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Scientific Method in Aristotle's De Caelo, I, I-II, VI

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SCIENTIFIC METHOD IN ARISTOTLE'S

DE CAELO, I, i - II, vi

by

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the Requirements for the Degree
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LIFE

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**I. INTRODUCTION**
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CHAPTER I

INTRODUCTION

It is extremely difficult to deduce the Aristotelian scientific procedure—to take, for example, his definition of science or dialectic or of physics or mathematics, and to show that his actual method in a particular work is adequately explained by the initial definition. And yet, the actual scientific method used by Aristotle is very much worth understanding. It will give us a deeper insight into the totality of Aristotle's work and will lead to a better understanding of much of the subsequent history of philosophical and scientific thought. In the following study I have tried to discover the method at work in a particular scientific treatise. I have not, however, tried to reduce everything to a mere instance of a general theory of the nature of science. Too many nuances would be rubbed away and an impression of simplicity and order created which would hardly be substantiated by an inspection of the text.

Rather I have attempted to represent the process out of which a scientific treatise has emerged. The work is Aristotle's De Caelo, more exactly the first book and a half of this work.
It provides a doctrinal totality within itself and is brief enough to allow us to examine it in detail in the space at our disposal.

The contents of the *De Caelo* may be summarized briefly as follows: books one and two present the science of the supralunary world and the laws governing its motions; books three and four treat of the sublunary world, the world of generation and corruption, and the laws according to which the elements pass over one into the other. Within the first two books we have a possible tripartite division: through chapter six of book two, Aristotle develops his general doctrine of the heavens; chapters seven through twelve take up the problems of the stars; and in the final two chapters of the second book Aristotle considers the earth as a part of the system of the heavens.\(^1\) Our concern will be primarily with his general doctrine of the heavens.

To separate what is true from what is false in the *De Caelo* would be an endless and, I believe, a fruitless task. Galileo performed this criticism centuries ago, and there seems little reason to go back over his work.\(^2\) What interests us here

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\(^1\)For a fuller summary of the contents, see, Aristotelis *De Caelo, Libri Quattuor*, edited and with introduction by D.J. Allan. Oxford, 1936, pp. ix-xii.

\(^2\)For Galileo's criticism of Aristotle, see Galileo Galilei, *Dialogue on the Great World Systems*, Salusbury translation re-
is not the actual astronomy but rather the way in which a deep and lastingly influential thinker went about trying to understand the world.\(^3\)

We must be careful not to generalize too facilely on the basis of the texts studied here. If the Aristotelian studies of the past generation have taught us anything it is that Aristotle is an exceedingly complex, sometimes apparently even contradictory thinker, and that quick generalizations about him are almost certain to be wrong.\(^4\) In dealing with the nature and movements of the heavens, Aristotle is faced with uniquely difficult problems,\(^5\) and it would be highly uncritical for us to suppose that the techniques which he works out in the present context are characteristics of all of his scientific work. Nevertheless, the conclusions which we reach here ought at least to suggest questions and approaches for further, more general study.


\(^5\) That Aristotle was clearly aware of the difficulties of the problems studied in the *De Caelo* is clear from *De Part. An.*, I, 5, 644 b, 23-645 a, 7. The text is quoted below, on page 53.
Within the scientific process of the first section of the *De Caelo*, I have marked off three moments—experience, question, and theory. I have tried to grasp the intelligibility of Aristotle's method by analyzing these components and then seeing them go together to form a scientific whole. This division cannot, for the present, seem anything but arbitrary. As we proceed, however, I think that we shall see that it is not without foundation.

By taking this approach we shall come to a discussion of such topics as science and dialectic, conjecture and certitude. But we shall not take our point of departure from these concepts, any more than did Aristotle when he worked out his science of the heavens.
CHAPTER II

EXPERIENCE IN THE DE CAELO

In his logical work on the structure of science, Aristotle says of experience and science: "So out of sense-perception comes to be what we call memory, and out of frequently repeated memories of the same thing develops experience; for a number of memories constitute a single experience. From experience again--i.e. from the universal now stabilized in its entirety within the soul, the one beside the many which is a single identity within them all--originate the skill of the craftsman and the knowledge of the man of science."¹ From this we might conclude (and rightly) that a study and understanding of experience in Aristotle will be of the utmost importance for an understanding of his scientific method.

Experience does not enter as a neatly packaged unit into the formation of the De Caeio. It comes in both at the beginning and at the end of the scientific process, first as source then

as justification of the science. As source it serves the double function of providing the data, the stuff of science, and the principles of the scientific deduction. At the end, it provides a means of verifying the statements advanced by the scientific theorist. We shall examine in order these three aspects of experience: its role as source of data, its role as source of principles, and its role as means of verification.

In the first place, then, experience provides the initial data for scientific enquiry. This is merely to say that the world presents itself in experience as something potentially intelligible, which solicits the human mind to work out in detail the structure of this intelligibility. Aristotle develops this point in the early chapters of the Metaphysics. Men find themselves in a world that is ordered or structured in such a way, and their very situation in this world leads them to seek science:

For all men begin, as we said, by wondering that things are as they are, as they do about self-moving marionettes, or about the solstices or the incommensurability of the diagonal of a square with the side; for it seems wonderful to all who have not yet seen the reason, that there is a thing which cannot be measured even by the smallest unit. But we must end in the contrary and, according to the proverb, the better state, as is the case in these instances too when men learn the cause; for there is nothing which would surprise a geometer so much as if the diagonal turned out to be commensurable. 2

2Met., A, 2, 983 a, 14-20. Cf. also Met., A, 1, 981 a, 29-31; Phys., I, 1, 184 a, 9-27.
The stuff of experience can be subjected to the working of understanding: it can be grasped according to principles. The view that the world of experience is intelligible provides the guiding ideal for Aristotle's scientific work. There are real answers to intellectually posed questions about our ambient world.

The De Caelo forms part of a general attempt to reduce the real to some sort of intelligibility, or rather to discover the intelligibility that is potentially there already. Aristotle does not ask here whether such a science is possible. This and similar questions he would relegate to more basic studies, to the Physics and Metaphysics.³

The fact that Aristotle viewed experience in this way is hardly remarkable and scarcely needs further comment. An attitude of this sort will stand at the beginning of almost any scientific endeavor. But what does require closer investigation, since it sets Aristotle off from other traditions in science, is the nature or quality of this initial experience.

What precisely are the given facts which Aristotle as a scientist considers himself obliged to incorporate into his

³Cf., for example, Phys. II, 8, which the Oxford translator has entitled, "Does nature act for an end?" For an account of the place of the De Caelo within the totality of Aristotelian science, see S. Thomae Acquinatis in Aristotelis Libros De Caelo et Mundo Expositio, ed. Raymundus M. Spiazzi, O.F. (Romae, 1952), pp. 1-3. The account may strike one as being somewhat more rational than the facts warrant.
scientific synthesis? The question is crucial. The final pattern of a scientific system will be determined largely by what one takes as one's initial complexus of data. What needs explaining? In order better to understand the nature of the data in the De Caelo, let us first examine two texts from a closely related work, the De Generatione et Corruptione. They occur within a single chapter, and their apparent contradiction underlines the peculiar quality of Aristotle's experience:

To resolve bodies into planes and no further--this, as we have also remarked elsewhere, is in itself a paradox. Hence there is more to be said for the view that there are indivisible bodies. Yet even these involve much of paradox. Still, as we have said, it is possible to construct 'alteration' and coming-to-be with them, if one 'transposes' the same by 'turning' and 'inter-contact', and by the 'varieties of the figures', as Democritus does. (His denial of the reality of colour is a corollary from this position; for, according to him, things get coloured by 'turning' of the 'figures'.)4

It is wrong, however, to suppose, as some assert, that coming-to-be and passing-away in the unqualified and complete sense are distinctively defined by 'association' and 'dissociation', while the change that takes place in what is continuous is 'alteration'. On the contrary, this is where the whole error lies. For unqualified coming-to-be and passing-away are not effected by 'association' and 'dissociation'. They take place when a thing changes, from this to that, as a whole.5

What Aristotle apparently grants in the first text he takes back in the second. The contradiction, however, is only apparent.

4De Gen. et Cor., I, 2, 315 b, 32 - 316 a, 3.
5Ibid. 317 a, 18-23.
It is possible, he first grants, to elaborate a theory which will cover all the facts, provided you mean nothing more by facts than what is materially given and verifiable. That out of an aggregate having such and such a size, shape, color, you can obtain another aggregate having a different size, shape, and color, simply on the basis of the hypotheses which Democritus wanted to make,—this Aristotle is willing to grant. But, as he insists in the second text, there is something more given, something more to be explained: "a thing changes, from this to that, as a whole." It is his insistence that this something more is a part of the data, and that as such it must be incorporated into one's scientific explanations, that sets Aristotle off from his materialistic predecessors and from many of his successors.

This something more is given in experience. It is the conception which the intelligent, observant man makes of the nature of events or things and which he expresses in words. Aristotle states the position most uncompromisingly in his Nicomachean Ethics: "The good man judges each class of things rightly, and in each the truth appears to him."6 True, he is here talking about a class of phenomena which has its own

peculiarities. We cannot simply assume that what he says in
an ethical study is completely pertinent in the natural sciences.
But, as a matter of fact, we find a profoundly similar attitude
toward the significance of the experience of the ordinary in-
telligent man in Aristotle's physical works. Relative to the
De Generatione, for example, it is the common judgment of men
that when seed becomes a plant or a man the fact is that there
was one thing and it became another thing. There was a change
from this to that, as a whole. It is this fact, conceived in
this way, that must be retained in an adequate scientific theory.

This is the conception of experience which we find in the
De Caelo. We find it to a marked degree in the second chapter
of the first book. Because of the manifold importance of this
chapter, we quote it almost in full here:

The question as to the nature of the whole, whether
it is infinite in size or limited in its total mass, is
a matter for subsequent inquiry. We will now speak of those
parts of the whole which are specifically distinct. Let
us take this as our starting-point. All natural bodies and
magnitudes we hold to be, as such, capable of locomotion;
for nature, we say, is their principle of movement. But
all movement that is in place, all locomotion, as we term
it, is either straight or circular or a combination of
these two, which are the only simple movements. And the
reason of this is that these two, the straight and the cir-
cular line, are the only simple magnitudes. Now revolution
about the centre is circular motion, while the upward and
downward movements are in a straight line, 'upward' meaning
motion away from the centre, and 'downward' motion towards
it. All simple motion, then, must be motion either away
from or towards or about the centre. . . .

Bodies are either simple or compounded of such; and
by simple bodies I mean those which possess a principle of
movement in their own nature, such as fire and earth with
their kinds, and whatever is akin to them. Necessarily, then, movements also will be either simple or in some sort compound—simple in the case of the simple bodies, compound in that of the composite—and in the latter case the motion will be that of the simple body which prevails in the composition. Supposing, then, that there is such a thing as simple movement, and that circular movement is an instance of it, and that both movement of a simple body is simple and simple movement is of a simple body (for if it is movement of a compound it will be in virtue of a prevailing simple element), then there must necessarily be some simple body which revolves naturally and in virtue of its own nature with a circular movement. By constraint, of course, it may be brought to move with the motion of something else different from itself, but it cannot so move naturally, since there is one sort of movement natural to each of the simple bodies. Again, if the unnatural movement is the contrary of the natural and a thing can have no more than one contrary, it will follow that circular movement, being a simple motion, must be unnatural, if it is not natural, to the body moved. If then (1) the body, whose movement is circular, is fire or some other element, its natural motion must be the contrary of the circular motion. But a single thing has a single contrary; and upward and downward motion are the contraries of one another. If, on the other hand, (2) the body moving with this circular motion which is unnatural to it is something different from the elements, there will be some other motion which is natural to it. But this cannot be. For if the natural motion is upward, it will be fire or air, and if downward, water or earth. Further, this circular motion is necessarily primary. For the perfect is naturally prior to the imperfect, and the circle is a perfect thing. This cannot be said of any straight line:—not of an infinite line; for, if it were perfect, it would have a limit and an end: nor of any finite line; for in every case there is something beyond it, since any finite line can be extended. And so, since the prior movement belongs to the body which is naturally prior, and circular movement is prior to straight, and movement in a straight line belongs to simple bodies—fire moving straight upward and earthy bodies straight downward towards the centre—since this is so, it follows that circular movement also must be the movement of some simple body. For the movement of composite bodies is, as we said, determined by that simple body which preponderates in the composition. These premises clearly give the conclusion that there is in nature some bodily substance other than the formations we know, prior to them all and more divine
than they. 7

We shall return for a closer inspection of some of the argumentation later. What is important to note now is that basic to the argument is an experience typically Aristotelian. If one were to drop a somewhat heavy object, there would be a general agreement among men that what happened was that the object fell down. Likewise, most men would find no difficulty in admitting that it is simply a fact that the flames of a fire rise up. We who live and think in a later scientific tradition see no difficulty in admitting this as a fact, but then explaining that fact as something merely relative which may easily be transmuted by being placed in another explanatory context. To men like Galileo and Newton nothing seemed more evident than that the intelligibility that is given to experience in a judgment such as, "This object falls down," is relative. For scientific purposes, other points of view can be introduced and made to yield results which would otherwise be unattainable. Newton, for example, makes it one of the fundamentals of his physics that experience must be so re-interpreted if we are to escape from the purely relative notions of space, time, motion, and attain to the Newtonian absolutes. 8 And if we study Galileo's

7 De Caelo, I, 2, 268 b, 12 - 269 a, 32.

8 Sir Isaac Newton's Mathematical Principles of Natural Philosophy and his System of the World, tr. Andrew Motte, revised and with an appendix by Florian Cajori (Berkeley, 1946), pp. 6-12.
Dialogue on the Two World Systems, we find that what often distinguishes Simplicius (the Aristotelian) from the other two speakers is his inability to view things from the non-common-sense point of view.  

Be the subsequent history of scientific method what it may, Aristotle did not use the same initiative and imagination in his handling of experience that we have grown used to. To him, the fact, the scientific fact, was that objects fall down. As J.M. LeBlond has observed, "Aristote n'exige donc, pas seulement de s'accorder avec certains faits, mais il veut qu'on rejoigne l'ensemble, et tout spécialement les apparences qualitatives. Au fond, même, il ne s'agit pas pour lui de rejoindre les faits: il s'agit de ne pas les quitter."  

We speak of the world as given. For Aristotle this expression would have methodological import: the scientist is essentially receptive or passive before experience. It is something that is given; it is not to

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9 Galileo Galilei, Dialogue on Two World Systems, p. 38, n.32. The following judgment by an historian of science harmonizes with the view we are taking here of the Aristotelian attitude toward experience: "The special contribution that Galileo's conception of science as a mathematical description of relations enabled him to make to methodology, was to free it from the tendency to excessive empiricism which was the main defect of the Aristotelian tradition." A.C. Crombie, Robert Grosseteste and the Origins of Experimental Science: 1100-1700 (Oxford, 1953), p. 305.

be created.

Such an attitude is in basic harmony with the many theoretical statements which Aristotle makes about the nature of science. If the aim of science is to understand things in their ultimate causes, it can easily tend to suppose that the "things" are already given in some pre-scientific experience. I do not suggest that the Aristotelian attitude toward experience is a necessary correlate of his definition of science, but I do think that the attitude is abetted by the definition.

Aristotle's passivity toward experience is two-fold: in one direction it leads to a restriction of hypothetical boldness. This we have already considered. In another direction it leads to a de-emphasis on "experimentation." There is no direct impetus given to expand experience. On several occasions in the De Caelo, Aristotle speaks of the difficulties caused him by a lack of precise or sufficient data. He does not, however, see in this an invitation or a challenge to discover ways of creating new experience which might lead to a definitive

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11 Phys., II, 3, 194 b, 19-23; De Part. An., I, 1, 640 a, 1. For further references, see Troy Wilson Organ, An Index to Aristotle in English Translation (Princeton, 1949), p. 144. The entries of this index are based upon the Oxford translation.

12 De Caelo, I, 3, 270 b, 13; II, 3, 286 a, 3-7; II, 3 287 b, 32-34.
solution of his problems. He sees it rather as an essential limitation of the human powers of knowing.

This is not to say that he does not make use of what we would today call experimental data. To say that would be a drastic over-simplification. He not infrequently has occasion to use the astronomical data of his age. Even in the chapter quoted above, there are data which could hardly be called man on the street experience. That the heavens move in a circular path would hardly be a spontaneous judgment of the ordinarily intelligent man, but it was the common view of the early astronomers. Aristotle does incorporate astronomical data, but what is significant is that he does not seem to have seen new possibilities for science in the sort of work the astronomers were doing. He takes what they give him, and his science is deeply influenced by the data so obtained; but he neither participates in nor encourages their studies. He does not here seem to conceive of an experimental procedure as an intrinsic part of scientific method: experience is received, not created.

\[\text{E.g. De Caelo, II, 12, 292 a, 8. For further references see Allan, De Caelo, Index, under \textit{αστρολογία} and \textit{Α\ιγυπτικός}.}\]

\[\text{The following passage suggests that in some other works Aristotle saw greater scientific possibilities in experimentation: "This seems to be the manner in which the generation of the bees occurs, both according to argument and according to what seems to take place among the bees. What takes place, however, has not yet been explored sufficiently, but if it ever is, then credit must be given to sensation rather than arguments, and to arguments only if they accord with the observed phenomena." De Gen. An., III, 10, 760 b, 27-33.}\]
Due to this passivity before experience, the Aristotelian scientist finds himself in what may seem to us an anomalous position. The accumulation of data or experience, though it is necessary to science, is an extra-scientific procedure. It will not be the scientist's special work or special competence to supervise or to criticize this accumulation. Though he may sometimes doubt the value of the experience presented to him, he is in no position to carry out a radical evaluation of it. There is an ambient fund of experience made up of elements from common sense, empirical and mathematical astronomy, and tradition. This entire complexus is the scientist's starting point: this is his experience. Experience "est la qualité que l'on se plait à attribuer au vieillard, qui a beaucoup vu et beaucoup retenu, mais que l'enfant ne possède jamais."15 There are several interpenetrating levels within this experience, but Aristotle makes no sustained effort to separate these various levels. "Il veut se tenir d'une façon constante en contact avec les phénomènes, et avec les phénomènes de tout ordre, mais il ne voit nullement la nécessité d'en approfondir l'analyse."16

The second function of experience--experience as source

16Ibid., p. 222.
of scientific principles— is very similar to the first. Experience as it is manifest in common sense judgments already has something of a structure. By elucidating this already present structure the scientist will obtain his scientific principles. Aristotle speaks of the connection between principles, science, and experience in many contexts. We quote several of the more important passages:

In each science the principles which are peculiar are the most numerous. Consequently 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. 18

What has been said is confirmed by the fact that while young men become geometricians and mathematicians and wise

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17 Principle has at least two senses, both of which are related to experience. The first is the fact—δτι; it is a principle in that it initiates science. The second scientific principle—διότι—is the rationale of the fact, its intelligible basis. These two senses work into one another, so that it is not always easy to distinguish exactly between them; for, as we shall see in the case of natural motion, to announce what the fact is goes a long way toward giving its rationale. Nevertheless, in so far as we can distinguish these two senses, it is our present concern to show that experience (which is almost equivalent to principle in the sense of δτι) provides, or at least leads up to, principles in the sense of διότι—i.e. principles of rational explanation. For an extended list of texts in which Aristotle speaks of ἰγκαί as principles of knowledge, see H. Bonitz, Index Aristotelicus, 2nd ed. (Graz, 1955), III b, 59 - 112 a 40.

18 Prior Anal., I, 30, 46 a, 17-22. For further references, see Bonitz, 242 a, 59 - b, 10.
in matters like these, it is thought that a young man of practical wisdom cannot be found. The cause is that such wisdom is concerned not only with universals but with singulars, which become familiar from experience, but a young man has no experience, for it is length of time that gives experience; indeed one might ask this question too, why a boy may become a mathematician, but not a philosopher or a physicist. Is it because the objects of mathematics exist by abstraction, while the first principles of these other subjects come from experience?19

We can see the process of transition from experience (or principles in the sense of ὁτι) to principles of deduction in the already quoted second chapter of the first book of the De Caelo. As we shall show later, the definition of the elements in terms of their natural motions is the principle of the De Caelo; and the stuff of these definitions is already contained in "the phenomena ... adequately apprehended."20 'Phenomena' as used here has the meaning of humanly interpreted data, and comes very close to meaning the same thing as experience. In De Caelo, I, 2, the adequately apprehended phenomena are that earth falls down, fire rises, and the heavens revolve about us. It is a simple matter then to define up, down, and around in terms of a center and extremity of the world. This done, and Aristotle has most of what he will need for his science of the heavens.

19 Nic. Eth., VI, 8, 1142 a, 12-18.

20 From text cited above, note 18. 'Phenomenon' has several senses. The present context makes it fairly clear that Aristotle is using the word in the way in which I have defined it. On the various senses of the word, see Bonitz, 809 a, 23 - b, 7, especially a, 60 - b, 7.
We find a similar procedure in the second chapter of the second book. Here Aristotle discusses the suitability of using categories such as front and back, right and left, and up and down as scientifically explanatory principles. He observes that it is possible that some of these categories may be thought to be merely conventional or relative to the one using them, but he goes on to use them to solve problems which he raises in the fifth chapter of the same book. Once again, it is a question of principles which can come only from experience conceived in the Aristotelian sense: the ambient world as already understood by the intelligent man. Such a man will make distinctions about right and left or top and bottom in speaking of the heavens, and these prove to be the very categories which the scientist needs for his work.

Besides the two examples already cited (i.e. the formation of the doctrine of natural motion and the distinction of up and down, etc. as significant astronomical categories), we find that Aristotle is repeatedly drawing upon a not too clearly defined body of wisdom for the progression of his argument. This body of wisdom we will best describe as experience. One time he will seem to draw upon a corporate fund of principles: "But since the natural movement of the whole and of its part--

21 De Caelo, II, 2, 285 a, 2-5.
22 Ibid. 5, 288 a, 2-13.
of earth, for instance, as a whole and of a small clod—have one and the same direction." 23 Another time his reference will be to a generally admitted corporate observation: "But all natural bodies which change their properties we see to be subject without exception to increase and diminution." 24 In both cases there is an important similarity in the progression of thought. On the basis of something generally known and admitted, we proceed to some sort of scientific conclusion.

We begin to see an arbitrary quality in Aristotle's use of experience. He selects what he needs from experience and considers that the scientifically significant. The basis of his selection is not so much the experience itself as the goals which he must reach as a scientist. These goals, and the consequent use of experience, will depend largely upon the example of Aristotle's scientific predecessors and the questions which they posed for him to answer. 25 The somewhat haphazard search for principles amid experience is suggested by the following: "The principles of syllogisms have been stated in general terms,

23 Ibid. I, 3, 270 a, 3-6.

24 Ibid. 270 a, 30. For further instances of this type of experience as source of principles, see Ibid. I, 5, 272 a, 5-7; II, 6, 288 b, 9-10.

25 I will take up this question more in detail in the following chapter.
both how they are characterized and how we must hunt for them, so as not to look to everything that is said about the terms of the problem or to the same points whether we are confirming or refuting, or again whether we are confirming of all or of some, and whether we are refuting all or some; we must look to fewer points and they must be definite. 26

It is difficult to state precisely how the scientist should move from experience to principles. Particularly in the realm of the physical sciences, Aristotle seems to have found it difficult to elaborate a general methodology on this point. 27 It would almost seem that by trial and error, and particularly by the accumulation of tradition, the discovery of principles within a science just happens and science becomes possible. A man finally comes along who uncovers the significant aspects of our experience, and he is able to carry the science near its final perfection.

The final function of experience in the scientific process is to provide means of verifying the statements of the scientist. There is chronological justification for postponing a consideration of this use of experience until the conclusion of this study, but we may consider it here for the light it will

26 Prior Anal., I, 30, 46 a, 10-16.
shed on Aristotle's general attitude toward and use of experience.

Aristotle calls upon two general types of experience to verify his scientific findings. The first type is, again, a sort of corporate wisdom; the second involves empirical observation. We find both kinds of experience in the third chapter of book one in the De Caelo. Aristotle has argued to the inalterability of the ether, and now goes on to show that his conclusion is in accord with the universal opinion of men, according to which the highest place in the world is attributed to the immortal gods: "Our theory seems to confirm experience and to be confirmed by it. For all men have some conception of the nature of the gods, and all who believe in the existence of gods at all, whether barbarian or Greek, agree in allotting the highest place to the deity, surely because they suppose that immortal is linked with immortal and regard any other supposition as inconceivable. If then there is, as there certainly is, anything divine, what we have just said about the primary bodily substance was well said."  

He then calls upon empirical observation to substantiate the same conclusion: "The mere evidence of the senses is enough to convince us of this, at least with human certainty. For in the whole range of time past, so far as our inherited records reach, no change appears

\[\text{De Caelo, I, 3, 270 b, 4-12.}\]
to have taken place either in the whole scheme of the outermost heaven or in any of its proper parts." Finally, still trying to confirm his original deduction, he returns to corporate wisdom as embodied in language: "The common name, too, which has been handed down from our distant ancestors even to our own day, seems to show that they conceived of it in the fashion which we have been expressing. The same ideas, one must believe, recur in men's minds not once or twice but again and again. And so, implying that the primary body is something else beyond earth, fire, air, and water, they gave the highest place a name of its own, aether, derived from the fact that it 'runs always' for an eternity of time."  

One might ask how the popular theology can be considered 'experience.' Aristotle's philosophical predecessors were well aware of the fallibility of these theological views, and since Aristotle was well aware of the work of these men we naturally suppose that he knew the short-comings of this theology.

\[\text{29 Ibid. 13-17.}\]
\[\text{30 Ibid. 17-24.}\]
\[\text{31 It is to be noted that in the text cited above, note 28, Aristotle explicitly speaks of the popular religious views as experience.}\]
\[\text{32 The criticisms of Xenophanes, for example, are famous. See H. Diels, Die Fragmenten der Vorsokratiker, 5th ed. (Berlin, 1934), I, 132-133 (21. B 15).}\]
The reason for his use of these traditions is, I think, something like this: solidly traditional theological views form a part of the understood world out of which the scientist operates. They are data. Admittedly they are data of a peculiar kind, and may involve considerable error; but where they are serviceable and where there seems no good reason for calling them into question, Aristotle is ready to consider them as part of the complexus of fact with which his theories and their consequences are to conform. Aristotle does not thereby commit himself to a defense of these religious doctrines, but as long as they are there he seems to feel that he has every right to call upon them when they can be of use.

Verification is a part of the scientific process throughout the De Caelo, but the experience involved is never more exact or more exacting than it is in the texts just quoted. We can see, consequently, that verification will not play quite the same role in Aristotle's science as it would play in later scientific techniques. In Aristotle, verification functions mainly as a means of confirming something about which one has already decided or as a dialectical device by which to convince others of the truth of one's statements. It does not (and because

33For verification based on tradition, see De Caelo, I, 9, 279 a, 22-30; II, 1, 284 a, 11-14. For verification based upon a generalized empirical observation, see I, 8, 277 a, 28 - b, 3; II, 4, 287 a, 11; II, 6, 289 a, 7-8.
of its vaguely defined nature it could not) enter as the criterion by which to judge the truth or falsity of one's initial positions.

Theoretically Aristotle gives recognition to the exigencies and the integrity of experience in scientific verification. The real world, given only in experience, is the standard to which the scientist and his theories must measure up. He criticizes other philosophers because, "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." There is a modern ring to this, but the modernity ought not to be exaggerated.

Empirical verification as we know it today is possible only when


\[35\] Duhem remarks: "Aristote veut que la Physique soit une science d'observation; alors même qu'elle utilisera les raisonnements du mathématicien, elle partira de la perception sensible qui lui fournira ses principes, et elle aboutira à la perception sensible à laquelle ses conclusions devront se conformer; la perception sensible sera, pour elle, la source de la certitude et le critérium de la vérité." Système, I, 150. The statement, though it certainly has its share of truth, would seem to make Aristotle a bit more of a modern than he actually turns out to be. The statement might hold about Aristotle the biologist, but Duhem is concerned with Aristotle the physicist and astronomer.
a theory can be shown to cover a totality of experience that is carefully defined both in extent and in structure. Before verification can be scientifically meaningful, it must be determined what is the area of facts to which theory must conform and what aspect of these facts must it explain. In Aristotle, experience simply does not have this precision. When he has reached a conclusion he can turn to a great mass of experience and can draw from it whatever will serve his purposes.

The data and theories of the mathematical astronomers might have provided a field of experience sufficiently well defined for significant verification; but, as we shall see in the following chapter, Aristotle's questions are never such as to lead to answers that could be judged by astronomical evidence. He seems to have been working in one scientific tradition, the astronomers in another; and though he might at times use their findings, he never attempted to subordinate his work to theirs.

36 Newton, for example, had in the data accumulated and organized by his predecessors a field of experience exactly limited both in extent and in structure. His theories would have to explain neither more nor less than this totality. His fourth rule for reasoning in philosophy reads: "In experimental philosophy we are to look upon propositions inferred by general induction from phenomena as accurately or very nearly true, notwithstanding any contrary hypotheses that may be imagined, till such time as other phenomena occur, by which they may either be made more accurate, or liable to exceptions." *Principia*, p. 400.

Thus we have considered the three major functions of experience in the first section of the De Caelo. By way of summary, let us state what our main conclusions have been.

(1) Experience--i.e. reality as found and judged by the ordinary intelligent man--provides the irreducible data of science. This data will include not only common sense experience but the available scientific data as well.

(2) Experience will provide the fundamental principles with which the scientist will create his science. At this level the scientist must work actively on experience, discovering in the confused ensemble of experience those aspects which will be scientifically fruitful.

(3) Experience functions in a process of verification. However, because of the nature of this experience and because of the use Aristotle makes of it, verification does not function in an absolutely decisive way in Aristotle's scientific method.
CHAPTER III

THE QUESTIONS OF THE DE CAELO

The scientist, working within a given totality of experience, poses the questions which he thinks will lead to an understanding of that experienced reality. It has been observed that "the formulation of a problem is often more essential than its solution, which may be merely a matter of mathematical or experimental skill. To raise new questions, new possibilities, to regard old problems from a new angle, requires imagination and marks real advance in science."¹ It will be the thesis of this chapter that the questions of the De Caelo are not original formulations of problems, that they are rather the questions posed for Aristotle by the tradition in which he was working.

We may break down the section of the De Caelo which we are studying into the following major questions:

(1) Is the world finite or infinite? (I, 5-7)
(2) Is this world the only world? (I, 8-9)

(3) Is the world eternal? (I, 10 - II, 1)

(4) Is the outer sphere of the world regular or irregular in its shape and motion? (II, 4 and 6)

(5) Why does the motion in the world take place as it does? (II, 2-3, 5)

The chapters which precede the fifth chapter of the first book, though of crucial importance, do not properly constitute a question. As we shall see in the next chapter, Aristotle is there rather establishing the principles which will found his answers in the subsequent chapters. The actual division which I have made is not the only one possible. One could, for instance, combine questions one and two, and make two questions of number four. The exact lines of division are not important. What is important is that the ensemble of questions has its roots in the historical tradition in which Aristotle the scientist is working. As Werner Jaeger has observed, the content and order of the questions in the De Caelo is intelligible only within the historic setting of the Academy.²

It would be perhaps impossible—certainly, for our present purposes unnecessary—to trace back these questions to their absolutely first sources. We shall aim here only to show that they point back behind Aristotle.

Aristotle considered his first question traditional. This is clear from the introduction to chapter five: "This being clear, we must go on to consider the questions which remain. First, is there an infinite body, as the majority of the ancient philosophers thought, or is this an impossibility?" The question is posed. Aristotle immediately testifies to its importance: "The decision of this question, either way, is not unimportant, but rather all-important, to our search for the truth. It is this problem which has practically always been the source of the differences of those who have written about nature as a whole." The reason for this stress becomes clear when we recall the Greek equation of the limited with the intelligible and the importance of this equation in Aristotelianism: the proof, for example, of an unmoved mover (or unmoved movers) depends on the impossibility of an infinite regress, and hence depends on the answer given to the present question.

The point which I would make about this question is that it is a part of an entire intellectual tradition, and that in

3De Gælo, I, 5, 271 b, 1-3.

asking and answering it Aristotle did not consider himself an innovator. The means he uses to reach a solution might be new—that remains to be seen—but the question is traditional.

The second question concerns a finite plurality of worlds. We do best, I think, to consider it as a subsidiary part of the first question. We may infer from the rather loose way in which Aristotle develops an answer to this question (as contrasted with his painfully exact and elaborate treatment of the first question) that he does not judge it to be of as fundamental importance. And indeed it should not be; for a science might still be possible on the supposition of a plurality of worlds, but not if there were an infinite number of worlds or if the one world were infinite. An infinite would have no first from which deduction could proceed. A finite plurality of worlds seems never to have been a popular doctrine in pre-Aristotelian thought. Plato suggests it as a possible position in the *Timaeus*, but seems himself to prefer a unique world. It is further instructive that Simplicius in his commentary on the *Physics*, divides all the opinions on the number of worlds into two: a unique world and an infinity of worlds. He places Plato with Aristotle as holding a single world.

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5 *Timaeus*, 31 A-B, 55 C-D.

6 *Simplicii in Physicorum*, II, 1121.
Therefore we can look upon this question and its answer as contributing to completeness of treatment rather than as a hotly disputed point. This view is substantiated by the academic way in which Aristotle approaches the question: "The question might possibly be raised whether there is any obstacle to our believing that there are other universes composed on the pattern of our own, more than one, though stopping short of infinity."?

We need only read Aristotle to learn of the traditional background of the third question, on the eternity of the world. The details of his account and criticism of his predecessors need not detain us here, since our present aim is only to indicate the role of tradition in the formation of the questions of the De Caelo. In the present case, Aristotle gives us all the information that we need.

The fourth question is this: Is the outer sphere of the world regular or irregular in shape and motion? Here Aristotle joins a long and rich tradition in Greek thought:

Le génie grec, si sensible à la beauté qu'engendrent les combinaisons géométriques simples, dut être singulièrement séduit par cette découverte; elle fortifia en lui, si elle ne l'y fit germé, l'idée que le Monde, et par

7De Caelo, I, 6, 274 a, 26-29; see also I, 8, 276 a, 19-22.
8Ibid. I, 10, is entirely devoted to a consideration of earlier theories about the eternity of the world.
ticulièrement le Monde céleste est soumis aux règles éternelles des nombres et des figures; elle suscita sans doute, en l'École pythagoricienne, la conviction que les cours des astres, quel qu'en soit le caprice apparent, se laissent résoudre en combinaisons de mouvements circulaires et uniformes; empruntée aux Pythagoriciens par Platon, transmise de Platon à Éudoxe, cette conviction donnera naissance à l'Astronomie géométrique; et elle ne cessera de dominer les divers systèmes de cette Astronomie qu'au jour où Kepler aura l'incroyable audace de substituer le règne de l'ellipse au règne du cercle. 9

The final question—why does the motion in the world take place as it does?—introduces a new type of intelligibility. It is not here a question of yes or no, but a question of why. We are reminded of the Socrates of Plato's Phaedo:

I rejoiced to think that I had found in Anaxagoras a teacher of the causes of existence such as I desired, and I imagined that he would tell me first whether the earth is flat or round; and after telling me this, he would proceed to explain the cause and the necessity of this being so, starting from the greater good, and demonstrating that it is better for the earth to be such as it is; and if he said that the earth was in the centre, he would further explain that this position was the better, and I should be satisfied with the explanation given, and not want any other sort of cause. And I thought that I would then go on and ask him about the sun and moon and stars, and that he would explain to me their comparative swiftness, and their returnings and various states, active and passive, and in what way all of them were for the best. 10

In posing what we have called his fifth question, Aristotle is carrying out the Socratic program.

9Duhem, I, 9. 'Cette découverte' refers to the discovery, made by the Pythagoreans, that the motion of the sun could be described by a combination of circles.

10Phaedo, 97 A - 98 D. The translation is from The Dialogues of Plato, tr. by B. Jowett, 4th revised ed. (Oxford, 1953), 1, 455.
I would conclude, therefore, that Aristotle was not an innovator in posing the scientific questions of the *De Caelo*. Neither, it seems, did he think that originality on this score was particularly desirable or 'scientific.' At one point he does bring himself up before one of his questions and asks whether the question which he is posing is a real question and whether it has an answer. But he does not try to carry out any kind of critique of the question to determine its significance. Apparently undisturbed, he proceeds to answer it.\(^\text{11}\)

We ought also to note at this point that each of the first four questions (and they seem to be more important to Aristotle's mind than the fifth) is posed as a dichotomy. If one opinion can be proved impossible the other will *ipso facto* be proved true. If the world cannot be unlimited it must be limited; if it cannot have a beginning and an end in time then it must be eternal; if there is no possible cause for its irregularity it follows that it is regular.

This 'either-or' in the questions will affect the method of investigation. There will be no need for an extensive empirical investigation if it can be shown deductively, on the basis of principles, that one part of a dichotomy is intrinsically impossible. And further, the very nature of the quest-

\(^{11}\text{*De Caelo*, II, 5, 287 b, 27-31.}\)
tions makes significant empirical investigation almost impossible. One cannot measure the eternity or the infinity of the world. One must reason to it or simply give up the scientific endeavor.
CHAPTER IV

THEORY IN THE DE CAELO

We can hardly over-estimate the importance of the ideas which the scientist brings to his scientific work, especially those ideas which concern what the scientist is looking for and how he is to go about finding it. These ideas we may call the scientist's heuristic structure. Before the scientist can even begin to work, he must have at least some idea about what it means to know--to know scientifically--and must have at least a general plan according to which he will try to advance toward this knowledge or understanding.

Aristotle had such ideas, and to understand why his science is what it is we must discover what these ideas were.

What does it mean to understand the material world? Plato (and others, of course, before him) had posed the question,¹ and had come to the conclusion that the material world--at least viewed precisely as material--could not be understood. Matter, viewed exclusively as matter, was a chaos about which no

¹Phaedo, 96 A - 98 D.
lastingly significant statement could be made. One could not say that it was anything in itself. The human mind makes statements about the material world—that this, for instance, is a man—but it is subsequently forced to negate its statement and to say that this is something else. If a permanently significant scientific statement is to be possible, obviously it cannot be of the type in which we predicate something of a material reality. Scientific statements will focus rather on the predicated natures in themselves. The scientist will study in their inner intelligibility the never-changing meanings which we find momentarily reflected in the world of our sense experience.

Aristotle works within the tradition created by Plato. True, there are other influences at work in the formation of his scientific method; but his conception of the structure of scientific explanation is, I think, most properly understood as a modification from within Platonism.

For Aristotle, scientific understanding is understanding

2Timaeus, 49 C - 52 D.
3Ibid., especially 52 A. See also Republic, 476 A-D.
in terms of four-fold causality: material and formal, efficient and final.\(^5\) Where he insists upon efficient and final causality as necessary for scientific explanation, Aristotle believes that he is going beyond Plato.\(^6\) In including material causality as a source of intelligibility he goes against the Platonic stream. But in his use of formal causality he is developing the Platonic tradition; and it is to be noted that formal causality is dominant in Aristotle's sciences, to the point that often it seems almost to absorb final and efficient causality.\(^7\)

Aristotle's running polemic against the Platonic theory of ideas can obscure the fundamental continuity between that theory and the Aristotelian theory of matter and form. Certainly there are important differences between the two. In Plato it is not the material thing that is known, but some ideal content that in itself is other than this or that partial and momentary realization. Aristotle tries to bridge this gap between object of knowledge and the transient data of experience by his matter-form, act-potency ideas.

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\(^{5}\textit{Post. Anal.}, I, 2, 71 b, 8-16; \textit{Phys.}, II, 7, 198 a, 14-22.\)

\(^{6}\textit{Met.}, A, 6, 988 a, 7-9.\) It is at least questionable whether Aristotle's judgment that Plato knew only two causes is justified.

Aristotelian matter we may describe as that which is never itself.\(^8\) Of its very nature it achieves the status of being only by being something,\(^9\) and this something that it is will be already trans-material. Form is the act of the matter, the perfection by which matter is something. Form, in thus making matter real, does not make it "real matter" but rather makes it a real thing; for in the material order, thing, "the individual horse or man,"\(^10\) material substance, is the only kind of reality there is.\(^11\) To ask what holds matter and form together so as to make but one being is to misconceive their relationship. Matter and form are not to be thought of as beings fully established in themselves, and thus requiring some sort of ontological glue to hold them together. In a certain sense the matter is the whole being; in another sense the form is the whole being. The form is what the matter is: it is the ontological significance of the matter.\(^12\)

Granted that these two conceptions of the nature of material

\(^8\) *Met.*, Z, 3, 1029 a, 20.
\(^9\) *Ibid.*, 7, 1033 a, 24 - 1034 a, 8.
\(^10\) *Cat.*, 5, 2 a, 13.
\(^11\) *Met.*, Z, 7, 1033 a, 24 - 1034 a, 8.
\(^12\) *Ibid.*, H, 6, 1045 a, 20 - b, 23.
\(^13\) On this entire rather intricate point, see Owens, pp. 220-225.
reality are very much different, we must note that they lead to deeply similar concepts of the nature of scientific intelligibility. Both Plato and Aristotle conceive intelligibility in terms of what a thing is, the former with his doctrine of ideas, the latter with his theory of form or essence. And where in Plato we find the ascent to the ideas of central importance, in Aristotle it is the definition that provides the center of intelligibility.

With this by way of preliminary, we can now briefly describe the ideal form of Aristotelian science. Through induction and insight we come to a knowledge of the essence of the subject of the particular science with which we are concerned. This subject may be the heavenly bodies, it may be human actions, the soul, changing beings in general. In each one we come to a primary subject matter which cannot be deduced from the sub-

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14 Owens, p. 225: "So in terms of scientific knowledge, matter will ultimately be explained in terms of form. The material cause, in scientific explanation, has to be reduced to the formal. The final 'why' in the realm of material as well as efficient causality, must be reduced to the form.

"This does not mean, however, that the matter any more than the efficiency can be deduced from the form. . . . But both are scientifically knowable only in terms of form, and accordingly their ultimate explanation in a science lies in their reduction to the formal cause." Compare Aquinas: "Quicquid igitur est in re quod non potest cognosci per cognitionem substantiae eius, oportet esse intellectui ignotum." 3. Thomae de Aquino, Summa Contra Gentiles, Editio Leonina Manualis (Romae, 1934), III, 56.

15 Post. Anal., II, 19, 100 a, 10; 100 b, 12.
ject matters of other sciences, but must be discovered in itself. The definition of the essence so reached will be the fundamental principle of the science. It is the most certain knowledge which we can have within the limits of this particular science, and will become the cause or intelligible ground of the entire body of scientific knowledge. Science, considered as a habit of the scientist, will be the ability to demonstrate from such a starting point all that is eternal and necessary about the subject. Our knowledge will be limited to these aspects because only such can be proved of a subject by a deduction from its immutable essence.

From this brief and general sketch, we can see the central position of the definition. To focus our study of the theory of the De Caelo, let us first outline Aristotle's ideas on the definition and then follow this outline through the work at hand, marking the significant convergences and divergences.

The definition can be seen from two points of view. We may consider it as a technique of classification or as the intelligible expression of the essence of the thing defined. In Aristotle's mind these two aspects involve one another. When he speaks of

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17 Ibid., II, 3, 90 b, 23-25.
the definition it is usually from the second point of view, but he thinks that he will have achieved an enunciation of the essence when he has succeeded in classifying it as an *infima species*. The essence is defined in terms of genus and specific difference.

But how is the definition obtained? This is certainly a crucial question in Aristotelian science. Yet, contrary to what one might expect, Aristotle worked out no general solution to the problem: "Aristote, malgré son gout prononcé pour l'étude théorique des méthodes de la science ou de l'art, et malgré une étude approfondie et plusieurs fois reprises des moyens qui permettent de définir, Aristote n'est point parvenu à élaborer une méthode ferme de définition. Ce n'est pas qu'il ne se soit fait une idée précise du but à atteindre."  

Aristotle approaches the problem of definition in the *De Anima* in the following words:

As the form of question which here presents itself, viz. the question 'What is it?', recurs in other fields, it

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19 *Met.*, Z, 5, 1031 a, 12; *Post. Anal.*, II, 3, 90 b, 16.  
might be supposed that there was some single method of inquiry applicable to all objects whose essential nature we are endeavouring to ascertain... In that case what we should have to seek for would be this unique method. But if there is no such single and general method for solving the question of essence, our task becomes still more difficult; in the case of each different subject we shall have to determine the appropriate process of investigation. 23

And from the difficulties which he encounters in elaborating the definition of the soul, it is clear that he does not consider any one technique as the method of attaining definition. 24 The point to be noted in this text is that the definition is not given in some sort of intuitive flash. In one way or another it must be worked to. The ingenuity of the scientist will be called into play for this crucial step in the scientific process. 25

Aristotle's long treatment in the Topics of the means of establishing and destroying definitions shows him well aware of the difficulties and insecurities which his doctrine of definition would involve. 26 It is his theoretical view that the definition ought to engender πιστις 27 in his hearers, which

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23 De Anima, I, 1, 402 a, 11-19.
24 Roland-Gosselin, p. 670.
26 Top., VI and VII.
27 Ibid., I, 1, 100 b, 19; De Caelo, I, 3, 270 b, 4. For the shades of meaning of this word, see Bonitz, 595 b, 8-59.
would mean that the hearers see and grant the definition, not merely for the sake of argument, but because they find it convincing. But along with this theoretical position we find a practical recognition that such assent is not easily won.28

For science as Aristotle conceives it to be absolutely certain, the definition would have to be attained in perfect clarity and certitude. But he was quite aware that we seldom if ever are given such ideal definitions. We must elaborate them out of experience by means of dialectic,29 and further debate on their validity will remain an almost endless possibility. If we fail to take this into account, we shall be mystified by much of what we find in the De Caelo.

We have, then, made the following points about the Aristotelian definition: (1) It is an expression of an essence in terms of genus and difference. (2) It is not simply given or intuited; it must be worked to. (3) In the concrete, it is to gain the acceptance of the audience. (4) It is premiss, mediate or immediate, to all the demonstrations which follow in the body of the science.

In the De Caelo we find the doctrine of natural motion

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28Top., VII, 5, 155 a, 2-18.

29Prior Anal. I, 30, 46 a, 18-22; Top., I, 2, 101 a, 36.
fulfilling the functions of the definition.

Natural motion is an attempt at an essential definition of the nature or natures of the bodies moving in the world. The world which Aristotle is trying to understand, the subject matter of his science, is a world of bodies in local motion. "Let us take this as our starting-point. All natural bodies and magnitudes we hold to be, as such, capable of locomotion."30 Taking this world as a whole, the first thing he does is to define its specifically different components.31 Such definition will classify according to genus and specific difference, and so will enunciate the essences of the bodies involved. The genus is bodies in local motion. The differences will be based upon the nature of the motion which is intrinsic to the various bodies.

But why does the motion and the goal of that motion give us access to the very nature of a thing? The answer to this question arises out of Aristotle's conception of physics. We may define physics as the science of bodies which have within themselves an "innate impulse to change."32 This physis or nature is identified with the form of the physical body:33

30De Caelo, I, 2, 268 b, 15.
31Ibid. b, 14.
32Phys., II, 1, 192 b, 18.
33Ibid., 193 b, 3-7.
the principle which determines what a thing is becoming (i.e. the nature) and the principle which determines what a thing is (i.e. the form) are identical in all changeable things. To know what a thing is becoming is to know what that thing is.

Because nature is the principle which regulates activity from within a being, we can argue to nature from an empirically given regular activity which has no external source. If we find that something happens in a certain way always or almost always, we can validly reason to some nature as cause. In the De Caelo, where it is question of local motion, a regular local motion will reveal a nature, a natural body.

But since Aristotle is interested in finding the ultimate natures out of which all bodies are composed, he is first of all interested in those bodies which have a perfectly simple nature; and these natures will be revealed by perfectly simple motions.

Aristotle has already\textsuperscript{34} considered the problem of simple motions in the Physics:

In every kind of motion we may have regularity or irregularity: thus there may be regular alteration, and locomotion in a regular path, e.g. in a circle or on a straight line, and it is the same with regard to increase and decrease. The difference that makes a motion irregular is

\textsuperscript{34}The problem of the relative chronologies of Aristotle's writings is a difficult one. Whatever the dates of the actual texts which we have, it is obvious that the assumption of straight and circular as the two simple figures in the De Caelo presupposes a previous discussion of the matter.
sometimes to be found in its path: thus a motion cannot be regular if its path is an irregular magnitude, e.g. a broken line, a spiral, or any other magnitude that is not such that any part of it taken at random fits on to any other that may be chosen.\textsuperscript{35}

The identification of the straight and the circular as the only simple figures presented no immediate problem in the \textit{De Caelo}. This is clear from the near-dogmatic manner in which he announces the fact: "But all movement that is in place, all locomotion, as we term it, is either straight or circular or a combination of these two, which are the only simple movements. And the reason of this is that these two, the straight and the circular line, are the only simple magnitudes."\textsuperscript{36}

Once granted that the simple bodies are to be identified by these precise motions, Aristotle proceeds to define what such movements will be in our universe: "Now revolution about the centre is circular motion, while the upward and downward movements are in a straight line, 'upward' meaning motion away from the centre, and 'downward' motion towards it. All simple motion, then, must be motion either away from or towards or about the centre."\textsuperscript{37} The next step is to line up the simple movements with the simple bodies. Earth Aristotle defines

\begin{itemize}
  \item \textsuperscript{35} \textit{Phys.}, V, 4, 228 b, 19-25.
  \item \textsuperscript{36} \textit{De Caelo}, I, 2, 268 b, 17-20. See also, \textit{Phys.}, VIII, 8, 261 b, 2; 9, 265 a, 14.
  \item \textsuperscript{37} \textit{De Caelo}, I, 2, 268 b, 21-24.
\end{itemize}
as the body which moves toward the center of the world; fire is the body which moves away from that center. And because there must be a body which moves with the simple circular motion, we can be sure that there is a non-terrestrial element which moves in a circular path which encloses all the rest. 38

In this way Aristotle has established the essential definitions of the basic constituents of the universe of moving bodies. The genus is "moving body"; the differences are the specific motions or places. 39

The second observation which we made about the definition in Aristotelian science was that it is neither demonstrated nor simply given, but that it must be worked to. This is notably true in the *De Caelo*. The exact process by which Aristotle came upon his definitions was perhaps never put down, 40 but

38 *Ibid.* 269 a, 2-7. Is this argument simply a saltus from the geometrical to the physical order? Perhaps, but it seems not. Such, at least, is not the only possible interpretation. The argument seems rather to be from the fact of bodies moving in a circular or near-circular way to the conclusion that there is some real body to which such motion belongs by nature. That the fact of such motion was an assumption common to both Aristotle and his audience is clear from *De Caelo*, I, 5, 272 a, 5-9. See also Duhem, I, 9.

39 For the ambiguity consequent upon Aristotle's failure to define natural bodies consistently in terms of place or motion, see below, p. 58.

40 Jaeger, p. 300, argues that the note of triumph with which Aristotle exploits the idea of natural motion indicates that it was a new discovery for Aristotle and his circle.
we might reconstruct it somewhat as follows.

The experientially given contains, among its many details, the fact that earth moves downward, etc. It is this welter of experience that must be made to yield answers to the scientist's questions, and this must be done through the medium of essential definitions. Since the problems all involved moving bodies in our universe, Aristotle may have received some hint that precisely here would be found the generic definition which he would need. "Let us take this as our starting point. All natural bodies and magnitudes we hold to be, as such, capable of locomotion."41 Add to this his ideas on the nature of the geometrically and physically simple figures, and he could mark out the significant distinctions among the various bodies. Looking back, we might find this progression of thought fairly simple, in a way almost inevitable. But for the man working out the theory for the first time, it involves a bold insight into an undifferentiated assembly of facts in order to fix on this or that as the scientifically fruitful. Not everything is fruitful, and it is for the scientist to determine what is. In the De Caelo, Aristotle's decision as to what is significant results in the doctrine of natural motion.

41De Caelo, I, 2, 268 b, 15-16. 'As such' translates ἀπὸ ἀυτῷ. It is difficult to say how much emphasis and how precise a meaning Aristotle intends for the expression. Cf. Bonitz, 369 b, 43-61.
But since it is a difficult and often somewhat hazardous labor for the scientist to establish his basic definition, the question naturally arises: What attitude does he expect his definition to engender in his auditors, those who are collaborating in his scientific endeavor? The definition is the foundation of the entire science. It would seem therefore that it should lead to an absolute certitude. Otherwise, how could science be science? Viewing matters in the abstract, we might suppose that Aristotle assigned to the definition just such a certitude. However, if we study the text of the *De Caelo*, and try to correlate it with hints gathered from various other works, we find at least an ambiguity on the point. In fact, it seems that Aristotle was willing to grant that at times the fundamental principles of a science were merely the best available and perhaps not all that the scientist would like them to be.

There is frequent reference to the initial definition throughout the *De Caelo*. Sometimes these references do not even hint that the starting point was in any way problematic. Just as often, however, there is a note of uncertainty: not that Aristotle would call into question the validity of his starting point, but he does seem to recognize that his procedure does not guarantee the impossibility of error at this fundamental point.

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42 *De Caelo*, I, 8, 276 b, 4-10.
The following texts illustrate this attitude:

Every body must necessarily be either finite or infinite, and if infinite, either of similar or of dissimilar parts. If its parts are dissimilar, they must represent either a finite or an infinite number of kinds. That the kinds cannot be infinite is evident, if our original presuppositions remain unchallenged. 43

The result is that we must either abandon our present assumptions or assert that the centre and the extremity are each numerically one. But this being so, the heaven, by the same evidence and the same necessary inferences, must be one only and no more. 44

The reasons why the primary body is eternal and not subject to increase or diminution, but unaging and unalterable and unmodified, will be clear from what has been said to any one who believes in our assumptions. 45

Even more decisive than these texts is the following: "In general, our quarrel with those who speak of movement in this way cannot be confined to the parts; it concerns the whole universe. One must decide at the outset whether bodies have a natural movement or not, whether there is no natural but only

43 Ibid. I, 7, 274 a, 30-34. The last sentence in the Greek reads: δει μεν τοινυν ουχ ουδον τε εξ ἄπειρων, φανερόν, ει τις υμίν εδήσει μένειν τας πρῶτας ὑποθέσεις.

44 Ibid. I, 8, 277 a, 9-13. Ὡς ἀναγχαγάν ἡ κίνειν ταύτας τὰς ὑποθέσεις, ἢ τὸ μέσον ἵνα εἶναι καὶ τὸ ἔσχατον. τούτου δ' οὖν τὸν ἀνάγκη καί τὸν οὐρανὸν ἕνα μόνον εἶναι καί μὴ πλείους, τοῖς αὐτοῖς τεκμηρίοις τούτοις καὶ ταῖς αὐταῖς ἀνάγκαις.

constrained movement. Seeing, however, that we have already decided this matter to the best of our ability, we are entitled to treat our results as representing fact.⁴⁶

As suggestive as this last, though of a more general nature, is this passage from the first chapter of book three: "Discussion of the other views may be postponed. But this last theory which composes every body of planes is, as the most superficial observation shows, in many respects in plain contradiction with mathematics. It is, however, wrong to remove the foundations of a science unless you can replace them with others more convincing."⁴⁷

These texts represent, I believe, Aristotle's working attitude toward the scientific endeavor. He seems to look upon science as a difficult, often imperfect thing. It depends entirely upon a foundation (the definition), but the human mind

⁴⁶Ibid. II, 13, 294 b, 30 - 295 a, 2. ὅλως δὲ πρὸς τοὺς οὖσα λέγοντες περὶ τῆς κινήσεως οὐ περὶ μορίων ἐστὶν ἢ ἀμφίσβητης, ἀλλὰ περὶ διὸν τινὸς καὶ παντὸς. ἐξ ἀρχῆς γὰρ διώριστον, πότερον ἐστὶ τις τοῖς σώμασι φύσει κίνησις ἡ σύνθεσις, καὶ πότερον φύσει μὲν οὐκ ἐστὶ, βία δ' ἐστιν. ἐπεὶ δὲ περὶ τούτων διώρισται πρότερον δοκα κατὰ τὴν παροδοσαν σύναμιν εἴχομεν, χρηστέον δὲ ὑπάρχουσιν.

⁴⁷Ibid. III, 1, 299 a, 1-6. The last sentence reads: καὶ τοι δύκαιον ἢν ἢ μὴ κινεῖν ἢ πιστοτέρως ἄτα λόγοις κινεῖν τῶν ὑποθέσεων.
often reaches this foundation in a very imperfect way.

And when it comes to a science of the heavenly bodies, Aristotle recognizes special difficulties and limitations.\(^{48}\) This diffidence, already present in the *De Caelo*, is underlined in a work of later origin. Because of the importance of the text, we quote it in full:

Of things constituted by nature some are ungenerated, imperishable, and eternal, while others are subject to generation and decay. The former are excellent beyond compare and divine, but less accessible to knowledge. The evidence that might throw light on them, and on the problems which we long to solve respecting them, is furnished but scantily by sensation; whereas respecting perishable plants and animals we have abundant information, living as we do in their midst, and ample data may be collected concerning all their various kinds, if only we are willing to take sufficient pains. Both departments, however, have their special charm. The scanty conceptions to which we can attain of celestial things give us, from their excellence, more pleasure than all our knowledge of the world in which we live; just as a half glimpse of persons that we love is more delightful than a leisurely view of other things, whatever their number and dimensions. On the other hand, in certitude and in completeness our knowledge of terrestrial things has the advantage. Moreover, their greater nearness and affinity to us balances somewhat the loftier interest of the heavenly things that are the objects of the higher philosophy. Having already treated of the celestial world, as far as our conjectures could reach,\(^{49}\) we must proceed to treat of animals, without omitting, to the best of our

\(^{48}\) *Ibid.* II, 3, 286 a, 3-7; II, 5, 287 b, 31-33; II, 12, 291 b, 24-28; 292 a, 14-17.

\(^{49}\) 'As far as our conjectures could reach.' The Greek for this reads: λέγοντες τὸ φαινόμενον ἡμῖν.
ability, any member of the kingdom, however ignoble. 50

On the basis of this text, especially when we read it in the light of the frequently hesitant passages of the De Caelo, I think that we can safely assert that Aristotle did not consider the scientific work done in the De Caelo as ideal. The human mind is limited and so is its science. When we study the heavens, we can achieve only a limited certitude and completeness.

It would seem that the rigor of the definition and the labor of the scientist-teacher will be proportioned to the demands of his hearers. He will have to labor as much and only as much as is necessary to win the assent of his hearers to his originating definitions. A more radical founding of a scientific deduction, though it might seem called for by Aristotle's theoretical views about the nature and necessity of scientific first principles, is not carried out in practice, at least not

50 De Part. An., I, 5, 644 b, 23 - 645 a, 7. Jaeger, p. 337, sees in this text a sharp break with Aristotle's older attitude toward science, and at the same time a program for a new kind of study. The entire fifth chapter of the first book of De Partibus Animalium certainly manifests a change, but it is questionable how radical this change is. The study of animals is different from what is going on in the De Caelo, but it seems, in light of the argument which we are making in the text, rather a change in emphasis than a fundamentally new conception of science. The present passage from De Partibus Animalium is fore-shadowed by the passages cited from the De Caelo. The difference, perhaps, is that in the biological work Aristotle takes more seriously the limitations on human knowing which he had earlier experienced and described in the De Caelo.
in the *De Caelo*. Thus we find deep in the core of Aristotle's actual scientific methodology a suggestion of the thought-structure of the Platonic dialogue: principles derive from the common consent of the participants to the discussion. 51

Such a starting point for science, with its possibilities for basically wrong orientations, may seem almost incomprehensible to us today; yet I think that it ties in closely with the Aristotelian conception of experience which we have already discussed. Through the active inter-communication of minds, we are most likely to discover the fundamental truths. If we do not find them in this way, it is more than likely that we will not find them at all.

The final note which we have designated as characteristic of the definition in Aristotelian science is that it serves as the source of all the knowledge within an individual science. Though other aspects of the scientific process may involve the scientist in greater difficulties, it is in his deduction that he does the actual scientific work. "The scientist should assume both the existence of his subject matter and the fundamental principles involved in it, and he should take as his task the demonstration that his principles are connected with the class of facts on which his inquiry turns and that they do

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explain those facts."52

We have classified the major questions of the section of the De Caelo which we are studying as follows:

(1) Is the world finite or infinite?
(2) Is this world the only world?
(3) Is the world eternal?
(4) Is the outer sphere of the world regular in shape and motion?
(5) Why does the motion in the world take place as it does?

All of these questions, in varying degrees, receive an answer from the doctrine of natural motion.

Is the world finite or infinite? The question is easily answered, once one has the proper definitions.53 The world can be proved to be necessarily finite if its constituent elements can be proved finite, and this is how Aristotle proceeds. Bodies are divided into straight-moving and circlilinear-moving bodies. Since it would involve contradiction to say that a body of either of these types could be extended to infinity, the world as a whole cannot be so extended.54

52McKeon, p. 41.
53De Caelo, I, 6, 271 b, 18-25; I, 7, 274 a, 30.
54A more general solution to the problem is offered in I,7. Aristotle states here that he is moving out of the range of the science that is his immediate concern, so that the chapter is something of an extended foot-note. He attempts to solve the problem on the basis of an analysis of the possibility of
Involved with the question of the infinity of the world is the question of a possible plurality of worlds. Granted that an actual infinite is impossible, is there any reason to think that the world that is accessible to our experience is the only world that there is?\textsuperscript{55}

In the deduction of the necessary unicity of the world, we see the meaning which Aristotle intends to give to his principle of natural motion and place: "et peut-être n'est-il point dans toute sa Physique, de problème où se marque mieux le sens exact qu'il attribuait à ces deux notions."\textsuperscript{56} The argumentation of this chapter lays bare an ambiguity in Aristotle's original definitions.\textsuperscript{57} In I, 2, Aristotle had determined the number of specifically irreducible elements on the basis of the possible number of simple motions, but the nature of these elements was conceived in terms of the actual place toward which these motions were directed. The simple bodies were properly defined interaction between the infinite and anything else. He concludes: "Since every perceptible body possesses the power of acting or of being acted upon, or both of these, it is impossible that an infinite body should be perceptible." 275 a, 5-7.

\textsuperscript{55}\textit{Ibid.} I, 6, 274 a, 25-29.

\textsuperscript{56}Duhem, I, 230. For a more extended analysis of the entire argument, see \textit{Ibid.} 230-234.

\textsuperscript{57}Zürcher, \textit{Aristoteles' Geist und Werk} (Paderborn, 1952), pp. 134-135, takes a harsher view of the argumentation on this point. He concludes: "Dass das reine Sophisterei ist, muss jedermann zugeben."
in terms of their form—i.e. their natural place. Aristotle is right, on his principles, to suppose that simple bodies anywhere will have a simple natural motion, and that this simple natural motion must be either straight or circular. But he has established really no basis for the further position that it is impossible for there to be a greater number of natural places than the number given in our world. The view operative in the argument about the unicity of the world is that only so many natural motions (considered in their geometrical structure) are possible; all bodies having the same natural (geometrical) motion have the same nature and the same natural place. Therefore all natural bodies, even those outside our world, will have as natural goal the center or the extremity of our world. Hence all worlds will become one with ours. The difficulty with the argument is that Aristotle has given no suasive reason why the bodies of a hypothetical other world could not have their own proper natural places. Even the highly sympathetic Pierre Duhem observes that the postulate of the specific identity of the simple bodies of all possible worlds "ne tient que par un lien assez lâche à l'ensemble de sa Physique."  

58 On natural place as form, see De Caelo, IV, 3, 310 b, 10; Duhem, I, 207-208.
59 Duhem, I, 231.
But whatever the solidity of the argument, it should be clear that it is entirely a deduction from the theory of natural motion and natural place.

The problem of the eternity of the world finds solution in much the same way. In chapters ten through twelve of the first book, Aristotle is concerned to show that what is incorruptible is ungenerated, that what is ungenerated is incorruptible, and that both are eternal. The connection between this discussion and the principles of the rest of the De Caelo is made in chapter three of book one. There Aristotle shows on the basis of natural motion that the fifth element must be unalterable: "And so, if the body which moves with a circular motion cannot admit of increase or diminution, it is reasonable to suppose that it is also unalterable." The step from here to eternity is simply a matter of definition. The result of the argument is that the heavens are and must be eternal and immutable.

Aristotle brings natural motion to bear on the fourth question too, though less directly and exclusively than heretofore. The heaven is perfectly spherical in shape because (among other reasons) it is revolving in a circular path, and for a non-spherical body to revolve in this manner there would

60 De Caelo, I, 3, 270 a, 33-35.

61 See Bonitz, 14 b, 15-25, for the meaning of eternal in Aristotle.
have to be a void and place and time outside the universe, which conditions have been proved impossible.

The argument is again questionable, since Aristotle has shown the impossibility of these conditions from the fact that there is no body outside the last sphere. On the supposition of a non-spherical, revolving world, these conditions would no longer be fulfilled; and so it seems to be something of a circle when Aristotle argues that, "since the whole revolves palpably and by assumption, in a circle, and since it has been shown that outside the farthest circumference there is neither void nor place, from these grounds also it will follow necessarily that the heaven is spherical." But valid or not, this is the argument which Aristotle makes, and we can see that it derives from the initial definition of the fifth element as the body in circular motion. For the present, that is all that need concern us.

The fifth question is of a special type. Actually, I have summarized two questions under one heading. The Oxford translator gives the following titles to the two chapters involved in the question: "Why there is a plurality of movements and of bodies within the heaven"; and "Why the first heaven revolves

62 De Caelo, I, 9, 279 a, 12-18.
63 Ibid. II, 4, 287 a, 11-23.
in one direction rather than the other." Neither of these problems resolves itself entirely in terms of natural motion, but even here the doctrine is still pertinent and fruitful.

In II, 3, Aristotle sets out to deduce the necessity of more than one element in the cosmos. Starting from the circular body which envelops the universe, he shows that it must move about a stationary center, and that this center (since stationary) must be of a nature different from the outer sphere. Hence there must exist an earth. "But if earth must exist, so must fire. For, if one of a pair of contraries naturally exists, the other, if it is really contrary, exists also naturally," And in much the same fashion he proceeds to deduce the necessity of air and water. With these four elements he can deduce generation and at least some sort of irregular secondary motion which will account for the changes involved in generation. Thus we have reached the necessity of a plurality of bodies and of movements.

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64 Ibid. II, 3, 286 a, 11-12.
65 Ibid. 20.
66 Ibid. 23-24.
67 Ibid. 28.
Aristotle approaches the last question which we are to consider with a noteworthy mixture of confidence and diffidence:

Now there are two ways of moving along a circle... and we have already explained that these movements are not contrary to one another. But nothing which concerns the eternal can be a matter of chance or spontaneity, and the heaven and its circular motion are eternal. We must therefore ask why this motion takes one direction and not the other. Either this is itself an ultimate fact or there is an ultimate fact behind it. It may seem evidence of excessive folly or excessive zeal to try to provide an explanation of some things, or of everything, admitting no exception. The criticism, however, is not always just; one should first consider what reason there is for speaking, and also what kind of certainty is looked for, whether human merely or of a more cogent kind. When any one shall succeed in finding proofs of greater precision, gratitude will be due to him for the discovery, but at present we must be content with a probable solution.69

To solve the knotty problem which he has set himself, Aristotle calls upon distinctions which he originally made in his De Incessu Animalium70 and which he has already reviewed in De Caelo, II, 2:

If nature always follows the best course possible, and just as upward movement is the superior form of rectilinear movement, since the upper region is more divine than the lower, so forward movement is superior to backward, then

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69 De Caelo, II, 5, 287 b, 23 - 288 a, 2. The italicized words (Italics not in the original) read as follows in the Greek: οδάν δεί τὴν αἰτίαν τοῦ λέγειν τίς ἐστιν, ἢτι δὲ πῶς ἔχων τῇ πιστεύειν, πότερον ἀνθρωπίνως ἢ χαρτεριχώτερον... νῦν δὲ τὸ φαινόμενον ρητέον.

70 De Inces. An., 4-5, 705 a, 27 - 706 b, 17.
front and back exhibits, like right and left, as we said before and as the difficulty just stated itself suggests, the distinction of prior and posterior, which provides a reason and so solves our difficulty. Supposing that nature is ordered in the best way possible, this may stand as the reason of the fact mentioned.71

Aristotle is admittedly on insecure ground here. In order to find a 'why' he must apply categories to the heavens which he recognizes are applicable only to living beings.72 Still, he goes ahead and applies the categories: the world is intelligible, and if something happens eternally it must have an explanation. To be noted here is that this particular question is not answered by means of a deduction from the theory of natural motion. New categories of explanation must be introduced owing to the exigencies of the question.

Consequently it will be something of an over-simplification to unify an Aristotelian science entirely in function of a single definition or set of definitions. In the description of the ideal Aristotelian science which we have given above,73 it may have appeared that the Aristotelian scientific technique was quite similar to an axiomatic system. Its difference from modern axiomatic systems would be that the Aristotelian science would insist that its first principles are true and not merely useful for the construction of a system. But on closer in-

72 Ibid. II, 2, 284 b, 32.
73 Supra, pp. 40-41.
spection we have found that Aristotle does not attain this perfect deductive unity. At least one question necessitates the introduction of new principles, which have no intelligible connection with the central principles of the science. Also, on almost every question, Aristotle is not content merely to deduce an answer from natural motion and then pass on. If he can, he brings in subsidiary arguments based upon different principles. When possible, he shows that his conclusion is in harmony with principles which his auditors already hold.

Thus, if we would understand the unity of Aristotle's actual scientific procedure in the De Caelo, we must understand it from the point of view of the questions posed and within the dialectical context in which Aristotle was thinking and working. Aristotle discovers his questions ready-formed, and both he and his hearers want answers to these questions. His work as a scientific thinker will be to discover a basis for answers to these questions and to convince his interlocutors of his principles and his answers. Within the framework of the plurality of questions which he must answer, Aristotle attempts to elaborate a single source of intelligibility—his doctrine of natural motion—but if this single principle does not suffice for the proposed questions he will introduce subsidiary principles.

74 See, for example, all of I, 9.
75 Ibid. I, 3.
The labor of the scientist will thus not be merely to articulate the latent intelligibility of an original definition.

This primacy of the question and the dialectical context of scientific work will also account for the often strained reasonings which we have already remarked in the *De Caelo*. The juggling with the concepts of natural motion and place in order to deduce the unicity of our world is incomprehensible in so able a discoverer of logical fallacies, if we suppose that all that he is trying to do is to see where his principles logically lead him.

But if we grant this primacy to the question we are faced with a fundamental problem: What sort of knowledge or certitude did Aristotle think he could attain by this sort of procedure? Let us first enunciate the problem more in detail.

If we suppose that Aristotle begins a scientific treatise with a definition about which there can be no question, and that he then proceeds via deductive syllogism to enunciate all the latent intelligibility of that definition, then we can only suppose that the certitude of the science so constructed will be absolute, as unquestionable as the original definition. But if we approach from the opposite end and suppose that Aristotle is first faced with questions and that he must then construct a theoretical system which will yield scientific answers, the problem is not so easily solved.
We are, since the seventeenth century, familiar with two ideals of scientific certitude. The first, incarnate in Descartes, would involve two fundamental activities, intuition and deduction: "Praeter intuitum, hic alium adjunximus cognoscendi modum, qui fit per deductionem: per quam intelligimus illud omne quod ex quibusdam aliis certo cognitis necessario concluditur." This procedure would result in a body of scientific knowledge all of which would have the certainty of intuition.

The second ideal is that provided by Newton and by the many men who led up to him or followed his example. We have already quoted the highly characteristic fourth rule of reasoning in philosophy, but it is again pertinent here: "In experimental philosophy we are to look upon propositions inferred by general induction from phenomena as accurately or very nearly true, notwithstanding any contrary hypotheses that may be imagined, till such time as other phenomena occur, by which they may either be made more accurate, or liable to exceptions." Beginning with carefully defined data, this approach would have one work to principles, in the sense that a principle will be a single formula unifying all (or nearly all) the phenomena. It has no inner necessity or intelligibility. The only reason

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76 Regulae ad Directionem Animae, in Oeuvres de Descartes, ed. Charles Adam et Paul Tannery (Paris, 1908), X, 388.
77 Newton, Principia, p. 400.
for affirming the principle is that it is adequate for the phenomena as we now know them. Certitude reached by this technique makes no claim to finality: it is avowedly open to new and radical re-formulation whenever the phenomena outgrow the principle. 78

Aristotle's De Caelo refuses to fit into either of these later classical patterns. He does not begin with an intuited principle, at least not in the sense of a Cartesian clear and distinct idea. Instead, from the beginning he is committed to answer questions; and though he knows from his more basic researches that all questions have answers, he has no a priori guarantee that he will be able to discover those precise principles that could give him the true answers. Further, even when he has discovered principles which yield an answer to a question, it is not always evident that this is the answer to the question. His is thus not a Cartesian rigor.

Nor does his science derive its certitudes from its em-


79 This statement is certainly simpliste, yet I think that it does express something of the spirit in which Aristotle views the matter.

80 Cf. De Caelo, II, 5, 287 b, 30; Post. Anal., I, 9, 76 a, 26-30.
pirical applicability. This we have already seen in our study of the nature and place of verification in Aristotle's scientific procedure. Owing to the nature of the questions and the techniques of investigation, the scientific answers which Aristotle reaches will not be such that experience will testify in a decisive manner either to their truth or falsity. When one has proved the eternity of the world by the theory of natural motion, it is not likely that one can then verify the conclusion in experience and thereby reflect an empirical certitude back upon one's principles.

The problem grows more decisive when we realize that Aristotle was certainly aware of it. He realized the overwhelming difficulties involved in establishing one's basic definitions: "It is clear also that the easiest thing of all is to overthrow a definition." Further, it is significant that Aristotle considered at least one of the questions which he considers in the De Caelo to be a dialectical question (as contrasted with a scientific question). "Dialectical problems also include questions in regard to which reasonings conflict (the difficulty then being whether so-and-so is so or not, there being convincing arguments for both views); others also in regard to which we have no argument because they are so vast, and

81 Top., VII, 5, 155 a, 2-3.
we find it difficult to give our reasons, e.g. the question whether the universe is eternal or no: for into questions of that kind too it is possible to inquire. "$^82$

It is in Aristotle's idea of dialectic that we shall, I think, find some answer to the problem and shall thereby discover something of the inner intelligibility of the De Caelo. Aristotle gives his fundamental statement of the nature of dialectic in the following passage from the Topics:

Now reasoning is an argument in which, certain things being laid down, something other than these necessarily comes about through them. (a) It is a 'demonstration', when the premisses from which the reasoning starts are true and primary, or are such that our knowledge of them has originally come through premisses which are primary and true: (b) reasoning, on the other hand, is 'dialectical', if it reasons from opinions that are generally accepted. Things are 'true' and 'primary' which are believed on the strength not of anything else but of themselves: for in regard to the first principles of science it is improper to ask any further for the why and wherefore of them; each of the first principles should command belief in and by itself. On the other hand, those opinions are 'generally accepted' which are accepted by everyone or by the majority or by the philosophers--i.e. by all, or by the majority, or by the most notable and illustrious of them. "$^83$

What should be noted here is the proximity of the originating sources of science and of dialectic. Dialectic has its beginnings in "opinions that are generally accepted"; science

$^82$"Ibid. I, 11, 104 b, 13-18.

$^83$"Ibid. I, 1, 100 a, 25-b, 23."
derives from sources that are "true and primary," and "which are believed on the strength not of anything else but of them­selves." In theory, nothing could be clearer; but we must not overlook the fact that for Aristotle scientific principles emerge out of experience, and out of experience conceived in such a way that it is not easy to distinguish it from the "opinions that are generally accepted."

Science is the recognized ideal of intellectual activity—science with its unquestionable certitude. But we must not see dialectic as something opposed to science as falsity to truth. It is, rather, analogous to science. The natural dynamism of dialectic will be to strive to turn itself into science by reaching for more and more evident and cogent principles; and the exact moment at which an intellectual system will cease to be a dialectic and will become a science will be determined, if at all, only with difficulty. In the real order, the order of labor and of achievement, it will be difficult to distinguish science and dialectic. And especially will this distinction be blurred if it is true—as we have argued—that Aristotle starts with a question and is driven to seek whatever principle he can find. The structure or movement of his thought will thus be to find as good a principle as he can for his deductions, and not to give primary or initial attention to the exact degree of cogency and certitude that his principle exercises.
But why did Aristotle think that he could use dialectical principles in his endeavor to lay hold of the truth? Two reasons, I think, can be offered. The first is developed by Fr. Régis in his study of Aristotle’s dialectic. According to this view, Aristotle’s use of dialectical principles as a means to truth is founded in his confidence in common sense, which, in turn, is based upon his philosophical views of the dynamic finality and normality of human nature and human knowing. In the opening sentence of the Metaphysics, Aristotle proclaims that man desires by nature to know. This desire for knowledge is a natural activity in a sense not entirely unlike the falling of earth and the rising of fire. In the case of the elements, that which happens always or for the most part is a result of nature and hence is ordered to nature’s end. So it is in human knowing. Where we find the majority of the best men agreeing on certain principles, we are justified in considering these principles as natural, and hence ordered to truth, the end of knowing. The truth of such principles will be subject to correction when they conflict with something more certainly known, but in the absence of such criteria we are justified in working our way to truth with these natural dialectical principles.

The second reason is actually just a variation on the first, but it is a significant variation and so merits separate consideration. It is to be found in Aristotle's view of the place of man within the hierarchy of intelligent beings. There is a suggestive passage in the De Caelo: "One thing [the first, God] then has and enjoys the ultimate good, other things attain to it, one immediately by few steps, another by many, while yet another does not even attempt to secure it but is satisfied to reach a point not far removed from that consummation." There is a danger here of explaining too much on the basis of a single passage, but I think that the present passage is pertinent to our problem. Man's function in the world is understanding the universe. In this he imitates the first, the highest. Yet the present text, though it is primarily concerned with the multiplicity of movement in the heavenly and other bodies, suggests that in imitating the highest certain beings (those of the sublunar world) must be satisfied with reaching a point "not far removed" from the perfection toward which they are striving. Thus, if perfect knowledge is characteristic of the highest, it may well be that man will have to stop somewhat short of the perfect knowledge which would be science, and rest content with dialectic.

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85De Caelo, II, 12, 292 b, 11-13.
The limitation on human knowing which makes itself felt in dialectic is, accordingly, not merely a transient difficulty. Though Aristotle was clearly aware of the fact of development in ideas, he did not view the process of development as a progression without end or as a finite progression terminating in a perfect comprehension of the truth. The present state of science (the state which it attains in the Aristotelian achievement) is not perfect, but in most respects it is terminal. The possibility of a "break-through" seems not to be envisaged. At least such would seem to be the case in the De Caelo. Because of the weakness of our senses and the lack of data, because those things which are most intelligible in themselves are not the most apparent to us, there are areas in which we, as human beings, cannot attain to the perfection of knowledge. Hence, though in dialectic there may be some imperfections, it points in the direction of knowledge. Its answers are perhaps not the very ultimate ones, but they are the last answers that we shall ever see.

86 This is not to suggest that all of Aristotle's science is actually just a disguised dialectic. I am sure that he thought his grasp of the principle of non-contradiction was as perfect as possible. But the area of thought surveyed by the De Caelo is not so immediately accessible to human intelligence, and consequently this science will have its own peculiar structure and certitude. It is the laws of this structure and certitude which I have tried to sketch in this chapter.
CHAPTER V

CONCLUSION

So far we have tried to describe the details of Aristotle's scientific procedure. By way of conclusion, let us try to synthesize these details by seeing them develop from a single attitude, which is fundamental in Aristotle. In attempting this, we run the danger of over-rationalizing Aristotle; but if we keep this danger in mind and lay no claim to having said the final word on Aristotelian science, we may come to a deeper and more unified understanding of what we have been studying.

We take as our germinal idea Aristotle's conception of man as a being having a nature. From this point devolve what seem to me to be the significant factors in Aristotle's scientific method.

Man's nature is scientifically relevant in two directions: vertically and horizontally. Vertically, man has a definite status in the hierarchy of beings; horizontally, he is a member of a species, part of a community.

The place of man the scientist within the cosmos sheds light on the tension in Aristotle's science between the absolute and the provisional in truth, as well as upon the apparent lack
of initiative or inventiveness that we remarked in chapter two. As we pointed out at the end of the fourth chapter, Aristotle views man as "mid-way" in the order of beings. Like all the sublunary world, he is subject to change, even to generation and corruption, yet he is at the same time capable of understanding reality.

The hierarchical order of being is an absolute. There are principles of being within this absolute order of things, and science is an intellectual reiteration of things according to these principles or causes. Being has this necessary structure; and because science (as an ideal) models itself on being, it too has a necessary structure. For Aristotle, being is and non-being is not; and to know is to know being as it is and not as it is not. Further, because the totality of the real is a system--i.e. being is related to being--to know beings as they are is to know them in relationship to their principles or causes, and ultimately as they relate to the universal principles of all reality. And because the fundamental cause or principle of the properties or operations of a thing is "what the thing is," the fundamental principle in a science will most often be the enunciation of that "what"--the definition

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1 This is Aristotle's view of man and hence of the scientist, since for Aristotle the scientist is man par excellence.
Thus both the fact of the intelligibility of being and the general structure of that intelligibility precede the actual scientific work of the *De Caelo* and provide it with a context which Aristotle will not call into question and which will not be affected by any difficulties or doubts which may arise within the individual scientific treatise.

But though the context of scientific work is absolute, the human achievement within that context will usually be only provisional, and this because of what man is. There is an order in being which runs counter to the order of human knowing: "for the same things are not 'knowable relatively to us' and 'knowable' without qualification." This inversion of orders is simply an expression of the fact that man is a subordinate part of the universe. The natural order of his thought is not the determining order of reality. Hence human science will be an attempt to attain to the universal principles of the real: "So in the present inquiry we must follow this method and advance from what is more obscure by nature, but clearer to us, towards what is more clear and more knowable by nature." But

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2 Post. Anal., II, 10, 93 b, 29.
3 Phys., I, 1, 184 a, 18.
4 Ibid. 19–22.
often there is no prospect of complete achievement.

Despite this ultimate falling-short, however, man necessarily pursues knowledge since it is unquestionably a good. For all beings capable of thought it is the good. The value of intellection is as absolute in Aristotle as is the Good in Plato: it is good to know the real. Within this context, man works out whatever science he can, convinced that whatever level he attains is his good.

Human science, therefore, just like human nature, has its a priori limitations. Just as Aristotle did not envisage an evolution of the various species into something higher, so he did not look for a science that would eternally progress toward a full comprehension of the real. There is a progression in science, but it ascends from man to the unmoved movers and finally to God,\(^5\) and not from one generation of men to another and so on ad infinitum.

Still, we must not reduce science and man to complete immobility; and here we rejoin the idea of the individual scientist as a member of a species. There is an aspect of Aristotle's thought which (perhaps because it did not fit in well with the temporal, created world of Christian thought) receives

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\(^5\) We bypass here the thorny problem of Aristotle's theology. The exact number and relative position of the supra-human beings is, though important, not immediately relevant here.
little emphasis but which is of moment here. I refer to Aris-
totle's cyclical theory of intellectual history. According
to this theory, human intellectual achievement is an eternally
repeating process. Mankind repeatedly comes into possession
of its intellectual fullness, and then, for whatever the cause,
loses it again. Aristotle nowhere develops the theory at
length, at least not to my knowledge, but he periodically refers
to it as to something rather generally recognized and held:
"For the same opinions appear in cycles among men not once nor
twice, but infinitely often." And indeed something of the sort
ought to be expected in an eternal universe in which each
generation of men is like every other: "Let us remember that we
should not disregard the experience of the ages; in the multitude
of years these things, if they were good, would certainly not
have been unknown; for almost everything has been found out,
although sometimes they are not put together; in other cases
men do not use the knowledge which they have." Without some
sort of theory of cyclic collapse, there could be no intellectual
history; just as without corruption there could be no generation.

6 Meteor., I, 3, 339 b, 27; De Caelo, I, 3, 270 b, 19-21;
Met., A, 8, 1074 b, 10-13; Pol., VII, 10, 1329 b, 25. See to
the same effect, Plato, Timaeus, 21 D, 25 E; Jaeger, Aristotle,
pp. 130-137.

7 Pol., II, 5, 1264 a, 2-5.
Because man's quest for wisdom is a specific undertaking (specific in the sense that it is the work of a species) the individual scientist will work within the context provided him by "man." The scientist will, in a word, draw heavily upon tradition. The world in which man lives is man's scientific problem, and hence the data of man's science will be the world as assessed by the significant portions of the human community. And since man as man is ordered to science, the principles of science will lie within this specifically human experience. It may take careful reflection to find these principles—usually the definitions of the subject matter involved—and one may never render these principles quite as clear and decisive as one could wish; still it is always in the common conceptions and experience of men that they are to be found.

Further, since man is ordered to a search for truth, there is significance in the questions which men ask. It is the function of a scientific tradition to elaborate and purify questions. The traditional questions reveal the mind of man at work trying to understand the real.

Aristotle, it seems, viewed his work as the fulfillment of a tradition, a maximum point in one of the phases of human scientific history. In Aristotle's scientific synthesis, man

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8 Again, we must beware of facile generalizations. What we say here applies to the Aristotle of the De Caeilo; but that
is aware both of his own achievement and of the intrinsic inadequacies of that achievement.

Too much could be made of the connection between Aristotle's theory of man and his scientific method. I would certainly not argue that the former was explicit in Aristotle's mind at all times, or that it was consistently influential upon his method. Nevertheless, it provided Aristotle with a context within which his scientific method was adequate and satisfying; and it provides us who are studying Aristotle's method with a unifying point of view from which to interpret the constituents of that method.

And if, from our present study, we seek some insight into the later rise and fall of Aristotelianism, I would suggest that it is this: the Aristotelian scientific method could survive (which is not to say that it necessarily would survive) only within a context at least similar to the one provided by Aristotle's doctrine of man. If that context were to break down, men would soon experience the need for a new science. But these matters belong to later history, and, for all their importance, we cannot treat them here.

Aristotle did not look upon science as fully achieved in every department is clear from the passage quoted above, p. 15, n. 14: De Gen. An., III, 10, 760 b, 27-33.
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APPROVAL SHEET

The thesis submitted by James Francis McCue, S.J. has been read and approved by three members of the Department of Philosophy.

The final copies have been examined by the director of the thesis and the signature which appears below verifies the fact that any necessary changes have been incorporated, and that the thesis is now given final approval with reference to content, form, and mechanical accuracy.

The thesis is therefore accepted in partial fulfillment of the requirements for the degree of Master of Arts.

June 15, 1957
Date

Signature of Adviser