is always determined by its function: a thing really is itself when it can perform its function; an eye, for instance, when it can see. When a thing cannot do so, it is that thing only in name, like a dead eye or one made of stone.[17]

Given this definition through function, or final cause, Aristotle now seeks a demonstration of the material cause of the eye, the matter from which it is constructed.

Some of Aristotle's predecessors thought that the eye

437a 2-3.

17 *Meteorologica,* Bk. 4, Chap. 12, 390a 10-14. Cf. *On the Soul,* Bk. 2, Chap. 2, 412b 19-23, where he shows that the faculty of vision is the form of the visual organ.

was composed from the element fire. Their main reason for saying this was that "when the eye is pressed or moved, fire appears to flash from it."[18]* This was also consonant with their theory of vision as an emanation of light from the eye, as from a lantern. Aristotle shows the impossibility of this opinion. Then he establishes his own, that the eye is composed from the element water, because water is translucent.[19] The element air is also translucent, but it is not as well adapted for the purposes of the eye. "Water," he says, "is more easily confined and more easily condensed than air; wherefore it is that the pupil, i.e. the eye proper, consists of water."[20] He shows that experience testifies that this is so, for water issues from a decomposing eye. He then gives his demonstration.

> Accordingly, that the inner part of the eye consists of water is easily intelligible, water being translucent. Now, as vision outwardly is impossible without light, so also it is impossible inwardly (without light within the organ). There must, therefore, be some translucent medium within the eye, and, as this is not air, it must be water. The soul or its perceptive part is not situated at the external surface of the eye, but obviously somewhere within: whence the necessity of the interior of the eye being translucent, i.e. capable of admitting light. And that it is so is plain from actual occurrences. It is matter of experience that soldiers wounded in battle by a sword slash on the temple so inflicted as to sever the passages of (i.e. inward from) the eye, feel a sudden onset of darkness, as if a lamp had gone out; because what is called the pupil, i.e. the translucent, which is a sort of inner lamp, is then cut off (from its connexion with the soul).[21]

This can be formalized as follows:

The eye is the organ of vision.
But the organ of vision must be composed from

[18] De *Sensu,* Chap. 2, 437a 24.
[19] Cf. *ibid.,* 438a 13sq.
[20] *Ibid.,* 15-16.
[21] *Ibid.,* 438b 5-15.

a translucent element, as vision is not possible without light.
Therefore, the eye is composed from a translucent element, either air or water.
But air is not sufficiently adapted to this purpose.
Therefore, the eye is composed of water.

The major premiss (the organ of vision must be composed from a translucent element) is made evident for Aristotle because the visual faculty is seen to reside not on the surface of the eye, but within; hence, light must be admitted.

This cursory glance at Aristotle's demonstration of the composition of the eye suggests the rich understanding we can attain, in terms of final causality, of the structure of the eye. We can demonstrate the reason why the cornea, aqueous humor, lens and vitreous humor are transparent, namely, in order to admit light stimuli to the retina. We can also demonstrate that a more perfect and more adaptable vision requires an adjustable lens for focussing light stimuli, and that such a lens must have a focussing mechanism, which is what the ciliary muscle is. We also know that the choroid coat is highly pigmented in order to prevent light from entering the eye except through the pupil. Such properties as the enlarging or closing of the pupil may be demonstrated to result from the increased or decreased light for the purpose of equalizing the stimuli on the retina. All these are proper final causes and hence constitute middle terms of demonstrations.

Since Aristotle gives the example of respiration in one of his methodological tracts,[82] it will be helpful to consider it briefly. The little work *De Respiratione* is a signficant example of Aristotle's method. Be begins by saying:

> A few of the previous physical philosophers have spoken of respiration. The reason, however, why it exists in animals they have either not declared, or when they have, their statements are not correct and show a comparative lack of acquaintance

[22] *Parts of Animals,* Bk. 1, Chap. 1, 642a 31—b 2. Cf. *supra, Chap.* 3, note 36 where the text is quoted.

> with the facts. Moreover they assert that all animals respire—which is untrue. Hence these points must first claim our attention, in order that we may not be thought to make unsubstantiated charges against authors no longer alive.[23]

This is a remarkable passage, showing Aristotle's devotion to observed facts, his demand for causal explanation, and his intellectual honesty.

He first establishes the proper subject of respiration, namely, animals that have lungs, especially those whose lungs are charged with blood.[24] He proceeds then to the opinions of some of his predecessors, and concludes:

> The main reason why these writers have not given a good account of these facts is that they have no acquaintance with the internal organs, and that they did not accept the doctrine that there is a final cause for whatever Nature does. *If they had asked for what purpose respiration exists in animals,* and had considered this with reference to the organs, e.g. the gills and the lungs, they would have discovered the reason more speedily.[25]

Aristotle now considers facts that throw light on the purpose of respiration. He is particularly impressed by the fact that in hot weather, when we grow warmer, respiration is increased, whereas in cool weather breathing is retarded.[26] What we breathe out, moreover, is hot, whereas what we breathe in is cold.[27] He notices that some animals with a spongy lung, little blood and low body heat have less need for respiration; they remain a long time under water. Such are frogs, tortoises and the like.[28] He finds it impossible that fishes breathe at all.[29] These facts seem to link respiration to body heat. This is Aristotle's approach to building up his definition of respiration by function.

23 *De Respiratione,* Chap. 1, 470b 6-12.
24 *Ibid.,* 13, 24-26.
25 *Ibid.,* Chap. 3, 471b 23-29. (Italics ours.)
26 *Ibid.,* Chap. 4, 472a 29—b 4.
27 *Ibid.,* 472b 35-473a 2.
28 *Ibid.,* Chap. 1, 470b 13-20.
29 *Ibid.,* Chap. 2, 470b 28-471b 30.

All vital processes involve a certain heat The digestive process does not occur "apart from soul and warmth, for it is to fire that in all cases elaboration is due."[30] If this heat becomes excessive, it will burn out the organism. Hence it must be cooled.[31] In a later chapter Aristotle says that "The universal cause of the need which the animal has for refrigeration, is the union of the soul with fire that takes place in the heart."[32] Water animals and small bloodless land animals can be adequately cooled by the surrounding medium. Some insects, such as bees, cockchafers and crickets are wanper and require more refrigeration; this is supplied by a deep indentation beneath the waist covered with a thinner membrane.[33] Animals with blood, heart and lung require to be cooled by breathing in air.[M] Thus, respiration can be defined as the process of tempering the heat of an organism. Such a definition is through final cause.

Aristotle can now demonstrate "why animals with a full-blooded lung respire most."[35] We can formalize the core of the argument:

> The process of tempering the heat of an organism by aerating the hot blood in the lungs is respiration.
> But animals with full-blooded lungs have greater need to have their blood cooled, because they cannot deviate much from normal temperature.
> Therefore, animals with full-blooded lungs respire most.[30]

It can be demonstrated on Aristotle's principles why more perfect animals have greater respiration. He holds that "the higher animals have a greater proportion of heat, for at the same time they must have been assigned a higher

[30] *Ibid.,* Chap. 8, 474a 26-28.
[«] *Ibid.,* 474b 20-25.
[33] *Ibid.,* Chap. 16, 478a 28-29.
[33] *Ibid.,* Chap. 9, 474b 25-475b 14.
[3'] *Ibid.,* Chap. 10, 475b 15-476a 15.
[33] *Ibid.,* Chap. 15, 478a 21.
[33] *Ibid.,* Chap. 15 gives the fuller development of this demonstration.

soul and they have a higher nature than plants."[37] Plants are cold, and the scale of life and the scale of natural heat correspond. Therefore:

The more perfect animals are those with greater heat.
But animals with great heat need a more perfect process for tempering their heat.
Therefore, more perfect animals have a more perfect process for tempering their heat.
But the process of tempering natural heat is respiration.
Therefore, the more perfect animals have a more perfect process of respiration.

The middle term in the first syllogism (animals with greater heat) is a descriptive definition through a formal cause. In the second, the middle term is a definition through final cause. We could go on to demonstrate the correspondingly perfect anatomy of the respiratory system in higher animals:

A more perfect process of respiration demands more perfect lungs.
But higher animals need and have more perfect respiration.
Therefore, higher animals need more perfect lungs.

Aristotle's doctrine on respiration is intimately connected with his theory of the elements. That is why he was naturally led to speak of the process in terms of heat and cooling. Let us glance for a moment at what we moderns know of respiration.

For us, respiration is defined in terms of oxygen needs for cellular activity and of the discharge of waste products in the form of carbon dioxide. Carbon dioxide is given off by the tissues, is flushed out in the blood stream and released to the air in the lungs. Likewise, the aerated blood in the alveoli of the lungs receives oxygen molecules and carries them to the tissues throughout the body. Respiration, then, can be defined as "the physiological process which

[37] *Ibid.,* Chap. 13, 477a 16-19.

is concerned in the intake of oxygen and the output of carbon dioxide."[38] This is a definition by function or final cause, for the process is a means to secure the end of oxygen intake and carbon dioxide output. Taken in this general sense, respiration can be demonstrated as belonging to every living body.

Every living body needs a normal oxygen supply and must throw off cellular waste products.
But the physiological process which is concerned in the intake of oxygen and the output of carbon dioxide is respiration.
Therefore, every living body must have the process of respiration.

In the minor premiss we have a definition of living things in terms of a need or of an end to be attained. This need, is evident from induction. This definition by final cause corresponds to the definition of respiration by final cause. Therefore, we see that respiration is coextensive with living body. Taking material structure into account, i.e. the possession of lungs, blood, etc., we would demonstrate the necessity of respiration by breathing air into the lungs.

When there is an increase of carbon dioxide in the alveolar air, the blood becomes insufficiently aerated and the arterial blood stream carries carbon dioxide to the respiratory center in the medulla. This sets to work a complicated physiological mechanism that increases the rate of respiration until the excess carbon dioxide is removed from the blood and normalcy is restored.[38] This is a mechanical action, but a proper reason may be given for it in terms of final causality, and so it can be demonstrated.

Restoration of a normal carbon dioxide content in the blood is the purpose of the physiological process whereby carbon dioxide in the arterial blood stimulates the respiratory center in the medulla and causes increased respiration.

[38] J. S. Haldane, "Respiratory System," *Encyclopaedia Britannica,* (11th ed.), XXIII, 187.

[38] On this complex process cf. J. S. Haldane, *art. cit.,* 187-192; E. S. Russell, *The Directiveness of Organic Activities,* 51-60.

> But increased respiration in animals possessing the anatomical structure corresponding to the said physiological process is for the purpose of restoring the normal carbon dioxide content in the blood.
> Therefore, increased respiration in these animals is the result of the above-mentioned physiological process.

Notice that the proper subject of the physiological process is indicated in terms of animals having the corresponding anatomical structure. If the proper subject were not thus identified, there would not be a strict demonstration, for the general subject "animal" is too broad.

Admittedly, the physiological process as described above is over-simplified. But even in all its complexity, there are demonstrations at every stage of the process. In such matters it would become cumbersome to formalize every demonstration. Whenever there is a proper cause assigned for any fact, however, the matter for a demonstration is present and according to the rules of logic, it can be put into form. The true scientific procedure is not just to accumulate facts, but to assign the commensurate causes for facts.

It belongs to the natural philosopher to consider the final end of man. Although modern scholastic manuals have turned over this task to the moral philosopher, still it belongs by rights to the pyschologist, who must investigate the causes and properties of his subject. In fact, this consideration is most essential to natural philosophy. The teleological ordination of all physical beings focusses upon man. In the order of generation, prime matter tends to the most perfect act that it can attain, namely, the human soul, so that

> ... the last end of all generation is the human soul, and to this does matter tend as its ultimate form. Consequently, the elements are for the sake of the mixed body, the mixed body for the sake of living things, and of these plants are for the sake of animals, and animals for the sake of man.

Therefore man is the end of all generation.[40]

A similar order obtains in the preservation of beings. Composite mineral bodies are preserved by the chemical affinity of their elements; plants are nourished on the minerals and provide protoplasm whereby animals are nourished. All animals feed on plants, and the higher animals on the lower. Man uses all: minerals, plants and animals.

> As for man, he employs all kinds of things for his own use: some for food, some for clothing.... Some things also he employs as a means of transit, for he is inferior to many animals in swiftness and endurance, as though other animals were furnished for his needs.[41]

This ordination of things cannot be demonstrated directly, since the final cause is the first of causes. The order of the world is a fact of observation. As St. Thomas says vigorously in a parallel passage: "As anything acts in nature, so it is natural for it to act."[42]

All things are ordained to man in another and even more perfect way. "Over and above this (i.e. that generation and preservation are directed toward man), he employs all sensible things for the perfection of his intellectual knowledge."[43] The natural philosopher, therefore, will show that the intrinsic final end of man in the natural order, his highest perfection, is the highest activity of which he is capable, namely, the contemplation of the speculative intellect. To this all nature is ordained, as providing objects of contemplation. In fact, St. Thomas holds that in the state of innocence man did not need the animals for food, clothing or transportation. "But man needed animals in order to have experimental knowledge of their natures."[44]

40 *Contra Gent.,* Bk. 3, Chap. 22. Cf. *In II De Anima,* lect. 7,, n. 321-322.

41 *Ibid.*

42 "Secundum autem quod agitur unumquodque in rerum natura, ita natum est agi." *(In II De Anima, lect.* 7, n. 322.)

43 "Et super hoc omnibus sensibilibus utitur ad intellectualis cognitionis perfectionem." *(Contra. Gent., ibid.* Our transi.)

"*Summa Theol.,* I, q. 96, a. 1, ad 3.

We thus see that man's contemplation is the end of the whole physical universe, as such a universe is necessary to provide a rich treasury of species for contemplation.

The contemplation of the natural philosopher is limited. He considers all the natures of his material universe, their beauty and coordination. But it remains for the metaphysician to show that all beings are reflections of the grandeur of the Creator, and that all things are ordained to man's knowledge in order that through man all physical creation may return to its Principle unto His glory and the praise of His Goodness. Such a vision requires the light of a higher science than that of natural philosophy.

We can now construct an easy demonstration that the physical universe is ordained to man. We shall use a final cause as middle term.

> A composite spiritual-material being ordained to contemplation is a being that needs a universe of species for objects of contemplation.
> But man is such.
> Therefore, man is a being that needs a universe of species for objects of contemplation.

The middle term is a formal cause with an added determination from final cause; hence, the proof proceeds especially from final cause. The major premiss is in the fourth mode of essential predication, the minor is in the first, and the conclusion is in the second. The terms are all commensurate. Therefore, we have manifested the *propter quid* reason for the conclusion.

SUMMARY AND CONCLUSION

Logic is the general methodology of science; and all logic is orientated toward a specific type of science, which Aristotle called ἐπιστήμη and the Scholastics name *propter quid.* This is the kind of knowledge that the Scholastic tradition identifies as science simply. It is the next most perfect type of knowledge after the intellectual intuition that we share with the angels. The instrument for attaining this knowledge is the demonstrative syllogism, whose nature and requirements we investigated at length in the first chapter. It is by definition a syllogism productive of scientific knowledge, that is, a syllogism which makes known "the cause on which the fact depends, as the cause of that fact and of no other, and further, that the fact could not be other than it is."[1] From this Aristotle concluded another definition, one by material cause: "The premisses of demonstrated knowledge must be true, primary, immediate, better known than and prior to the conclusion, which is further related to them as effect to cause."[2]

"To have knowledge, if it be not accidental knowledge, of things which are demonstrable, means precisely to have a demonstration of them."[3] If we neglect the strictly demonstrative process in building up and developing a science, we will indeed attain much knowledge of the intuitive sort, which issues in definition, and many proofs of the existence of facts. But there will be a hiatus in our science. We shall not attain the fullness and perfection of knowledge possible to us about the subject of our science.

We made mention of the lesser types of demonstration, both *a priori* and *a posteriori,* down to the level of opinion

[1] *Post. Analyt.,* Bk. 1, Chap. 2, 71b 9-12.
[2] *Ibid.,* 19-21.
[3] *Ibid.,* 27-29.

and of systematic explanation. These are all situated in a science with an essential orientation toward the perfect kind of demonstrative syllogism. All the elements that enter a science and all the moments and movements of the science must be directed according to the exigencies of the highest type of science, for it is the higher that orders the lower.

In the second chapter we investigated the meaning and requirements of the subject and object of a science and applied our findings to determining the subject and object of a science of the physical world. We saw how sensory motion is the key that opens up nature to us and how the science of nature proceeds, according to the mode of human knowing, from general considerations toward ever further specifications, attaining perfection only when it can arrive at demonstrative knowledge of the lowest species.

A doubt suggested itself as to how we can have certain and necessary knowledge about things essentially involved in matter, the principle of uncertainty and of contingency. In the third chapter we solved this difficulty by showing that the certitude of natural science is not the purely deductive certitude of mathematics, nor even the more perfect type of science attainable about the immaterial realities and formalities of metaphysics, but that on the universal level even mobile things have, by reason of their natures that transcend motion, enough stability to furnish a basis for science. Moreover, just as the certitude about physical beings is of an inferior sort, so is their necessity. The science of nature unfolds by reason, not of the absolute necessity following upon essence, but of the hypothetical necessity following upon final cause, that is, upon the existing nature and its proper motions manifested through sensory experience. In this is verified the word of St. Thomas, "Nothing is so contingent as not to have some necessary aspect to it."[4]

4 "Nihil enim est adeo contingens, quin in se aliquid necessarium habeat." *(Summa Theol.,* I, q. 86, a. 3. Our transi.)

From this we saw spontaneously that natural science is essentially experimental and inductive, that it seeks, not to deduce facts, but to explain facts in the light of their *propter quid* causes and of the principles of the subject The fourth chapter, accordingly, discussed and explained the manner of demonstrating in the philosophy of nature. It showed how the physicist must answer the question *why* in terms of all four proper and proximate causes of every natural thing. The following chapters made a few refinements of principles and gave illustrations of the demonstrative process.

We have gained some insight into the kind of integral natural science that Aristotle and St. Thomas were striving for. And we came to see that the method of natural philosophy according to Aristotle and St. Thomas cannot be understood without their concept of the nature and extent ôf the science. Is it extravagant to suggest that when men threw out the outmoded special science of Aristotle and philosophers retired into the ivory tower of generalities, men destroyed too much, that they discarded the ideals and the method that should be guiding us today to understand the meaning of the world in which we live?

Our study has brought us to think that this is so.

As a final word, the author feels that he cannot express himself better than did that great Thomist, Cardinal Cajetan, as he laid down his pen in completion of his commentary on *De Ente et Essentia*-*

> *Ultimo epilogue fit eorum quae dicta sunt in quorum explicatione meam opinionem ita prolatam esse volo, ut ubi veritati consentanea inventa non fuerit et ingenio et aetati venia detur: adolescentium enim adhuc ago. Ubi autem veritatis tramitem secuta videbitur, gratiarum debitae actiones divo Thomae habeantur a quo quidquid veri est didici.*

5 *In De Ente et Essentia,* n. 156.

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♦An asterisk indicates the editions we have used.