ABSTRACT. This paper offers a detailed account of arguments in De Caelo I by which Aristotle tried to demonstrate the necessity of the perpetual existence and the perpetual rotation of the cosmos. On our interpretation, Aristotle's arguments are naturalistic. Instead of being based (as many have thought) on rules of logic and language, they depend, we argue, on natural science theories about abilities (δύναμεις), e.g., to move and to change, which things have by nature and about the conditions under which these abilities can be exercised. Our interpretation locates the De Caelo arguments in the context of some central doctrines of the Organon, the Metaphysics, the Physics, and other texts. The De Caelo arguments fit a number of views developed in these texts. Aristotle's treatments of local motion, of natural motion and change, of necessity and possibility, and of abilities and their exercises are examples. But, as we interpret them, the De Caelo arguments raise serious questions about the role of (and the need for) Metaphysics A's soulful Unmoved Mover in Aristotle's overall natural-scientific picture.

De Caelo I.12 sets in place an important piece of the engine that drives Aristotle's philosophy of nature: the doctrine that the cosmos rotates always and of necessity, and that it and its rotation are eternal, having no beginning and no end, no coming to be, and no possibility of passing away. This doctrine and its presentation are crucial for many reasons, two of which motivate this study: (a) Aristotle's account of time requires a clock which is provided by the eternally rotating cosmos, and (b) part of the importance he attaches to his account of necessity and possibility is the grounding it provides for the arguments and the doctrine of De Caelo I.12. These considerations alone are enough to establish that a satisfactory interpretation of De Caelo I.12 is needed for the understanding of Aristotle's philosophy.

There are obvious connections between De Caelo I.12, and texts from the De Anima, Physics, Metaphysics and the Organon. The arguments of De Caelo I.12 depend upon the treatment in these texts of the concepts of nature, ability, and the conditions under which abilities are exercisable. And second they depend upon notions of necessity, possibil-
ity and impossibility. These connections raise two logistic questions for
the commentator. The first is whether the main goal of an interpretation
of De Caelo I.12 should be the exposition of its doctrine concerning the
rotation of the cosmos, or whether it should be studied for what it tells
us about Aristotle's conception of modalities, and the rest. The latter
tack has been taken by a number of recent commentators (including Wa­
terlow, Judson, and Hintikka). They are more interested in modality, and
they hold the plausible expectation that Aristotle's views on modal no­
tions should prove more interesting and sound than his views on the
cosmos. Although we will consider (and it is impossible not to) those
features of Aristotle's modal theory which are foundational to De Caelo
I.12, we believe the theory of cosmic motion merits study for its own
sake. Accordingly, our approach is the opposite of Waterlow's, Judson's,
and Hintikka's.

The second logistic question is whether to treat De Caelo I.12--
along with the arguments of I.2-4 upon which it depends--as complete
and self-contained. Our answer is no. The text bristles with technical
terms for which it provides little or no explanation. Among these are
'possible', 'impossible', 'necessary', and other modal terms which are in­
troduced and discussed by Aristotle in the Posterior Analytics (and oth­
er parts of the Organon), which are generally agreed to have been writ­
ten no later than the De Caelo. It would be perverse not to use these
latter discussions to interpret the De Caelo's arguments. Furthermore,
almost everyone who has commented on De Caelo I.12 has been impressed
by its logical gaps and its apparently unmotivated inferences. This, to­
gether with the terseness and abstract nature of the presentation (re­
markable even for Aristotle) makes it natural to look elsewhere in the
corpus for supplementary material. As we shall argue presently, the ar­
guments of De Caelo I.2-4 and 12, gain considerably in interest and
plausibility when supplemented by doctrines from other works, including
Metaphysics θ, Physics I.2, De Anima, De Interpretatione, and others. Al­
though the dating of some of these is highly speculative and problemat­
ic, many passages to which we shall appeal are thought to have been
written after De Caelo. But even if they were written later, there is no
reason to ignore them. Suppose, for example, that Metaphysics θ is much
later than De Caelo. It certainly would not follow that Aristotle neither
thought about nor began to formulate the ideas which are required by
De Caelo before he actually wrote them down in the Metaphysics. Alter­
natively, it is entirely possible that De Caelo contains gaps which Aris­
totle was not able to fill in until later. Most importantly, we are con­
cerned with the concepts involved in the doctrines of De Caelo I.12, and
the logic of the Aristotelian arguments for them. The chronology of Aris­
totle's composition (a great deal of which is not presently decidable in
any case) is not particularly germane to this. It is common for notions
sketched at one point in a philosopher's career to reach their full de­
velopment years later. For our purposes, it is equally mistaken to ignore
passages whose doctrines can be shown to implement earlier programs
just because they were written later, as it is to argue that because one
passage answers a question left over by another, the second one must
have been written before the first.

Accordingly, we treat the arguments of De Caelo I.12 (together
with I.2-4) as incomplete and non-self-contained. And since little can
be made of its arguments without supplementing them by modal claims de­
veloped elsewhere in the corpus, we think De Caelo should be read less
as a source of refinements in, and clues to, the details of Aristotle's mo-
dal theory, than as a text whose interpretation requires an independent account of what Aristotle says about the modalities.

(ii)

The topic of I.12 is announced at the beginning of De Caelo I.9 (227b27). Here Aristotle says again that he will consider how many cosmoi there are, and whether the cosmos is eternal, ungenerable, and imperishable. The former question is considered in I.9, and the latter in I.10-12. The discussion of the eternality, ungenerability and imperishability of the cosmos begins with a characteristically Aristotelian prologue—a consideration of received views and problems (I.IO), and a clarification of the terms and notions Aristotle will use in presenting his own views (I.11). According to I.11, to say the cosmos is 'imperishable' will mean (280b32-35) that there was, is, and will be no time at which it was, is, or will be possible for it to cease to exist. To say it is 'ungenerable' will mean (280b12-13) that there can never have been a time at which the cosmos failed to exist, and hence that it could not possibly have come into existence. Given these senses of the terms Aristotle will argue in I.12 that the cosmos is ungenerable and imperishable, and therefore it is not, never has been, and never will be possible that the cosmos fails to exist. A step toward proving this will be a demonstration of the thesis that the rotation of the cosmos always was, always will be, and is now necessary, a result Aristotle says in De Caelo II.1 he has already established De Caelo I.12.

(iii)

The arguments which begin I.12 involve the following moves. First,

(DCA) What is able to be for an unlimited stretch of time (a time . . . longer than any arbitrary time and shorter than none) cannot have the ability not to be. (281a18-35, b1-3)§

By 'unlimited stretch of time', Aristotle means a stretch such that for any arbitrary moment, t, there is no moment before or after t which does not belong to it. Thus there is no time at which an unlimited stretch begins and no time at which it ends (De Caelo 1.12. 281a33-44).

It is tempting, but clearly mistaken, to think that in using 'to be' (and forms of εἶναι corresponding to 'is', 'being', 'was', 'will be', etc.) Aristotle is talking about existence. He tells us, in the passage which argues for (DCA) not to read him this way. At 281a30-33, he says explicitly and emphatically that by 'to be' he means to be '. . . a man, or white, or 3 cubits long', or anything else in any of the categories. Although nothing can exist without being something from some category, and although what is something in some category exists, existence itself does not fall under any of the categories.° The claim of (DCA) amounts then to this: where F is any member of any category (and, we repeat, this does not include existence), what is able to be F for an unlimited stretch of time cannot have the ability to be not F, or to be anything opposed to F.¶ Having reserved forms of 'to be' for predication (for being F), Aristotle needs other terminology to talk about questions of existence. The topic of the existence of the cosmos is taken up for the first time in I.12 at 281b20-30. In this passage, instead of asking whether the cosmos can cease to be, Aristotle asks whether the cosmos can perish (φθαρέων). And instead of asking whether the cosmos ever
failed to be, he asks whether it could have been generated (γενητόν). Thus he uses 'to be' in connection with predication, and (φαινετόν) in connection with existence. Because (DCA) uses the phrase 'to be', that does not make it a claim about the ability of the cosmos to exist or not to exist. Instead (DCA) has to do with the ability to be or not to be F, where F is some item from some category. (Accordingly, we shall, where appropriate, use forms of 'to be F' as translation for forms of εἶναι.)

Aristotle goes on to claim abruptly that what is (i.e., what is F) for an unlimited time cannot be perishable unless it has the ability to not be (i.e., to be not F) (281b19-25). Maddeningly, he does not explicitly say what he has in mind, either for the thing which always has the ability to be F, or for the F for which it has the ability. But the structure of De Caelo Book I and the text of I.12 (including the summary of results from I.12 which begins II.1) leave no doubt that the general principles Aristotle introduces are meant to apply to the cosmos and to its ability to rotate. According to (DCA), then, if the cosmos has at all times the ability to rotate for an unlimited time, it cannot at any time have the ability to not rotate. Since rotation is the relevant F, and non-rotating is the relevant not F, our present passage (281b19-25) is a generalization that has as an instance the principle:

(DCB) If the cosmos rotates for an unlimited time it is impossible for the cosmos to perish (to cease to exist), unless it has the ability to not rotate.

This is the second of Aristotle's basic moves.

(iv)

Although (DCA) and (DCB) are apparently meant to establish the imperishability of the cosmos, it is obvious that they do not provide much of an argument unless a number of gaps are filled in. These include the following. According to (DCB), the cosmos is imperishable if the cosmos rotates for an unlimited time and if it lacks the ability to not rotate. According to (DCA), it does rotate for an unlimited time if it has the ability to rotate for an unlimited time. But (1) why does Aristotle think it has the ability to rotate for an unlimited time? (See section (x) of this paper.) And if it does have this ability, and we can conclude that it therefore lacks the ability to not rotate, (2) how can Aristotle show that the cosmos not only has the ability to rotate, but that it actually does rotate for an unlimited time? (See section (xii.) The difficulty here is that the exercise of an ability does not always follow from its possession. Aristotle opposes the Megarian doctrine that nothing has the ability to be, to do, to suffer, etc., anything F, unless it actually is, does, suffers, etc., F. This requires him to acknowledge cases where what is able to be F fails to exercise its ability (Meta. 6). Aristotle provides a number of examples of this. A man who is able to sing, may play the lyre instead; a man who is able to sit, may stand instead; and a man may not speak when he is able to, etc. Some of these examples of unexercised abilities are included in I.12 itself. Why, then, since Aristotle thinks some abilities may go unexercised, should not the cosmos sometimes fail to rotate?

If Aristotle can answer these questions, he will then be able to show that imperishability follows from (DCB). But there are further diffi-
difficulties. (3) Why should we believe (DCA)? Suppose the cosmos does always have the ability to rotate, why could it not also have the ability for non-rotation? Of course, the cosmos could not exercise both abilities at once, but why could it not exercise the one without the other? (See section (xiii).) Next, (4) why should (DCB) be true? If Aristotle can show that the cosmos always rotates and that it lacks the ability to not rotate, how would that establish that it is imperishable? (See section (xiv).) Finally, (5) how can Aristotle show that the cosmos always rotates (as required by the antecedent of (DCB)) without either begging the question of imperishability, or rendering (DCB) superfluous? The problem here is that according to Categories IV, 2a35–2b6, nothing can be F (where F is anything from any category) unless the thing which is F exists, and to rotate is to be something from a category. Thus, it would seem, at first thought, that Aristotle could not prove that the cosmos will always rotate without either assuming it will always exist (begging his question) or offering an independent proof that it will always exist (thus rendering (DCB) unnecessary and superfluous). (See section (x).) We shall attempt to answer these questions after completing our survey of the opening passages of I.12, and after introducing some material required for their answers. Finally, Aristotle must make good the claim (De Caelo 281b26ff.) that:

(DCC) Because the cosmos (in virtue of the fact that it will always rotate) is imperishable, it is also ungenerable (so that there was never a time at which it failed to rotate, and thus to exist).

These are the three moves to whose discussion the next sections of this paper will be devoted.

(v)

Both Aristotle's argument for, and his employment of (DCA), depend in part upon the use he makes in De Caelo of what he has established elsewhere concerning necessity and possibility. And they depend also upon his account of abilities of the kind he thinks enable the cosmos to rotate. We now turn to these.

In order to discuss them, it will be convenient to introduce some jargon. We have arbitrarily chosen the terms 'obtaining of a situation' and 'non-obtaining of a situation' for what can be said to be actual, necessary, possible, or impossible. By 'situation' we mean the having or not having, the being or not being, the coming to be (or have) or ceasing to be (or have) any item in any category by one or more things of any of the kinds of which category items can be predicated. Thus, Thelonius playing the piano is a situation, and so is his not playing. If Thelonius plays at a time, t, the situation (Thelonius playing) obtains, and the situation, Thelonius not playing, does not obtain at t. If he does not play at t, the latter situation obtains at t, and the former does not. It will occasionally be convenient to have a variable which ranges over situations, and a dummy name for an arbitrary situation. We use the bolded number sign, #, for both purposes. For example, 'the obtaining of # is possible if . . .' will mean that the obtaining of an arbitrary situation is possible if . . . ; 'for all #' means the same as 'for all situations', etc. Finally, we shall use '# is possible, necessary, impossible, etc.' as an abbreviation for 'the obtaining of # is possible (etc.)'. The situations with which we are chiefly concerned in connection with
(DCA) are, of course, the rotation of the cosmos, which Aristotle thinks is necessary, and its non-rotation, which he thinks is impossible.

(vi)

According to the Prior Analytics 32a18, 32b4-11, a situation is possible ἔνδείχται (or in our jargon, can obtain) if and only if (a) its obtaining is not necessary and, (b) its obtaining requires nothing ἀδύνατον (impossible). Situations which are not necessary include #s which obtain for the most part by nature (e.g., a man growing, declining, or turning grey) but which sometimes fail to obtain. (A man may die before he grows fully or declines, and some men do not turn grey.) Also included are #s whose obtaining is made no more likely than unlikely by the natures of the things they involve. Such situations obtain or fail to obtain by chance. To be 'possible' ἔνδείχται, then, means a situation's obtaining and non-obtaining is contingent, and 'contingent' here means: not necessitated by the natures of things. With regard to condition (b) the term ἀδύνατον has an etymology which we take extremely seriously. It derives from δύναμις, Aristotle’s term for the abilities in virtue of which things are, have, do, suffer, etc. A thing is δύναμις if it is able to do, to be, such and such. A situation is δύναμις if it is able to obtain, i.e., if things are able to do, to be, to suffer, etc., what is required for its obtaining. In saying, then, that a situation is possible ἔνδείχται only if it involves nothing ἀδύνατον Aristotle means that a situation can obtain only if its obtaining requires nothing of which things are incapable. Accordingly, here is what (DCA) claims when it says that what is able to be F for an unlimited stretch of time cannot have the ability to not be F. The 'cannot' in (DCA) means that the having of an ability to not F by something which always has the ability to F is a situation which nothing is able to make obtain. In particular, all things are incapable of bringing it about that what is able to rotate for an unlimited time also has the ability for non-rotation.

(vii)

Meta A.12 distinguishes two broad categories of ἀδύνατα. The characterization of the first of these depends upon a general inventory of kinds of abilities (δύναμεις) provided at A.12 1019a15-b15. This includes abilities which are sources of motion or change (1019a15ff). These are of three kinds. First, there are abilities in virtue of which one thing is able to move or change itself or something else. Second, there are abilities which enable a thing to be moved or to be changed by itself or by something else. Third, there are abilities in virtue of which a thing is able to stay as it is, resisting motion or change (1019a25ff). Things which have, and can exercise abilities (δύναμεις) of any of these kinds are said to be able δύναμις (1019a33ff) (i.e., to be able to move, to change, or to resist motion or change). The first category of ἀδύνατα, then, are situations whose obtaining would require individuals to exercise abilities of any of these three kinds which they lack (1019b16-22). Aristotle illustrates this with an example of a situation which is temporarily ἀδύνατον, and another which is permanently ἀδύνατον. Bruce's conceiving a child requires what is ἀδύνατον for a time if Bruce is a normal but sexually immature boy. It is ἀδύνατον at all times if he is a eunuch. (1019b17-19) Generalizing from this, we obtain the principle:
(MI) For any $\phi$, if the obtaining $\phi$ at any time requires the exercise of an ability or abilities by one or more things, and if the relevant things lack the required abilities, then the $\phi$ is $\acute{\delta}\nu\nu\alpha\tau\omicron \acute{\omega}$ (and hence the $\phi$ is impossible).

This sort of impossibility will figure importantly, if obviously, in De Caelo I.12. If the cosmos lacks the ability to stand still, the cessation of its rotation will be impossible, requiring what is $\acute{\delta}\nu\nu\alpha\tau\omicron \acute{\omega}$ because of the lack of an ability its obtaining requires. This is why Aristotle needs to establish (DCA) that the cosmos never has the ability for non-rotation. But in De Caelo I.12, the cosmos' having an ability for non-rotation is not said to be $\acute{\delta}\nu\nu\alpha\tau\omicron \acute{\omega}$ in the sense of MI. For the requisite sense, we need to look at the second class of inability set out in Meta Δ.12.14

The second category of $\acute{\delta}\nu\nu\alpha\tau\omicron \acute{\omega}$ includes situations whose non-obtainings are necessary (e.g., the incommensurability of the diagonal of a square with a side (1019b24-5)). Here, says Aristotle, neither 'δυνατόν' nor 'δυνατον' depends upon the presence (or absence) of a specific ability. (1019b23-4) Instead, these class two $\acute{\delta}\nu\nu\alpha\tau\omicron \acute{\omega}$ involve what cannot in general be true.15 That this is the sense in which Aristotle thinks the cosmos' possession of an ability for non-rotation is $\acute{\delta}\nu\nu\alpha\tau\omicron \acute{\omega}$ is strongly suggested by the language of De Caelo at 281b3ff. Here Aristotle says that his argument depends upon distinguishing what is false from what is necessarily false, and he offers the incommensurability of the diagonal (an illustration of the second sort of $\acute{\delta}\nu\nu\alpha\tau\omicron \acute{\omega}$ given in Meta Δ.12) as an example. Similarly, De Caelo 281b21ff says that in order to think what has the ability to be (F) for an unlimited time also has the ability to be not (F) we must assume what is not just false, but also $\acute{\delta}\nu\nu\alpha\tau\omicron \acute{\omega}$. For this would be to assume the obtaining of a situation whose non-obtaining is necessarily the case.

The first category of $\acute{\delta}\nu\nu\alpha\tau\omicron \acute{\omega}$ includes every situation whose obtaining requires one or more specific abilities (δυναμισς) which are lacking. The second category represents general constraints on all abilities. No matter what abilities anything or things may possess or lack, there are some situations whose obtainings cannot be brought about because of general limitations on all abilities. For example, there is no ability the exercise of which allows an even division of a diagonal and a side by the same unit.

One of these general constraints on abilities and their exercise which will figure in the argument for (DCA) is illustrated as follows in De Caelo and the Metaphysics. Even though a man has the ability to sit and to stand, or the ability to sing and to refrain from singing, these abilities do not enable their possessors to do the one at the same time that they do the other. That a man sits while he stands, or sings while he refrains from singing is not just false, but impossible. (De Caelo I.12, 281b10-18, Meta. Θ.5 1048a21-24).

Generalizing from such cases we get the principle:

(MII) No ability can be exercised in such a way as to bring about the simultaneous obtaining and non-obtaining of one and the same $\phi$. 
(MI) is an instance of what Aristotle calls the firmest and most intelligible of all principles:

It is impossible (δενωρόν) for one and the same thing (i.e., for any item in any category) to belong to and not to belong to the same subject at the same time and in the same respect κατὰ τὸ αὐτὸ. (Meta. Γ.3,1005b18-20)

In this text, Aristotle is trying to complete the refutation of views ascribed by Plato to the Protagoreans and the Herakleitians in his Theseutetus. Accordingly, Aristotle treats the principle as a constraint on rational discourse. But the instances cited above from De Caelo and the Metaphysics leave no doubt that it represents a general limitation on all abilities (De Caelo 281b10-18; 1048a21-4).

(viii)

In addition to (MI) and (MII), there is (among others we shall not consider) a further and obvious kind of δενωρόν relevant to De Caelo I.12 which falls under the second of the categories distinguished in Meta. Δ.12. This kind of δενωρά involves situations whose obtaining would not violate (MI) or (MII) but which would be impossible because of circumstances preventing the exercise of abilities required for their obtaining. Obvious examples are fatigue, drunkenness, disease, broken bones, etc., which prevent a man from doing what he has the ability and would otherwise be able to do. (Jones has the ability to finish typing his book into the word processor in his office but he cannot exercise his ability because he is asleep, is too tired to concentrate, is too drunk to find the key to the office, or is unable to climb the stairs to get in because of his broken legs, etc.) Facts about living things which prevent them from doing what they have the ability to do have counterparts in inanimate objects. For example, the computer cannot print out the text if there is a short in its power switch. The exercise of an ability may also be prevented by something external to its possessor. The line between internal and external preventers if vague, but some clear cases of the latter are the ball and chain tied to Jones' legs to prevent him from running or an obstacle which prevents fire from exercising its natural ability to move upward. Further kinds of external prevention depend upon the fact that an ability to move or to change something is not the same as the passive ability to be moved or to be changed; together with the fact that the two abilities usually belong to different things, or different parts of the same thing, neither of which ability can be exercised without the other. (Meta. Θ.Ι, 1046a20ff, Phys. VIII.4, 254b20ff). For example, a builder cannot exercise his ability to build when building materials are unavailable; and fire cannot exercise its ability to warm things up if nothing adjacent to it has the ability to be warmed. (Gen. & Cor. I.7, 324b9) In general then,

(MIII) for any $\#, \#$ is impossible at any time at which its obtaining requires the exercise of abilities whose exercise is prevented.

(ix)

The application of these features of Aristotle's modal theory to (DCA) requires one final bit of stage setting, a point about the kind of ability in virtue of which Aristotle thinks the cosmos is able to rotate.
According to *Physics* II.1, all natural (i.e., non-manufactured) things—both animae and inanimae—do whatever they do, suffer whatever they suffer, etc., according to their natures. This is because the abilities they have by nature are constitutive of what they are, and comprise their 'inner source of change and remaining unchanged' (192b20). This does not apply only to what a thing does, suffers, etc., naturally, when nothing interferes (e.g., to an oak tree's growth from an acorn, or a bit of earth's moving down when nothing blocks its path). It holds also for departures from the normal exercises of natural abilities caused by interfering factors. If extreme heat, lack of water, and noxious insects keep a tomato plant from producing fruit, that is because of its natural abilities to suffer changes brought about by heat and the rest. If a solid floor holds up a bit of earth, that is because by nature the earth cannot fall when thus constrained. In general, all things being equal (e.g., in the absence of anything to prevent it), a thing does whatever, by nature, it has the ability to do; and is forced to do whatever by nature, it can be forced to do (given something acting to force it). According to *De Caelo*, the cosmos is by nature something naturally constituted (οὐσία) so as to move according to its own nature. (I.2 269a5-7) What Aristotle thinks, then, is that by its nature, the cosmos has the ability to rotate, and that therefore, all things being equal, it does rotate.

(x)

This brings us to question (1) of Section (iv): how can Aristotle show that the cosmos by nature has the ability to rotate for an unlimited time, and question (5): how can he maintain that it always has this ability without an independent proof that it always exists? The answer to both these questions is an instance of the method, sketched in *Posterior Analytics* II.19 through which the ἀρχή or first principles of scientific demonstrations are discovered. The nature of a thing, according to *Physics* II.1, is primarily its form, and secondarily its matter, understood in terms of its (the matter's) form. To discover the nature of the cosmos, then, is to discover the form of the αἰθήρ (aether), the matter of the cosmos, and the form in virtue of which the aether is the cosmos. Because, (as we shall see when we consider *De Caelo* I.2-4), the cosmos' ability for rotation depends upon its matter, we shall therefore ignore the form of the cosmos and concentrate on the form of its matter (i.e., the aither).19

In general, forms are discovered through a process beginning with repeated perceptions of the things in question and ending with an analysis of 'experience' (ἐμπειρία) constituted out of memories of the perceptions. A part of the analysis through which a definition of a form is reached involves a consideration of received doctrines (ἐνδοξά).21 This appears to be what Aristotle is doing in *De Caelo* I.3. In a passage (*De Caelo* 270a12-34) to be considered later in more detail, he claims that the natural motion of the cosmos is circular. In support of this he cites both the evidence of the senses (270b12ff) and ἐνδοξά, the opinions of the ancients. According to all reports of observations of the heavens '... in the whole range of time past ... no change appears to have taken place either in the whole scheme of the outermost heaven or in any of its proper parts (i.e., the sun, stars, etc.)'. And the name of the matter of the cosmos, aither, (deriving, according to Aristotle, from the idea that it 'runs always') provides further confirmation for the claim that it is natural (and hence indicative of a natural ability) for
the cosmos to rotate at all times. The opinions of the ancients according to which the cosmos is akin to the divine (270b10-11) lend further support to the claim that it never changes with regard to its ability for rotation.22

The answer to question (5), then, is that the ascription to the cosmos of an ability to rotate for an unlimited time does not beg the question whether or not the cosmos will always exist. Instead, it is based on past and present evidence concerning the cosmos, rather than the assumption of eternal existence. The Aristotelian methodology for bringing present observations, the testimony of the ancients, and the rest to bear on the question whether the cosmos always has by nature the ability to rotate is, we hasten to add, not a matter of simple induction. Aristotle does not argue that because the cosmos has always been able to rotate up to now, it will, therefore, continue to be able to do so, e.g., because the future resembles the past, or because it is reasonable to adopt the straight rule, or any other such inductive policy. Rightly or wrongly, Aristotle believes that the dialectical investigation of ἔνδοξα, (received doctrines) and the development of ἐνεπερίος and conceptions of essence from repeated observation, provide reliable procedures for determining the natures of things. None of this depends upon what we and our contemporaries in the philosophy of science, probability and statistical theory, etc., think of as induction. Whether Aristotle’s claims about the natural ability of the cosmos are justified depends, then, upon the reliability of the relevant observations, and the Posterior Analytics methods by which claims about natures or essences are developed and checked. There are, of course, serious empirical questions about the reliability of the dialectical methods (the process discussed in Posterior Analytics II.19), and, in general, about Aristotle’s philosophy of science. But a consideration of the merits of Aristotelian scientific methodology is not our concern here. Our point is that the methods by which Aristotle would try to establish the crucial claims about the natural ability of the cosmos to rotate, do not presuppose an independent proof that the cosmos will always exist.

To summarize: the answer to both questions (1) and (5) is that if the methods by which natures are discovered are reliable, the recorded observations and ἔνδοξα confirm the claim that the cosmos has the ability to rotate for an unlimited time. This in turn, provides the basis for the argument for imperishability. If that argument is cogent, and if the methodology for determining the nature of the cosmos is reliable, no independent proof of eternal existence is required. And the claim that by nature the cosmos has the ability to rotate for an unlimited time is arrived at from present and past experience without begging the question of future existence.

(xi)

We have now seen that the ability of the cosmos to rotate is due to its nature. Metaphysics θ.8 tells us more we will need to know about what kind of ability this is. At 1050b23ff, the abilities of 'the sun and the stars and the whole of the cosmos' are said to resemble the abilities which account for the natural motions of earth and fire in the following respect. The abilities of all of these are "non-rational" ἐλεντοῦ (1050b33). Aristotle has already distinguished "non-rational" abilities from "rational" abilities (abilities exercised μετὰ ξόνου) at Meta. θ.2, 1046a37-b3. Rational abilities are possessed only by beings with souls (1046a35-b3);
their possession is constituted by the mastery of a craft, like medicine (1046b7). Non-rational abilities differ from rational abilities in two respects which are crucial to (DCA). First, rational abilities enable their possessors to produce opposite results. For example, the ability in virtue of which a doctor can cure is identical to the ability in virtue of which he can aggravate one and the same disease. In contrast, the exercise of a non-rational ability can produce only one of a pair of opposites. For example, the ability in virtue of which fire or any other thing heats something does not enable its possessor to cool it. Cooling requires a different non-rational ability, whose exercise can cool, but cannot warm things. (1046b19) The non-rational ability for one opposite can explain the other opposite only by its absence. (1050b31-4). In contrast, a rational ability can produce either of two opposites (so long, of course, as it produces them at different times).

The second difference between rational and non-rational abilities is that the exercise of a rational ability depends upon desire, or deliberated desire (δεξία νη προοεισειαν), which Aristotle calls the source of motion (κινησεως αρχην) in the agent's soul. (Meta. θ.2, 1046b22-25; 5, 1048a10) Given a predominant or ruling κυριως desire (deliberated or not) to produce one or the other of two opposites, the exercise of a rational ability follows straightway as long as it requires nothing of which things are incapable. (1048a13-15) But lacking a desire for either opposite, the agent does nothing. Thus, a doctor who wishes neither to help or to harm his patient will do neither. In contrast, the non-rational abilities of soulless things are themselves sufficient for the initiation of motion or change. Whenever they are present, and there is nothing to prevent it, their exercise follows straightway and of necessity. (Meta. θ. 8, De Caelo I.8 276a23-b22, De Caelo III.2-3 passim, and Gen. & Cor. 1.7, 324b9). Thus, fire's ability to warm is exercised whenever this requires no impossibility. And as we have seen, nothing but warming can result from its exercise. This amounts to a limited "principle of plenitude" which holds for non-rational abilities:

(MIV) for every #, and for every time, t, if the obtaining of # at t requires nothing more than the exercise of a non-rational ability, and if its exercise involves nothing of which things are incapable, then # will obtain at t.23

We say (from Metaphysics θ.8) that the ability of the cosmos to rotate—like the natural abilities of earth and fire which resemble it—is non-rational. Therefore, the relevant instance of (MIV) is that, as long as nothing prevents it, the cosmos' ability to rotate will be exercised, and the cosmos will rotate.

(xii)

The modal principles (MI), (MII), (MIII), and (MIV) together with the distinction between non-rational and rational abilities provide sufficient background for the interpretation of (DCA) and all but one assumption in the overall argument which runs from De Caelo 281a28 to 281b29. The argument (as we have seen) incorporates a reference to the usage of 'ungenerable' (to imply that there can never have been any time at which the ungenerated thing failed to exist), and 'imperishable' (to imply that there can never be a time at which the imperishable thing can fail to exist) stipulated in De Caelo I.11.24 Aristotle refers also to a further doctrine of I.11 which we shall call "the principle of maximal ex-
exercise" or "PME". (De Caelo 281a7ff) Instances of PME are: (a) even when nothing interferes with its exercise, a man's ability to hold up a certain weight enables him to hold it up only for a certain (maximal) amount of time; and (b) a man's ability to walk enables him to walk only a certain (maximal) distance. (De Caelo 281a9-10) Abilities are defined in terms of their maximal exercise (281a11-12). There is no such thing as the ability simply to F; every ability (for every F) is the ability to do some amount of F-ing (when nothing interferes). The maxima may, however, be unlimited. At Meta. 6.8, 1050b23ff (for reasons to be considered in Section (xxxvi) of this paper), the cosmos is said not to tire in the exercise of its ability to move in the sense that that ability's exercise has no limit.

(xiii)

Appealing to PME, Aristotle begins the argument for (DCA) as follows: If anything, X, is able both to be F and to be not F, there must be a maximal stretch of time for the exercise of these abilities, (281a29-31) regardless of the category to which F belongs. Since what Aristotle has in mind is the cosmos (that is the X with which he is concerned) and its rotation (that is relevant F), we can assume from Meta. 6.8, 1050b29ff, that the ability to F considered in the ensuing discussion is non-rational. Because non-rational abilities can produce only one result, and not its opposite, the ability to F must be distinct from the ability to not F. So far (and for the last time in this argument) all is plain sailing.

But, says Aristotle, it would be impossible ἄνυποστον for both abilities (the ability to F and the ability to not F) to have unlimited durations of maximal exercise. Here is his argument for this. Suppose the times of maximal exercise for the ability to F and the ability to not F are unlimited (i.e., suppose each is longer than any and shorter than no time and therefore that each has neither a beginning nor an end). Then, if one and the same thing (X) has both abilities, (X) '... will be able (ἀμυνόστον) to be (F) for an unlimited (time), and able to be not (F) for another unlimited time'. (281a34-b1). This, says Aristotle, is impossible (281b1-2); and so X cannot have the non-rational abilities both to be F and to be not F for unlimited times.

It is easy to see that if the cosmos did have the ability to rotate for an unlimited time, as well as the ability to not rotate for an unlimited time, it could not exercise both abilities to their maximal extent. If the cosmos rotates for an unlimited time which has neither beginning nor end, there can be no time left for it to exercise its ability not to rotate. By (MII) it could not exercise both abilities at once, for this would require it to rotate and not to rotate at the same time. Therefore, the cosmos cannot exercise both abilities to their maximal extent. But that is not Aristotle's announced conclusion, given the structure of the overall argument under consideration. What he effectively says is that he can show that no X can have non-rational abilities for both of a pair of opposites. As we asked in section (iv) (question (3)), why can X not have the non-rational abilities to F and to not F as long as X does not exercise them both at the same time? In particular, why cannot the cosmos rotate for an unlimited time while possessing, without exercising it, the ability to not rotate?
Recall that Aristotle is aware that at least some kinds of abilities can be possessed without exercise. As we said above, he offers examples of this in the very next passage of *De Caelo* (281b9ff): a man’s failure to stand while he sits does not show that he lacks the ability to stand. Since Aristotle must have been aware of this problem in I.12, his failure to address it suggests that he thought it does not arise. If so, he must have thought it was ruled out by machinery already in place elsewhere. We think this is his view, since the machinery required to rule it out is provided by (MIV), the principle of plenitude for non-rational abilities discussed in Section (xi).

Assume, as Aristotle does, that nothing internal nor external to the cosmos can prevent it from exercising its natural abilities. (See section (xi).) Suppose (what Aristotle needs to rule out) that the cosmos did have both (A), the non-rational ability to rotate for an unlimited time, and (A’), the non-rational ability to not rotate for an unlimited time. By (MIV), when nothing prevents it, non-rational abilities are necessarily exercised straightway. Assuming the lack of preventors, it would follow that the cosmos exercises A and rotates for an unlimited time, and also exercise A’, and refrains from rotation for an unlimited time. The time during which A is exercised must be distinct from (must not include, be included in, or overlap) the time during which A’ is exercised. Otherwise, the cosmos would rotate and not rotate at the same time, in violation of (MII). Therefore, the cosmos has abilities A and A’ only if there are two distinct stretches of time, both of which are unlimited. But a stretch of time is unlimited only if it is larger than all, and smaller than no stretch of time. Therefore, if there were two distinct, unlimited stretches of time (as would be required for the cosmos to possess both A and A’), each one would have to be larger than the other. But this too violates (MII); nothing can bring it about that one thing, x, is larger than another, y, while y is larger than x.

Therefore, the cosmos cannot have both the ability to rotate for an unlimited time, and the ability to not rotate for an unlimited time, and by a similar argument, (DCA) holds for all non-rational abilities. Aristotelian astronomy thinks that the cosmos has the ability to rotate for an unlimited time. This, according to (DCA) precludes it from having the ability to not rotate for an unlimited time.

If x has a non-rational ability to F for an unlimited time, it follows by a similar argument not only that it cannot have a non-rational ability to not F for an unlimited time, but also (as the argument from (DCB) requires) that it cannot have a non-rational ability to not F for a limited time. Thus, if the cosmos did not rotate for even a very small stretch of time, that would violate (MII). Once again, (by the principle of plenitude, (MIV) and the assumption that nothing prevents the cosmos from exercising its natural ability) if the cosmos has the ability to rotate for an unlimited time, it rotates for a time, T, greater than all and smaller than no times. Suppose the cosmos also has A’’, the ability to stand still for a tiny stretch of time, t. On Aristotle’s conception time is linear in a way which guarantees that t is included in T. By (MIV) and the assumption that there are no preventors, the cosmos has ability A’’ only if it actually fails to rotate during t. But if it rotates throughout the whole of T, and T includes t, this would require it to rotate while not rotating at one and the same time. Because this violates (MII), it is impossible. This explains Aristotle’s belief that if the cosmos is always able to rotate it never has the ability to not rotate—neither for an unlimited nor a limited time.
The argument just concluded also provides part of the argument for imperishability from DCB: the cosmos lacks the ability to fail to rotate, even for a short time. And the principle of plenitude, together with the claim that the cosmos has the ability to rotate for an unlimited time gives us DCB's antecedent: the claim that the cosmos actually does rotate for an unlimited amount of time. (This answers question (2) of Section (iv)).

(xiv)

The fourth question outstanding from section (iv) is why the imperishability of the cosmos should follow from its perpetual rotation if it lacks the ability not to rotate (DCB). A tempting answer is that this inference is warranted by the doctrine of the Categories (2b5-6) that the occurrence of any item from any category requires the existence of something of which that item is predicated. Since rotation belongs to a category (it is a doing of something, Cat. Chapter 4), the rotation of the cosmos cannot occur at any time at which the cosmos fails to exist, and therefore the cosmos exists whenever it rotates. Therefore, if the cosmos will never stop rotating, it will never perish. Call this interpretation 'CA' (Categories).

We believe that CA is incorrect, and that (DCB) must be explained along other lines. The trouble with CA is that it does not explain why Aristotle says that anything which rotates for an unlimited time is perishable only if it has the ability not to rotate (De Caelo 281b29-30). If CA were correct, the perpetual rotation of the cosmos would be enough to establish its imperishability, regardless of whether it has the ability not to rotate. Furthermore, according to CA, imperishability would follow from the cosmos' having at all times, at least one item from a category; any item would do. Thus, assuming that the ability for non-rotation is, or requires, the possession of something from a category, the continued existence of the cosmos could be secured as much by its having the ability to fail to rotate as by the fact of its rotation. But according to (281b29-30), having the ability to fail to rotate would be a necessary condition for its perishability. We reject CA, then, because it fails to explain how the ability for non-rotation figures in Aristotle's formulation of (DCB).

(xv)

The significance of rotation for De Caelo I.12 is strongly indicated by an argument for imperishability in De Caelo I.3. The argument is introduced by the claim, developed in I.2 and I.3, 269b19-270a12, that in addition to earth and water, whose natural motions are toward the center of the universe, and air and fire, whose natural motions are away from the center, there is a fifth simple body, aither, whose natural motion is circular. Aither is the matter of the cosmos. Indeed, the cosmos just is the whole of the aither (De Caelo I.3; Meteorology, I.2).

If there are only five simple bodies, and the aither whose natural motion is circular is one of them, Aristotle says two conclusions follow. The first is that non-circular motion is not a natural motion of the aither. (269b32). The second is that the aither cannot be forced to move non-circularly. But all motion is either natural or forced (269a31-2).
And so the aither can move in only one way; motions other than the circularity which is natural to it are impossible.

In the passage with which we shall be concerned, Aristotle claims it is well to say for similar reasons ("Οἱ κλών καὶ τὸ κύκλον ἀποκαταβάλλεται") that the aither (the whole of which, it will be recalled, is the cosmos)

(AI) . . . is ungenerated and imperishable, and subject neither to growth nor to alteration, because (A) everything that comes to be comes to be from opposites and some substrate, and (B) perishes similarly (by) some substrate (going) from an opposite to an opposite (C) as was explained in our original discussions. Now (D) the motions of opposites are opposite. But (E) there can be no opposite for this (i.e., for the circular motion of the cosmos) because there can be no motion opposed to circular. Nature seems rightly to have exempted from opposites the body which was to be ungenerated and imperishable. For generation and perishing require opposites. (De Caelo 270a13-23)

Because the cosmos just is the whole of the aither, this passage claims it is reasonable to think the cosmos cannot perish (is not generated, and it neither grows nor alters) because it is reasonable to think that its rotation is the only motion of which the aither is capable. In discussing (AI), we want to show how the impossibility of non-rotary motion is supposed to establish imperishability, and why, contrary to CA (the interpretation we rejected in the last section) the argument for imperishability depends on this, rather than any other feature which can be predicated of the cosmos.

The "original discussions" mentioned in (C) of our passage, which establish the connection between the impossibility of non-rotary motion and imperishability are contained in Physics I.4-9, and summarized at De Caelo 270a11-16. According to Physics I.8-9, all change, including coming to be and passing away requires a substrate which endures through the change while losing (gaining) one feature or group of features and gaining (losing) its opposite. Where the change is the loss or acquisition of an accidental feature (e.g., where Socrates who is swarthy becomes pale), the replacement of one feature by its opposite does not destroy the individual which changes. In such cases, the individual is a substrate with a form or essence, (e.g., a batch of organs and limbs with the form of a living man). The individual which has the accidental feature is the composite of substrate and form (Socrates). Because the substrate (e.g., Socrates' bodily parts) maintains the form (e.g., whatever is essential to being a living man) the individual does not perish while losing the accidental feature with respect to which it changes. In contrast, an individual perishes only when its substrate ceases to have the required form or essence. Thus, Socrates perishes if his substrate ceases to be a living human organism. So, if perishing, like accidental change, involves a substrate going from a feature or features, F, to its (or their) opposite(s), F0, then F must be a feature such that if a substrate comes to be F0 and ceases to be F, it thereby loses the form required for the existence of the individual whose substrate it was. For each kind of individual, then, there will be one or more specific values of F such that if the individual's substrate becomes F0, the individual perishes. Not just any F will do. It must be an F such that what is F0 cannot have the form or essence required for the individual's existence.
At the same time, since the substrate endures the perishing of the individual whose substrate it was, the required \( F \) must be such that the acquisition of its opposite does not destroy the substrate. For example, suppose a particular bit of bronze is a sphere, and that sphere exists as long as the bronze is spherical. To destroy the sphere (e.g., by melting it down) is not to destroy the bronze; it is, instead, to render the bronze non-spherical. Similarly, the bit of bronze exists as long as its substrate has whatever features are essential to bronze. The bit of bronze ceases to exist when the substrate of the bronze loses those features, but their loss destroys the bronze, not its substrate, and so on.\(^\text{3}\)

According to 270a17 of our passage, the motions of opposites are opposite. For individuals consisting entirely of earth, air, fire, water, or aither, this means that for any \( F \) upon which the existence of the individual depends, whatever is \( F \) must have a natural motion which opposes the motion of things which are \( F_\theta \). In particular, suppose the aither is \( F \) and that the cosmos cannot perish unless the aither (its substrate) comes to be \( F_\theta \). If opposites have opposite motions it follows that the aither comes to be \( F_\theta \) only if it comes to have the opposite of circular motion. And in doing so, it must not cease to be aither; for the aither is the substrate of the cosmos, and must survive the process (if there is one) by which the cosmos perishes. But by AI (E), there is no opposite motion (no motion opposed to rotation) which the aither could have, either by nature, or unnaturally (by force). It follows that the aither cannot come to be \( F_\theta \), and therefore that the cosmos is imperishable. This, as we understand it, is why the impossibility of the cosmos (the whole of the aither) having a motion opposed to circularity makes it reasonable to think it imperishable. Rotation is not just any item from a category. It is an (or the) \( F \) such that the aither is the cosmos only if it is \( F \), and there is no cosmos if it is \( F_\theta \).

How then is the opposite of rotation impossible (\( \alpha\delta\upsilon\varpi\alpha\omicron\nu \)) for the cosmos? In discussing AI (E) in De Caelo I.2-3 Aristotle does not appeal to anything which is exercising an ability to prevent the aither from moving in a way opposed to rotation. Nor does he suggest that the aither has a passive ability to be forced to continue rotating. Thus the impossibility of non-circular motion for the aither is not an instance of (MIII). Nor is it straightforwardly an instance of (MII). Aristotle does not argue that in order for the aither to move non-circularly (MII) something would have to be in opposite states at the same time.\(^\text{34}\) Rather, he argues that if the aither is a simple body, it can have only one natural motion (i.e., rotation in one direction only). It cannot be forced to move non-circularly either. As we saw, the forced motion of a simple body must be, or must at least include, a motion which is the opposite of its natural motion. For example, since the natural motion of fire is upwards, its forced motion requires a downwards motion. But as Aristotle says repeatedly in De Caelo 1, 2, 3, 4, there is no opposite for the natural rotation of the aither. Because the natural motion of the cosmos is that of its matter, and its matter is the aither, there is no opposite for the rotation of the cosmos.

This is not because the definition or the "logic" of the term for circularity excludes an opposite. Opposites are pairs of features (category items), \( F \) and \( F_\theta \), such that
(a) one and the same thing, x, can have or be either F or F₀,
(b) x cannot be or have both F and F₀ at one and the same time and with respect to the same thing,
(c) F and F₀ belong to the same genus, and
(d) F is more different from F₀ than any feature in the genus which x can be or have.35

For example, upwards motion is the opposite of downwards motion for anything (fire, for example) which can move in both directions. Both belong to the genus of locomotion. Whatever Aristotle means by 'different', he supposes that moving upwards is more different from moving downwards than any other motion of which fire is capable. And, although fire can move both ways (upwards by nature and downwards by force), it cannot move in both ways at once. Similarly, a man can be both pale and dark; the opposites will be the darkest and the lightest color his skin is able to have.36 ('Difference' seems to be a primitive, and we have been unable to find any technical explanation of it.)

Accordingly, when Aristotle says there is no motion opposed to rotation, we should understand him as saying this with regard to the cosmos. He is claiming, then, that, although the cosmos has the ability to rotate F, there is no F₀ such that (a) the cosmos can have F₀; (b) the cosmos cannot have F₀ at the same time it rotates; (c) F₀ belongs to the same genus as rotation (i.e., F₀ is a motion); and, finally, (d) F₀ differs more from rotation than any other motion of which the cosmos is capable. The impossibility of forced, non-rotatory motion and the lack of an opposite for the rotary motion of the cosmos are, therefore, instances of [MI]: If the obtaining of a situation, #, requires the exercise of unpossessed abilities (in this case, the abilities that would be required for the cosmos to have a motion meeting the conditions the opposite of rotation would have to meet), # is impossible. (This is compatible with there being other things—wheels, for example—which can rotate and move in a way opposed to rotation—e.g., rotate clockwise or counterclockwise.37)

In other words, we read Aristotle as arguing that the only motion the cosmos can have is circular because neither it nor anything else has the abilities that would be required for it to move in any other way, either naturally, or by force.

If this is correct, then—contrary to CA—rotation is crucial to the imperishability of the cosmos in a way that other items from the categories are not. The nature of the cosmos (unlike natural substances whose natures derive mainly from their form) is constituted primarily by its substrate or matter. Thus its nature is inextricably bound up with the aither’s ability to rotate, and with its lack of abilities (both passive and active) for other motions. Indeed, the ability to rotate is the only feature of the aither explicitly and emphatically said by Aristotle to be constitutive of the nature of the cosmos. Accordingly, rotation can be identified as the feature which the aither must have in order for the cosmos to exist. Non-rotary motion is the feature whose possession by the aither would necessitate the cosmos’ losing that which constitutes its very nature. Therefore, the cosmos perishes only if its matter (the aither) moves non-circularly. And the cosmos is perishable (i.e., it is possible for the cosmos to perish) only if the aither is able to move non-
circularly. No other feature is crucial in this way to the existence of the cosmos.

(xvi)

One loose end remains to be tied before we say our last word about (DCB). If the aither cannot be the cosmos (and therefore, if the cosmos cannot exist) unless it rotates, we may presume that the cosmos would perish if the aither stood still. What rules this out? Since Aristotle does not tell us explicitly, we speculate that the reason lies in the doctrine that the cosmos has, by its very nature, a non-rational ability to rotate perpetually, and also that there is nothing else in existence to prevent its exercise of this ability. Given this, by (DCA), it lacks the ability to fail to rotate. Since non-rotation is just as much a case of failure of circular motion as is non-circular motion, the cosmos’ lack of an ability for non-rotation should preclude its standing still, just as it precludes non-circular motion. And by the argument of De Caelo I.8, imperishability for the cosmos would require it to lack the ability for stasis just as much as the ability for motion opposed to rotation.

In summary: we began this discussion with doubts about CA, which interprets (DCB) as an instance of the Categories’ doctrine that what has any item from any category exists. Our alternative is that (DCB) is a highly compressed statement of the following line of thought. The cosmos can cease to exist only if its substrate, the aither, is able to cease being whatever it is to be the cosmos. The aither could cease to be whatever it is to be the cosmos only if it could fail to rotate, for rotation is the (or an) F such that what is not F cannot be the cosmos. But the cosmos (the whole of the aither) always rotates, and because it lacks the ability for non-rotation (both for stasis and for non-circular motion), it is impossible for the aither to stop rotating. Therefore, the aither cannot cease to be the cosmos. And therefore (since the perishing of the cosmos would require a substrate which could lose the form in virtue of which it is the cosmos) the cosmos cannot perish.

(xvii)

Aristotle must now show that the cosmos is ungenerable in the sense which requires there never to have been a time at which it could fail to exist, and thus no time at which it could have been generated. This is the role of (DCC) which claims that because the cosmos is imperishable, it is also ungenerable. Having completed the argument for the imperishability of the cosmos, Aristotle says that similar reasons establish that it is ungenerable. He then recapitulates the arguments we have been examining, and indicates their applicability to ungenerability.

(AIII) For, on the one hand, as the perishable is what was formerly, but now is not, or what has the possibility of not being F at some future time, so, on the other hand, the generated is that which has the possibility of not being F at some time past. But there is not a time (οὐκ ἔστιν ἐν ἔχρόνυ), whether limited or unlimited, in which it is possible for the thing that is always F that it not be F. For if it is able to be F during a limited time, it is also able to be F during an unlimited time. It is not possible, then, that one
and the same thing be able both to be always F, and not to be F (281b27-34).

All! opens with a clear reference to the senses of 'generated' and 'perishable' discussed above and given at the beginning of De Caelo I.11. If, as (All) maintains, the 'generated' is that which has the ability to not be F at any moment in the past, the 'ungenerated' is that which at any time whatsoever lacks the ability to not be F. Although he does not spell it out at this stage, Aristotle's claim rests on an intrinsic ontological feature which a strictly ungenerated thing possesses. In passage All (De Caelo I.3) he maintains that nothing can perish unless it loses a feature essential to its nature. Here he makes the same claim concerning generation, namely, that the essential nature of an ungenerated thing remains the same: it still is what it was and it will continue to be what it is. Thus, there is no stretch of time, whether limited or unlimited, during which it can fail to be what it is. Let F be a feature of a thing whose nature is such that what lacks F cannot have that nature. Then Aristotle is saying that if it is always ungenerated, it is impossible that it can exercise an opposite ability for failing to be F for an unlimited time. Thus it cannot both be ungenerated at any time whatsoever, and also have the possibility of not being F at any past time.

(xviii)

Shortly we will look more closely at the ontological relationship between 'being imperishable' and 'being ungenerated'. But now consider an important statement in (All). Aristotle says "There is not a time, whether limited or unlimited, in which it is possible for the thing that is always F that it not be F." The argument should not be construed as follows: the ungenerated is what it is at every time in the sense that the crucial F is present in it, as such, at each moment. If the ungenerated exists at all moments of time, it cannot fail to be what it is at any given time, and is thus omnitemporally present. Therefore, to say that what is ungenerated is omnitemporally present, is to say that it is ungenerated necessarily. This argument, as such, is patently vacuous. But it is one to which those appeal who think that Aristotle derives necessarily F from always F. Simply to hold that what is ungenerated is F at all times, is not grounds for saying that it is ungenerated necessarily. In other words, that something is omnitemporal does not in itself entail that there is no time at which the thing that is ungenerated can fail to be. The modality embodied in the notion that at no time can the ungenerated fail to exist, cannot itself rest on the claim that it is F at all times. That an ungenerated thing is able to exercise its ability omnitemporally is a claim about its nature, not a claim about its sheer omnitemporal existence. In other words, the thing that is F always is not merely always exercising its ability to F; rather it is exercising at each single moment of its existence the ability grounded in its nature to be F always. This is why Aristotle says, (completely indifferent to the order in which the ascription of times are taken), that the thing cannot not be F either during an unlimited time or a limited time. And this is just to say that what does not begin cannot end and what does not end cannot begin. Thus, Aristotle's argument does not hinge on an illegitimate move from the temporal 'is F at all the times there are' to the modal 'cannot not be F (always)'. For it is clear that what happens to be F always is not sufficient in itself to secure that it is F of necessity—that is, that it is necessary at any time for it to be F at all times. Quite the con-
trary: it must be necessary at each individual time that the ungenerated obtain at all times.39

(xix)

Three important questions now require attention: (1) what intrinsic connection does Aristotle make between the predicates 'being imperishable' and 'being ungenerated' if applied to one and the same thing?; (2) if the cosmos has the ability necessarily to rotate at any time, past, present, and future, and if what is necessary must obtain, is Aristotle committed to a notion of actual infinity that contradicts the doctrine of the possibly infinite in the Physics?; and (3), although we have already explained why the cosmos' ability to rotate must be exercised as long as the cosmos has it, we must consider another question about that ability. As Aristotle asks in Meta 6.8, how is it that the exercise of an ability does not wear out that ability? (See section (xxxvi).) If its ability to rotate could be exhausted in some way the cosmos would cease to rotate and therefore to exist.

(xx)

Consider the first question. After again arguing that that which is always able to be F and that which is always able not to be F are opposites, Aristotle shows schematically that the intermediate position is that which is sometimes F and is sometimes not-F. He then turns to the relationship between the terms 'imperishable' and 'ungenerated'. His aim is to show that they 'go together' or 'imply one another' (ἀνακολουθοῦν ἀλληλοῦσιν). So that "If the imperishable and the ungenerated (τὸ ζέ‐θορος καὶ τὸ ἀγένητον) do not imply one another, it is not necessary for either the ungenerated (ἀγένητον), or the imperishable to be eternal (ἄνυτον)" (282b8-10). Aristotle's argument is this:

(AIII) It is clear that if anything is both generated and perishable, it is not eternal. For it will have at one and the same time the possibility always to be F and the possibility always not to be F; but that this is impossible (ἀδυνατοῦν), has been shown already. Surely, then, if something is ungenerated, and existing, it is necessary that it is eternal, and similarly if it is imperishable, and existing? (I am using 'ungenerated' and 'imperishable' in speaking strictly: 'ungenerated' to mean that which now is, and which earlier in time it was not true to say that it did not exist; and 'imperishable' that which now is, and which later in time it will not be true to say that it does not exist). Or, rather, if these terms mutually imply one another, and the ungenerated is imperishable and the imperishable is ungenerated, it is also necessary for 'eternal' to be implied by each of them, so that whatever is ungenerated is eternal and whatever is imperishable is eternal. (282a24-32; 282b2)

Interestingly enough, the initial argument of (AIII) makes appeal to what has been established at 281b 20-25 about the nature of what is imperishable. This is, that if something is imperishable, it is impossible that it can exercise the opposite ability for an unlimited time. In the present passage that principle is used to say that the generated and the perishable cannot be eternal because the impossible consequence would obtain that at one and the same time the same thing could exercise oppo‐
site abilities eternally, i.e., that it could be both F and not-F for an unlimited time (MII). But what of the claim that the 'ungenerated' and the 'imperishable' 'go together' or 'mutually imply one another'. The central conviction here is that if something is ungenerated and imperishable it cannot not be. And, if this is so, for Aristotle it cannot come to be and pass away. Thus, anything ungenerated and imperishable is always F in the precise sense that it is completely what it is at any given time. It is this notion to which Aristotle refers when he says that strictly at no time past or future is it true to say either that it was not F or that it will not be F. A thing, then, that is always F, is ungenerated, not merely in the sense that it could not ever have been generated, but in the stronger sense that its nature excludes the very possibility that it itself could ever have come to be.

(xxi)

Consider the aither again in the light of this. On the supposition that the cosmos came to be, it came to be out of the aither. And so it was generated only if there was a time during which the aither was not the cosmos but had the ability to be whatever it is to be the cosmos. By the arguments just considered, this requires a time at which the aither did not rotate. This in turn requires that the aither also has the ability not to rotate. But by its very nature the aither always has the non-rational, one-way ability to rotate for an unlimited time. Moreover, its nature is such that it cannot be changed or affected by anything in the natural order that exists separate from itself. In the absence of anything to prevent its exercise, a non-rational ability is exercised of necessity (MIV). Thus, in the case of the aither it has always rotated, rotates, and will continue always to rotate. And because non-rational abilities are exercised whenever there is nothing to prevent them, the aither could have the non-rational ability for non-rotation only if at some time it failed to rotate. But this is impossible since it rotates at all times. And so, if the arguments for DCA and DCB are cogent, they serve also to secure DCC.

(xxii)

Now consider question (2) of section (xx). This involves making sense of Aristotle's claim that the full exercise of the ability to rotate always, demands reference to an unlimited temporal maximum that is yet "in a way determinate" (283a9). An answer to this question begins to emerge if we consider the position that he both rejects and ascribes to the Plato of the Timaeus. After arguing at 283a4ff that what has a beginning has an end, and conversely, Aristotle entertains the following 'Platonic' supposition: could there be something that begins at a time to be F and continues to be F always, or which ceases to be F at a time, having previously always been F?46 He immediately replies that a supposition of this kind contradicts the principles that he has already established. He continues:

(AIV) For all things that are able either to do F or to suffer F, able either to be F or not to be F, are capable of these for a determinate (ὑποκόμενος) time, either unlimited or a certain quantity (νοῦς). On account of this, it [being determinate] also [applies] to unlimited time, because unlimited time is in a way determinate (ὑποκόμεν μέν), where there is not anything greater. But what is unlimited in one
direction only is neither unlimited nor determinate (283a7-10).

What is one to make of the terse argument of AIV? We take ὑπὸςεὶςνότον to apply to both ἄνευ ποιόν and ποσόν. It is, of course, possible grammatically to take it with ποσόν alone, but then the argument lacks sense. Notice also that Aristotle is emphatic that anything that is "unlimited in one direction only is neither unlimited nor determinate". He clearly has the following sort of objection in mind: even if the cosmos exists for an unlimited time after t, is it not possible that it could fail to exist during an unlimited stretch of time before t? And, of course, his argument reflects his anti-Platonic belief that if the cosmos rotates eternally, this must mean that it is necessarily impossible that it could ever at any time fail to exist. The argument also refers back to the rather enigmatic formula of the opening argument. There we are told that "if the time will not be some definite quantity (ποσός ἥν), but is always greater than which is set down and lesser than none, one and the same thing will be able to be F during an unlimited time, and able to be not F for another unlimited time, but this is impossible." (see section (iii), note 5.) In short, if the cosmos rotates eternally in the sense that its existence at any time implies that it rotates always, it can neither fail to be for an unlimited time nor can it exist for an unlimited time in one direction alone.

(xxiii)

As we have already noted in section (xii), in (AIV) Aristotle is not contrasting a finite and measurable quantity of time with a period of time that is merely indefinitely great; rather, his contrast is between a definite finite time and definite unlimited time, both of which are said to be determinate. And the notion of unlimited time that he has in mind is one with respect to which "there is not anything greater". In this sense an unlimited time lacks an end (πέρας) and hence cannot be said to be unlimited in one direction only. This conception of unlimited time is clearly the eternal time (i.e., time unlimited without qualification) that Aristotle takes to characterize the intrinsic connection which obtains between the cosmos' ungenerability and imperishability. (See AII.) But if at any t necessarily the cosmos is, has, and will rotate always, and if what is necessary must obtain, does this not commit Aristotle to an actually infinite number of rotations? And if the rotations are not actually infinite, what fixes the extension of 'all' in the notion that the cosmos must rotate during 'all the times there are'? But if the rotations of the cosmos are not actually infinite, how are we to understand the notion that unlimited time, like a finite time, is determinate?

(xxiv)

Waterlow has recently worried about these questions. Referring to the opening argument of De Caelo at I.12, 281a33-4 (see section (iii)), she says that Aristotle speaks "of infinite time as though it were an amount of time." Indeed, in 284a7-10 (AIV) she translates ποσόν as 'amount'. Her argument is this. On the one hand, she construes Aristotle as holding that the unlimited (as characterized by the genitive phrase "always greater than ... and lesser than none") "is not numerically specifiable". From this she concludes that Aristotle "denies that it is measurable". But on the other hand, she says that he "speaks of it as greater than measurable amounts. But this suggests that he thinks of
infinite time too as *an amount* (an immeasurable one). And her reason for this interpretation is the benign fact that if one term of a comparison is an amount then the other term of the comparison can be construed as an amount. But, as we have just seen, the contrast that Aristotle is drawing is not between a finite and measurable quantity on the one hand, and an indefinitely great period time on the other, but rather between a finite time, and an unlimited time than which none can be greater.

It seems to us misleading to translate *μονόν* as amount. The term 'amount' too easily tricks the mind into thinking of a quantity as an extended whole. Then, if we interpret Aristotle as comparing limited amounts of time with *an unlimited amount* of time, we can easily think of unlimited time as a collection of moments at once set out in an unending series which can be compared with any limited stretch of time. But this is tantamount to thinking of unlimited time as an *actually* infinite collection of times. Now Waterlow's concern is to fix the extension of the 'all' in 'all the times there are' in a way that clarifies the sense in which the extension is determinate. She is led, however, into construing the parallel between limited and unlimited times in a way that is seriously misleading. Given that Aristotle sees an eternal exercise (i.e., the rotation of the cosmos) as a manifestation of one and the same indivisible ability at each moment of time, and given that the duration of an exercise is characterized by an internally directed temporal maximum, Waterlow appears to accept the following analogy. Just as the exercise of certain individual abilities involves an activity that gets expended during a limited temporal span, so, the exercise of the cosmos' ability to rotate always is an intrinsic activity that gets expended during an unlimited yet determinate span of time. Since this picture prompts us to treat both limited and unlimited times as temporal stretches or extensions, it is puzzling just how an unlimited time can be determinate. The sense in which a limited stretch of time can be determinate (i.e., it is an item whose clockable measure by iterative units is completeable) is inappropriate. And the real mischief is that the spurious parallel suggests that Aristotle's unlimited time is somehow an omnitemporal totality, a mysterious, all-embracing actuality which includes at once all the times there are. Little wonder, then, that Waterlow puzzles as to whether or not the notion of unlimited time is to be parsed by either a distributive or collective use of 'all'. The distributive 'all' is inappropriate to Aristotle's position since it is compatible with the possibility that the cosmos might fail to exist at some particular time; and it is clear that the collective 'all' commits him to the absurdity that the cosmos at each moment in its rotation is all at once an eternal rotator. Waterlow rejects the distributive sense of 'all' as inappropriate to the exercise of an ability to F always; and she also hesitates to accept fully the implications of the collective 'all'. So in the end she remains in a quandary as to how Aristotle's unlimited time "is in a way determinate".

(xxv)

But Waterlow also raises the question whether or not De Caelo I.12 and Physics III.6 present a consistent view on the nature of the infinite. The Physics' view takes an unlimited time to mean a time beyond which there is always another; whereas, the De Caelo view can be read (Waterlow does not entirely disavow it) as saying that 'always' implies a completed whole. But then says Waterlow, the same "duration is to be regarded both as a whole and as an uncompletable series of finite
stretches." On her view, Aristotle gives no clear lead for answering this paradox. She concludes, however, that he need not, since he has grounds that do not involve the "concept of a temporal maximum" to show that what is always the case is necessarily the case.47

We think that the logic of the distributive and collective senses of 'all' is irrelevant to Aristotle's position; that the doctrine of the infinite in Physics III.6 is perfectly adequate to, and is indeed confirmed by, De Caelo I.12; and, lastly, that the notion of a temporal maximum is appropriate to the claim that the cosmos rotates always and necessarily, provided the sense in which it can be said to be determinate quantity is adequately understood.

(xxvi)

Recall what Aristotle has to establish regarding the rotation of the cosmos: (1) that something that has the ability to F always, exercises the same ability to F always; and (2) that at each and every moment it is necessary that it exercise that very ability always. If, therefore, he can claim at t that it is the case that the cosmos rotates at every time after t (as well as rotating at t and every time prior to t) he can conclude that necessarily the cosmos does, always did, and always will rotate.

But according to Physics III.6 the ἄνειρον is never fully actual. And given that the cosmos has actually rotated through an unlimited number of times during the past, it is still the case that the future is open-ended. What then fixes the 'every' in 'every time', if there can be no actual limit to the number of rotations that will take place? And if it is necessary that an unlimited number of rotations takes place (on the grounds that the necessary must obtain), how can an unlimited number of rotations fail to occur? But does this not deny the Physics III.6 doctrine that the ἄνειρον can never be actual?

(xxvii)

In response to these difficulties, and those raised by Waterlow's analysis, we propose the following strategy. No doctrine is more characteristic of Aristotle's natural philosophy than the claim that the cosmos is a great natural clock which defines the uniform motion necessary for the standard of time. We accordingly propose to show that there are intrinsic analogies between some central features of Aristotle's doctrine of the unlimited in the Physics, and the nature and function of his cosmic clock. In particular, we will show how the notion of the unlimited in the Physics pertains to time as the measure of the cosmic clock's rotation.

(xxviii)

First, what are the essentials of the Physics doctrine of the unlimited? Although the unlimited is not among the αἰσθητικα for Aristotle, he does consider its properties in the context of studying objects of perception. Thus, he is emphatic that the unlimited is not a thing that exists separately; in fact it is simply a category mistake to think of it in any sense as 'a thing or object'. It is this conception which motivates his appeal to the 'mode of being' which 'a day' or 'the games' can be said to have (Phys. III.6, 206a20-25). We can say of 'a day' that it is occurring and will occur, and of 'the games' that they are going on and will go on. Of 'Socrates' or 'a horse' this cannot be said; they are indi-
individuals which, qua individuals, exist at each and every time as wholes. But this cannot be said of 'a day' or 'the games', since their 'mode of being' is successive in character. Aristotle is here mobilizing a distinction between completed and uncompleted 'things'. 'A day', 'the games' or 'a walk to somewhere' fall into the second category. Of each it can be said that it is now occurring or is now going on, as well as that it will occur or will go on. Being successive in character, they possess a characteristic **nepos**, or limit, which indicates that they are processes which can be completed, i.e., we can at any time be walking to Thebes, though at a given time the process is still incomplete. However, of individuals like 'Socrates' or 'a horse', qua individuals, it cannot be said that they are occurring or are going on.

(xxix)

Despite Aristotle's claim that 'the unlimited' is unlike a thing, but like 'the games' is successive in character, there is an important disan­alogy between 'the unlimited' and 'the games'. As Aristotle understands the unlimited, it of course lacks any characteristic **nepos**; as such, it is limited and hence incompletable. We can say of 'the games' that they are going on at a time, since there is a characteristic **nepos** applicable to that type of phenomenon. However, it is self-contradictory to say that the unlimited is going on at a time; that would be to complete the incompletable. The point is not that (a) no application of an indefinitely repeatable operation can be accomplished at any t, but, rather, (b) that no step towards the completion of an unlimited succession can be taken at any t, since lacking a **nepos** it also lacks a completion. Given this fact, it is nonsense to suppose that a step closer to its completion is possible. (a) is false, but (b) is true. And it shows the difference between the games and the unlimited: a step can be taken towards the completion of the games, but it is impossible to take a step towards the completion of the unlimited. For the unlimited is that which always has something outside itself, and is "that which cannot be gone through" (Phys. III.6, 204a15; Meta. K.10, 1066b5-10). Furthermore, we can say of 'the games' that they take place in a stretch of time; but temporal notions are inapplicable to the way in which the unlimited, as such, is successive. It is not a process that takes time; rather, it is successive in the way in which a numerical series is successive.

(xxx)

Now the distinction between temporal successiveness and non-tel­poral successiveness is important. Aristotle's works are everywhere filled with talk of 'number' and 'measure'. This is nowhere more evident than in Book III of the Physics. There the unlimited is construed by means of operations that can be conceived in terms of what is limited. For example, a rule of division for any quantity can be articulated such that however many 'parts' are taken, more of the same can be taken without termination in the sense that the rule allows no result of a divi­sion which itself cannot be so divided (III.6, 206b1-16). Now implicit in Aristotle's thinking is the notion of a logos, or formula, that can be expressed in terms of an algorithm—a device that defines the mind's ca­pacity to go on in accordance with a rule. Just as we can articulate an algorithm that generates the series of positive integers, so we can artic­ulate an algorithm that defines completely any determinate rule of divi­sion pertaining to any quantity. For instance, given two unequal quanti­ties, from the greater half can be subtracted, and from its remainder a
half, and so on without a recursive terminator. Here a rule of indefinite division is stated without explicit appeal to any notion of infinity. This is consistent with what Aristotle has in mind when he states that any finite quantity is possibly infinite in division, a claim that does not entail that a stage can be reached at which the quantity is divided into an actual infinity of parts. Thus, division is unlimited in the sense that its algorithm provides no limit to its repetitions; the algorithm expresses the fact that the quantity has the permanent possibility of being successively divided.48

Now, if the precise sense in which an algorithm is determinate is that it at once encapsulates in its definition the rule that governs its procedure, an intuitive basis is provided for grasping how the unlimited rotations of the cosmos are determinate. The exercise of the cosmos' ability to rotate can be thought of as the operation of a 'natural algorithm' analogous to an algorithm for division. Thus, 'encoded' in the cosmos' nature at any time t, is the determinate ability to always rotate, an ability the exercise of which cannot fail to obtain at all times. So, if each rotation of the cosmos is an activity analogous to the performance of an operation defined by an algorithm for division, its ability for repeated rotations is analogous to the capacity of the algorithm itself. Moreover, just as an algorithm for division does not define any intrinsic recursive terminator, so the cosmos' ability for repeated rotations is preserved in the very act of being exercised. Finally, just as any line is capable of divisibility at any given point, similarly, nothing can prevent the cosmos for exercising its ability to rotate at any given time.

The sense, then, in which the rotation of the cosmic clock through unlimited time is determinate is clear. Its rotations are quantitative in the precise sense that they can be compared to the recursive operations defined by a determinate algorithm where the algorithm and its repeatable operations are comparable to the cosmos' intrinsic ability for repeated rotations. It is clear, then, that the distinction between the distributive versus the collective 'all' is irrelevant. For just as we cannot say that the unlimited is going on at a time, since that would complete the incompletable, so, similarly, we cannot say that the cosmos is eternally rotating at a time. Now, when Aristotle tells us that 'what is unlimited in one direction only is neither unlimited nor determinate' it is clear what he means. If 'being ungenerated' and 'being imperishable' imply one another, then both the 'ungenerable but perishable' the 'generated but imperishable' denote states-of-affairs that cannot obtain. For they combine two inconsistent attributes with the inconsistent claim that that which needs an unlimited time during which to expend itself can have at least one temporal boundary, i.e., either a beginning or an ending. But this is to limit the unlimited or to complete the incompletable. Moreover, it is to entertain a notion which is indeterminate. For to say that something is 'unlimited/limited' or 'incompletable/complete' is to attempt to specify a nature which does not embody a distinct or graspanle αὐτός. Either the time for the exercise of an ability is unlimited and eternal or it is not: there can be no tertium quid.
Thus, we need not suppose that an ability to F always has to be defined by reference to an unlimited time construed as a maximal amount of time in the sense in which the notion of an 'amount' is applicable to finite stretches of time. All we need is the application of the doctrine of the unlimited in Physics III to the exercise of an ability to F always where the exercise of that ability cannot fail at any time past, present, and future. In other words, the unlimited as deployed in De Caelo is not a constitutive fact about the indivisible ability to F always, qua ability; rather it pertains to an essential feature of the exercise per se that is licensed by that ability, namely, that it is an exercise that is both never complete and never ending.49 For just as an algorithm defines an operation that can produce any possible division of a line, so the cosmos' present ability to rotate always defines its exercise of 'every rotation' though 'every time'. To think otherwise, is to commit Aristotle to the present existence not only of times past, but of the times yet to come. In short, the puzzle as to how the duration of an unlimited time can be both a whole of time and an incompletable succession of finite times is purely illusory.

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Aristotle’s reasoning turns on the acceptance of two important concepts: a view of what a natural ability is, and a conception of the unlimited and eternal that is non-Platonic. The first commitment is developed further at 283a14-15 when Aristotle asks of an ability: "Yet, why was it destroyed at this particular time rather than any other, when up to now it always existed, or why was it generated now, when for an unlimited time it had not always existed?". His intention is to raise difficulties for the conception that there are natural abilities exercisable simply because they occur at a particular moment in time. For example, if something is said to have the ability to be imperishable once it comes into being, how are we to understand the notion that there is something whose nature has the ability both to come into being at a time and an ability to maintain its existence thereafter for an unlimited time? It is clear that the possibility of the thing's being imperishable in the past at any time prior to the moment it begins to exist is limited; otherwise nothing would have prevented it from having an ability to be imperishable during an unlimited period of time both past and future. But how, Aristotle asks, is the thing's coming into being, as an imperishable thing, at this particular time to be explained? Can one say that it has both an ability for not existing, and, at a particular moment, an ability for existing thereafter for an unlimited period of time? But to posit such an ability is to entertain a hybrid between a true non-rational ability to be F always, and opposing abilities to both be F and not F. For Aristotle, a 'hybrid ability' of this sort is patently contradictory. And, as such, it is something that cannot obtain naturally in the order of nature. Moreover, as he goes on to argue 'if the possibility (to be F or to be not F) is present prior to the actuality, it will obtain for all time (επικεφαλείαν τον χρόνον), even when the thing was ungenerated and not-existing (for an unlimited time), but able to come into being'. (283a20-23)50 But in virtue of this condition, if a thing of this sort is in actuality, it will still have the ability not to be F. Therefore, it has not got the ability to be completely what it is at any given time in the sense that there cannot be a time at which it can fail actually to be F always. But this is what it is to be an imperishable thing.
It is clear enough that Aristotle wishes to qualify certain natural abilities by referring their periods of exercise to definite stretches of time whether limited or unlimited. But it is not clear that this alone rules out those abilities that he thinks are not natural. So consider again Aristotle’s question why an ability gets exercised when it does. We have repeatedly stressed that he is committed to the view that when a natural ability gets exercised, the initiating of that change is to be explained in terms of certain internal features intrinsically present in the thing possessing the ability, and also by certain external conditions obtaining in the environment which are either necessary for its exercise or such as not to prevent it. But what cannot be explained readily is the exercising of an ability simply in virtue of its being concomitant with the occurrence of a particular moment of time. At 283a15-16 Aristotle asks why this change occurred at one particular time rather than another. Thus, if there seems to be no sufficient reason why the change occurred when it did, equally there is none to show why at any given earlier moment it did not occur then. Moreover, if there is no explanation for the change that rests on the nature and ability of what undergoes this change (together with what does or does not obtain in the environment), for Aristotle the initiating of the change is beyond natural explanation.

Aristotle clearly perceives a connection between the impossible consequences of the exercise of a ‘hybrid’ ability of this sort, and the need to posit a ‘unidirectional infinity’ to accommodate its exercise. Ironically enough, the notion of a ‘unidirectional infinity’ raises a putative difficulty for Aristotle’s general notion of the unlimited. The difficulty was first raised by Philoponus. In Physics III.6 Aristotle is clearly committed to the notion that the unlimited is never actual and never traversable. But he is also committed to the view that there is no beginning for time, motion, the cosmos, and the generations of men. If this is so, if time is beginningless, is it not the case that an infinity of days has elapsed prior to the present day? Have these days not actually occurred in some sense? And do they not form a definite collection which will be increased by the occurrence of days yet to come. Furthermore, is not the collection of past days a collection that has been traversed by the rotations of the cosmos? Even if we hold with Simplicius that the past days no longer exist, is it not the case that their occurrence still allows the formation of a collection? But even though the past days in a beginningless cosmos are no longer actual (in the sense of being mutually co-present) must not their infinity still be actual?

We think that these objections are irrelevant to Aristotle’s anti-Platonic conception of the unlimited. In fact, far from there being any inconsistency between the Physics and De Caelo I.12 concerning the doctrine of the unlimited, the latter makes explicit commitments only implicitly present in the Physics. Quite simply Aristotle’s purpose in I.12 is to deny that the unlimited in one direction only is truly unlimited. If the reference is to the past days elapsed up to the present day, then there is one temporal boundary, the present day; if it is a question of the days yet to come two boundaries can be posited, the present day and the nth day or the nth + 1 day, etc., that will occur subse-
quent. In both cases, the unlimited is limited and the uncompleted is completed. But as we have seen, what underlies Aristotle's position is the claim that not only are the years through which the cosmos has rotated an expression of its inexhaustible ability, but so too are its future years. Moreover, if the past days elapsed represent an unlimited time in one direction only, the addition of another day is irrelevant. For on Aristotle's conception of what is truly unlimited we cannot say either that one infinity is greater or lesser than another, or that there is a ratio between the finite and the infinite.\textsuperscript{54}

(xxxxvi)

Now consider question (3) posed in section (xix): what sort of ability is such that its exercise cannot exhaust that ability? Aristotle denies that what happens \textit{de facto} to last forever is genuinely eternal and unlimited. For him the eternal must necessarily last forever in the sense that its very nature excludes the possibility of failing to exist. So he must combine his claim that the cosmos' imperishable rotation is necessary with an account of the ability that can insure the inexhaustibility of its exercise. This is not to say that the necessity of the cosmos' eternal rotation is grounded in the inexhaustibility of its capacity so to rotate. That necessity is a modal fact about the cosmos' \textit{nature} as such. But that nature (comprising as it does the fact that the cosmos is composed of \textit{aither}) possesses an ability to exercise eternal rotation. In what follows we shall clarify this claim and argue that the ability for eternal rotation can be classed as an ability which shares some features in common with a second δύναμις (ability).

We begin our answer to (3) by considering a remarkable passage from Meta. 6.8, 1050b6–28. Its context (as already noted) is a general discussion of various sorts of abilities. There Aristotle criticizes the Megarians and specifies in detail what is possible and impossible in virtue of the natural abilities things possess. But the immediate context of the passage is a discussion of the senses in which different things are said to be prior. Eternal things are prior in substance and perfection to perishable things. The passage is worth producing in full:

But actuality is also prior more strictly; for eternal things are prior in substance to perishable things, and nothing eternal is possibly [i.e., merely able to be F]. This is the reason: every ability is at the same time an ability for the opposite; for whereas that which is not able to obtain cannot belong to anything, everything that is able to obtain still admits of not being actualized [μὴ ἐνεργεῖν]. Therefore, \textit{being able to be} [something], admits both being F and not being F. Therefore, the same thing is able both to be F and not to be F. And that which is able not to be F, admits of not being F; and that which may not be F is perishable, either \textit{simpliciter} [ἀνώς] or just in the sense in which 'to admit of not being F' is said, i.e., in respect either of place, or of quantity, or of quality [or whatever]—\textit{simpliciter} [being said] 'with respect to substance'. None, therefore, of the imperishable things \textit{simpliciter}, is possibly \textit{simpliciter} (though nothing prevents this being so in some respect, e.g., [being possibly] with respect to quality or with respect to place). All imperishable things, therefore, \textit{are} actually. Nor can any of the things [be possibly] that are of necessi-
ty (indeed these things are primary: for if these were not, nothing would be). Nor indeed does motion, if it is something eternal [exist possibly]; nor if there is any eternal thing moved, it is not a moving thing according to possibility, but only with respect to 'whence' and 'whither' (and there is nothing preventing matter for this [sort of motion] belonging to it). Wherefore, the sun and the stars and the whole heaven are always in activity [i.e., exercising their abilities to rotate], and there is no fear that they may sometime stand still, which is what those who study 'about nature' fear. Nor do they tire with respect to this activity. For movement is not for them, as it is for perishable things, concerned with the ability for the opposite, so that continuity of motion is laborious. For it is the [kind of] substance that is matter and potentiality, not actuality [alone], that is responsible for this [i.e., laborious motion]. And imperishable things are imitated also by things that are [involved] in change, e.g., earth and fire. For these things [i.e., imperishable things] are always in activity; for they have their movement of themselves and in themselves.

Aristotle here combines in one sustained argument both his theory of abilities and his conception of natural modality with his view that the heaven can uniquely rotate always and necessarily. His main conclusion is the claim that anything eternal cannot be possibly δύναμις, but must be actually and necessarily, since anything imperishable simpliciter cannot be 'possibly simpliciter'. That is, the cosmos cannot merely have an unexercised ability to be something from the categories, but must actually at all times be exercising its ability for rotation. And since he explicitly states that the heaven and its motion are imperishable simpliciter, it is impossible that it ever become other than it is at any time. Thus, necessarily, it is impossible that an imperishable heaven ever become a perishable one.

(xxxvii)

This conclusion is perfectly compatible with what we are told about the imperishability of the cosmos in De Caelo Book I. But Aristotle's argument to the effect that 'nothing eternal is possibly [i.e., merely able to be] F' needs comment. It begins with his standard claim that there are things which have the ability to be or to do both F and not F (see section (xvi)). Thus, what is white may become black, and what is may fail to be. Consequently, though something manifests one of a pair of opposites, it still has the ability to manifest the other, and either the possibility of not existing as such and such or of not existing at all, i.e., of being perishable with respect to features that fall under the categories or of being perishable simpliciter. But to be perishable simpliciter is impossible for an eternal thing. This would imply that an eternal thing has the possibility of failing to be δύναμις, and thus of perishing 'with respect to substance'. And this, of course, abrogates the premise that it necessarily lasts forever. Thus, the eternally rotating cosmos has the ability 'always [to be] in activity', which, if exercised, and nothing impossible follows, one state-of-affairs alone can actually obtain. As we noted earlier (see principle (MIV), section (xi)) the cosmos possesses a one-way non-rational ability that satisfies the principle of plenitude. In fact, Aristotle makes this point explicitly at 1050b31-34.
when he contrasts the nature of imperishable things with that of perishable things which have abilities for opposites.

(xxviii)

The passage also indicates that the cosmos is a unique entity which is not a composite of matter and form in the manner of perishable things (see again section (xv)). Moreover, we are told that its motion is without labor making its activity incessantly tiresless. Since cosmic motion does not involve progress from a state to its opposite, and since its substance is 'actuality alone', (i.e., it does not involve any unexercised ability) its continuity in motion is uninterrupted. Thus, the eternally continuous motion of the cosmos is effortless, because it lacks the possibility of a distinct opposite, having only the possibility of 'whence-whither'. This claim is consistent with De Caelo I.3 where we are told that the substance of the cosmos is the aither, 'from the fact that it runs always (ἐν τούτῳ ἀεί) and eternally'. Again, we are told in our passage that imperishable things (the cosmos included) cannot fail to exercise their abilities because 'they have their movement of themselves and in themselves'. This statement not only characterizes the cosmos as the source and subject of its own motion, but it also clearly focusses attention on the sort of ability it possesses which allows for its own inexhaustible exercise. In summary then: the cosmos is unique in nature as in matter, in its intrinsic ability to move itself as in the character of the ceaseless motion that it is.

(xxxix)

It is clear that the exercise of the cosmos' ability to rotate is a persistent actuality (ἐνέργεια). This is what Aristotle tells us at Meta. θ.8, 1050b6-34, and it is a conception that is consistent with the naturalistic approach to the nature and function of the cosmos in De Caelo itself. In this regard, it is well to remember what we are told of the simple, sublunary bodies in Physics VIII.4. The purpose of chapter 4 is to argue that the simple bodies are natural-movers but not self-movers. And, although Aristotle argues to the effect that if released the simple bodies passively undergo motions relative to their releasers in proceeding to their natural places, he nonetheless explicitly compares their natural motions with the knower's exercise of knowledge, something that can occur when nothing prevents it (VIII.4, 255a30-255b13). But the exercise of knowledge is a strict ἐνέργεια as Aristotle defines that term in contrast to a κίνησις at Meta. θ.6, 1048b18-35. There he argues that thinking and seeing, etc., are ἐνέργειαι, and therefore intrinsically complete so long as they last; whereas, a κίνησις (e.g., a walk to Thebes) is an incomplete process until its goal is achieved. That Aristotle thinks of the motion of a simple body as both the patient of its change and like the activity of a second δύναμις (ability) is indeed puzzling, but it is a problem that need not detain us here.

(xl)

We shall return to the distinction between a κίνησις and an ἐνέργεια shortly. But what needs emphasizing here is this. If Aristotle can consider the natural changes of the simple bodies in comparison to the exercise of a knower's knowledge, there is no decisive reason why cosmic rotation cannot be conceived as an ἐνέργεια of the appropriate sort. After all, the cosmic nature, although a fact of the physical order,
is not on par with the nature and motions of the simple bodies. It is prior to them in being, nature, and motion; it is immortal, divine, and of the highest excellence; it is unchangeably and unalterably what it is; its motion is ceaseless and unterminated; and it is the reality from which other things derive their being and life. Thus, we take seriously the ungenerability of the cosmos, and the fact that it possesses the ability for necessary and continuous motion that cannot be prevented. According to our analysis, then, the following comparison between the cosmos and the simple bodies cannot be made. This is the claim that the cosmos' relation to its own rotation is like fire's capacity to move upward by its nature if not prevented. That is, if the simple bodies are not self-movers but only natural movers (Phys. VIII.4), the cosmos cannot be thought of as a self-mover either. Therefore, the eternal and necessary rotation of the cosmos is simply a brute fact of its nature. On our view, however, cosmic motion cannot be explained as just a natural motion on par with that of the simple bodies; rather, it is to be explained as a persistent exercise, the continuing actuality of which is enabled by an ability that is constitutive of the cosmos itself. From this perspective, cosmic motion is neither agentless nor dependent upon a separate transnatural agency.

(xli)

To deny that cosmic motion can be explained by simply saying that it is in the cosmos' nature to do so, needs further clarification. Of course, the cosmos' nature is constitutive of what it is. But it is also constitutive of what it does. That is, the inherent nature of the aither is the motion-determinative basis of the cosmos' characteristic function—to rotate necessarily and always. Thus, although the cosmos' nature (understood as that which the cosmos is) does not itself do anything, the cosmos nevertheless possesses and exercises the ability for eternal rotation essentially, i.e., in virtue of what it is. Conceiving the cosmos thus, permits an account of an important notion. This is Aristotle's view that the cosmos possesses at each and every time—for all the times there are—the same indivisible exercise of the same indivisible ability.

(xlii)

A clarification of this ability must begin with a further consideration of an important distinction. This distinction is briefly discussed in (xxxix) and is found at Meta 8.6, 1048b18-35 and in the Nicomachean Ethics at X.4, 1174a13-19. In addition to what we have said the following should be noted. Aristotle holds that some processes have a limit to which they proceed such that prior to its cessation on reaching its goal their motion is essentially incomplete. Thus, these sorts of actions (e.g., walking with the purpose to be somewhere) are all relative to an end to be achieved. But actions of a second sort (ἐνέγραψα), are essentially complete, and always have their ends intrinsic to their activity itself. The nature of these actions Aristotle clarifies by noting that they alone satisfy the conjunctive application of the present and the perfect verbs. At one and the same time we are seeing and have seen, are understanding and have understood, and are flourishing and have flourished. But at one and the same time it is not the case that a thing is coming to be and has come to be, or is moving and has moved. Thus, these second sorts of actions (ἐνέγραψα) are true actualities, not just motions that need completion. At each moment in their activity, they are intrinsically
one and the same, requiring nothing more at a later time to perfect themselves.\(5^5\)

(xliii)

But how does this distinction help to clarify the claim that the eternal rotation of the cosmos is a complete actuality at all times? Moreover, if its rotation is actual and necessary, it cannot possess any unexercised abilities. But how can this be the case if at any time its rotation is incomplete? First, consider the relevance of the distinction. Just as seeing is an action complete at each moment, presently continuous with its past activity, and requiring nothing more at a later time to perfect itself, so also the exercise of the cosmos' ability to rotate is complete and actual at every moment in its rotation. Now since the cosmos is ungenerable there can never be a time at which it fails to have the ability to rotate; and since it is imperishable there can never be a time at which that ability will fail to be exercised. And although it is untrue to say the cosmos is eternally rotating at a given moment (just as it is untrue to say that one can be dividing infinitely at a moment), nevertheless at each moment in its eternal and necessary rotation one and the same indivisible ability is being completely exercised. Therefore, that ability can be characterized at any time as one that is being exercised and has been exercised. And, given that the cosmos necessarily rotates forever, if at any moment it is true to say it is and has been rotating, the exercise of that ability is complete at each moment and requires nothing at a later time to perfect itself. Thus, the function of the cosmos (i.e., to rotate eternally) is intrinsic to its activity. And this activity is the manifestation of a natural ability which is fully exercised at every moment in the career of the imperishable and ungenerable cosmos. Therefore, since at any moment in its eternal rotation it is true to say the cosmos is and has been rotating, the exercise of its ability to do so is necessarily inexhaustibly the same.

(xliv)

But we must still ask: can the cosmos possess any unexercised abilities (in the traditional jargon, any unactualized potentialities) if its rotation is always actual and necessary? If this is so, if it can, there appears to be a conflict with the Meta. 6.8 claim that the cosmos is always actually doing what it is able to do. But, what can it mean to say that the cosmos' ability is always exercised if there are stretches of time too small to encompass a complete rotation, and throughout which the rotation is incomplete? Furthermore, is it not the case that there can never be a finite temporal stretch during which the cosmos can have completed its unlimited rotation. It appears, then, that if there can never be a stretch of time during which the cosmos' ability is completely exercised, its nature must possess unexercised abilities. But according to the 6.8 account, the rotation of the cosmos is actual and necessary and never merely possible in the sense of what might or might not obtain, but as yet does not.

(xlv)

What is needed and what our analysis of the unlimited provides (see sections (xxviii)-(xxxii)) is an account of the cosmos' ability for unlimited rotation that commits Aristotle neither to the notion of the actually unlimited nor to the notion that the unlimited is merely possi-
ble. We argued in sections (xxxi) and (xxxii) that the exercise of cosmos' ability for rotating can be compared to the operations of a 'natural algorithm'. Thus, intrinsic to the cosmic nature at any t, is the determinate ability to rotate always, an ability the exercise of which cannot fail to obtain at all times. So, at every time the cosmos is actually rotating, has always rotated, and will continue always to rotate. It is in virtue of this ability, then, that each rotation is preceded and followed by another throughout a succession of unlimited rotations. And since the occurrence of each rotation counts as the exercise of that ability to rotate through an unlimited succession, its exercise is actual in the sense that it is and always will be exercised necessarily. It is clear, therefore, that the ability to rotate is never merely possible, since there is never a time at which the ability can, but may not be exercised. This is an evident instance of modal principle (III): that which is necessary is not possible. Thus, in the ever present rotation of the cosmos, capacity is not replaced in the manner of a first ability by being actualized in time. Rather, the ability that enables the cosmos to do what it does is actuality in the sense that at each moment in its endless career the cosmos is completely exercising its ability-to-rotate-always. Thus considered, the cosmos' nature satisfies the notion that what is necessary is that which cannot at anytime fail to obtain. It is actually and completely at all times what it is by nature.

Although decidedly not a second δυνάμει or ability, the natural ability of the cosmos for rotation shares an important feature of that notion. At De Anima II.5, 417a30-b7, Aristotle distinguishes two types of ability: the ability to acquire a skill and the ability to exercise it once acquired. A skill once acquired is a first actuality; but under a different description this first actuality is also a second ability δυνάμεις. Its exercise is a second actuality, i.e., the actual using of the skill acquired if not prevented. Typically, second δυνάμεις are rational abilities (e.g., thinking, understanding, seeing, etc.) that involve intentional acts of the mind. Moreover, their exercise satisfies the notion of a strict ἐνεργεία or action as defined in Meta. θ.6, 1048b18-35—i.e., at one and the same time one sees and has seen, understands and has understood. Now it is clear that the cosmos of De Caelo does not possess a second δυνάμεις. That would be a construe it in terms of an ability for rational and intentional action. But it is precisely this view that Aristotle rejects in favor of his naturalized conception of the aither as a self-mover. Thus Aristotle does not think of the aither of De Caelo as a god that wills itself into self-activity, but as a nature (φύσις) that is the ἀρχή κινήσεως ἐν αὐτῷ (I.2, 268b17). Furthermore, the cosmos' ability to rotate is not acquired and then exercised (if not prevented) in the manner of a second actuality or δυνάμεις. On the contrary, its ability is changelessly constitutive of what it is. Nevertheless, like the exercise of a second ability, the exercise of the cosmic ability is fully actual in the sense that its rotating now is continuous with it having rotating before. This perspective certainly illuminates the closing statement of Meta. θ.8, 1050b6-18 (See (xxxviii)), in which Aristotle says that imperishable things (the cosmos included) are always active, having their movement of themselves and in themselves.

Two questions arise here. (a) Aristotle's naturalized conception of the cosmos makes it the source and subject of its own motion. How is this to be understood? (b) How can the cosmos be in motion if its motion
is not consistent with the definition of motion in Physics III.1? After all, it is hard to see how rotation fits the Physics account of what motion is. And if it does not, it is hard to see how the Physics account of natural motion is applicable to the cosmos, and to the arguments of De Caelo I.12. First, question (a). Since the exercise of the cosmos' ability for rotation is beginningless and endless, there is never a moment at which its rotation can fail to be actualized by that ability. Thus, the cosmos is always doing what it is able to do in the sense that its ability for rotation is instantaneously exercised at every moment. Moreover, since that ability's exercise is a non-kinetic activity or ἐντολὴ in the sense of Meta. θ.6, it can never be conceived as the passive recipient of its intrinsic activity. But this also means that cosmic rotation is not the effect of a distinct, external agent as its source, but is itself the eternal and self-sufficient source of its own endless motion. If, as we have argued, the cosmic nature possesses a full-fledged ability to move, it can be conceived as both the mover and the moved. That is, the cosmos fails under two distinct descriptions: it is at once what is able to rotate eternally as well as that which rotates eternally. Thus, its ἔννομος or ability is the ground of the self-active element in its nature that never fails. And so conceived, this ability—to rotate always—is the eternally changeless feature of the cosmic nature, and one distinguishable from the physical bulk of the cosmos that rotates always. Moreover, since the rotation of the cosmos is an actuality whose present continuance is consistent with its earlier completeness, it is indistinguishably the same at any moment of the cosmos' unending duration. The cosmos is therefore at all times the same complete ἀρχή of its own motion. It is clear, then, that this interpretation satisfies the Physics II.2 notion that nature alone is the intrinsic source of motion in natural things. Moreover, one can well imagine Aristotle relishing the adoption of the Platonic conception of a self-mover to the nature of the cosmos in De Caelo (and in this connection to his own theory of ability and actuality), while rejecting Plato's conception of eternity.

(xlvii)

It is clear, then, that a thesis integral to De Caelo is the conception of the cosmos as a self-mover. But now consider question (b) which is intimately related to the self-mover conception: is cosmic rotation a κίνησις and, if so, need it satisfy the definition of motion in Physics III.1? The first difficulty is prompted by the Physics III.1 definition. In the light of it, we are told repeatedly in the Physics that linear motion has a definite point or place as its end. On the face of it, this makes it hard to see how rotation is a local motion: it has neither an end-point in the manner of linear motion, nor does it involve a change of place as do local motions. Moreover, the end of a linear motion is beyond the thing that is moving locally; but what is the analogue of this for rotatory motion? Aristotle anticipates these difficulties. At De Caelo I.8, 277a24-26, he tells that there is 'a kind of opposition' (ὅσ ἐντολή-μετα) between the ends of the diameter of the path defining cosmic motion, though (a point he argues earlier) there can be no opposition intrinsic to cosmic motion as a whole. Thus, there is a sense in which cosmic rotation has an opposed end-point. At De Caelo II.2, 285b8-25 he gives more substance to these ideas. There we are told that the initiation of cosmic motion can be located by reference to its poles, its right side being the point from whence (ὅσεν) its motion begins, that point being the place at which the stars rise. So, according to Aristotle, the place where the stars rise is the right side of the cosmos, and where
they set is the left. Against this framework, he states that cosmic motion begins from the right and moves to the right. Thus, one rotation is defined as starting at the point at which the stars rise, then moving away from that point toward the left, and finally returning to it again. For each rotation, then, the place where the stars rise serves as an external end. This schema clearly fits Aristotle's statement in Meta. 6.8 that the eternal motion of the cosmos is not 'with respect to possibility, but only according to whence and whither'. For to define a motion as 'whence-whither' with respect to the same point does not involve reference to the Physics III.1 doctrine that linear motion is incomplete prior to its actualization on reaching its external end-point or place. And it is this notion that motion is a process to actualization through opposites that Aristotle denies is appropriate to the necessity and actuality of cosmic motion (6.8, 1050b21-24; De Caelo I.8, 277a15-26). This point is confirmed at De Caelo I.9. After arguing that the cosmos is unique and immutable, and that its duration is immortal and divine since it is derived from ἄτη: τινα: 'to be always' (279a18-24), Aristotle tells us that its rotatory motion has one and the same 'place' from whence it begins and to which it returns (279b3-4). Its motion is unceasing in contrast to things whose motion ceases on arriving at their natural places. He asserts the same position at Physics VIII.8, 264b18-19. After arguing that there is no impossible consequence in holding that revolving motion is continuous he states his conclusion: 'rotatory motion is motion of a thing from its place to its place, whereas linear motion is from its place into another place'.

It is clear that Aristotle treats linear and rotatory motion as distinct kinds of motions. It would be a help if he had defined explicitly a genus of which linear motion and rotation are species. We think, however, that he has just this notion in mind. In De Caelo I.2 Aristotle argues that there are only two sorts of simple, natural motions—right line motion up or down, and revolving motion in a circle. At I.2, 269b8-9 he states explicitly that rotation is the only 'continuous and eternal motion'. These claims are developed in great detail in Physics VIII.8 and 9. At the beginning of VIII.8 he argues that the only continuous motion is rotatory motion. The argument is made within the framework of the same exclusive dichotomy evident in De Caelo: this is, that the simple motion of each thing that is 'carried or borne along' (τὸ ἐφεξῆς ἐχεῖν) is either rotatory or linear motion, or compounded of these two basic motions (VIII.8, 226b8-9). The argument is continued through VIII.8 and 9, where it is argued that rotatory motion is unique, eternal and prior (because perfect) to all other motions, and that it alone can be continuous and unlimited, since it alone is unceasing and imperishable (VIII.9, 265a25-27). It is evident, then, that Aristotle recognizes two basically different kinds of motion that fall under the genus of things that are 'carried or borne along'. This should not surprise us. After all, the ability of the weightless aither to rotate always and necessarily is very different in kind and account from what is appropriately said of the unexercised abilities of the sublunar simple bodies whose motions are in complete, prior to reaching their finite end-points. Thus, we see no compelling reason why the Aristotle of De Caelo need be concerned that cosmic rotation is not consistent with the definition of motion in Physics III.1. For its very nature it cannot be; but it is still a κίνησις for all that; though not in the sense that κίνησις is ἐντελέχεια κινητοῦ ἀτελής.
The conclusions we have reached immediately prompt three questions. (1) What of the passages that have been taken to refer to the unmoved mover in De Caelo? (2) What of Books VII and VIII of the Physics that argue that everything is moved either by itself (animate things) or by another (VI.10, 241b23; VII.4, 254b12-33), and that the cosmos is moved not by itself but by the unmoved mover? And (3) what of those passages in De Caelo that appear to conceive the cosmos as alive and ensouled? These are well known issues. But since they putatively qualify our strict naturalistic interpretation a brief indication of where we stand is necessary. Of course, one's ultimate reply will be conditioned by whether certain passages are thought to have been added to the main body of the text at a date subsequent to its main composition; and on whether one accepts the claim that Books VII and VIII of Physics as such (or in part) post-date the writing of De Caelo. There is also, of course, the related question whether or not the last two Books of the Physics supersede the theory of motion of the earlier books. And if one considers the 'dating-game' to be a hopeless quest, there is still the issue of how to construe the imperatives in Aristotle's thought that impel its systematic development. For certainly it is easy to confuse temporal with systematic priority. These are large questions of interpretation that cannot be settled here, though it must be said that there is a clear reference to Physics VIII.10 in De Caelo I.7, 275b22-24 that is integral to the latter's argument, and definitely not a later addition.18 Regarding question (1) we certainly agree with Guthrie that the two mentions of the unmoved mover in Books II and IV of De Caelo are dubious and isolated.49 In II.6 the subject is the regular and constant motion of the cosmos. None of the first four arguments is explicitly designed to establish the unmoved mover, the first and third being perfectly compatible with the conception of the aither as the self-moving and supreme reality of the physical world. The fourth argument appears to mention the mover, but its account makes no difference to the notion that the cosmos is the natural source of its own regular motion (288b22-26). Finally, the last two arguments in fact show that the regular motion of the cosmos results from its nature alone. As regards I.v.3 its topic is the motions of the elements to their natural places in exercising their abilities. At the end of iv.3 Aristotle refers to Physics VIII.4, 254b23-256a3 in support of his claim that the simple bodies do not move themselves. The fact that Aristotle characterizes the motion of a simple body as rising in part from its source and producer of motion εἴ ἀρχῆς ποιήσαν is no argument for an unmoved mover (IV.3, 311a10). This might seem plausible if we translate the phrase εἴ ἀρχῆς ποιήσαν as 'the original creative force' or 'the primary agent'.79 But, in any event, the context of the overall chapter is clearly against taking this phrase as a flat reference to the first mover. Lastly, De Caelo 1.9, 279a25-279b3 (though it considers what there is beyond the cosmos) is definitely not a reference to the unmoved mover. On the contrary, Aristotle says decisively that 'there is nothing superior that can move it [the cosmos]'; for 'if there were it would have been more divine'. This line of reasoning (as one would expect of De Caelo, Book 1) is perfectly compatible with the doctrine of nature of Physics II.1.
Now consider question (2). There is no doubt that the cosmos of *De Caelo* is a self-mover. As such it falls under the rubric of things moved by themselves. It is thus the πρῶτον σῶμα that causes by its natural self-motion (either directly or indirectly) all other forms of limited motion, change, birth and decay (II.1, 283b76-284a12). Why does Aristotle argue in *Physics* VII and VIII that the cosmos is moved by something other than itself—viz., an incorporeal unmoved mover? The standard answer is this. In the latter books of the *Physics* he came to think that everything that is moved (animate things excepted) is moved by something other than itself. In order to avoid an infinite regress of such movers (VIII, 256a, VII, 42a243a) there must be an external first mover and an eternal first moved, i.e., the sphere of the cosmos. This argument is conducted in terms of the conception of motion of *Physics* III, i.e., that a thing’s motion is incomplete prior to ceasing on reaching its goal. Given this, and given Aristotle’s principle that the initiation of motion demands the prior presence of something already in actuality, to avoid regress Aristotle posits an eternal and immutable ἐνέργεια. Within this framework, the rotation of the cosmos is an incomplete κίνησις that constantly strives for perfection by imitating the immutable unmoved mover. However, if we are right, the framework of *De Caelo* (based as it is on the necessary self-motion of the cosmos) is itself internally coherent. It might be objected that the cosmos does not satisfy an important criterion for self-motion advanced at *Physics* VIII.4, 255a5-10. This is the claim that animate things alone possess two-way δυνάμεις, i.e., they can both move and stop moving, both sit and stand, etc. We have argued, of course, that the ability of the cosmos for rotation is one-way and non-rational. But we have also argued that Aristotle has a powerful theory of naturalized abilities and the conditions under which they can, cannot, and must be modally exercised. Within this framework the exercise of the cosmic ability for rotation is unlimited, since it has, is, and will obtain necessarily and always. Thus, while the cosmos in *De Caelo* is not a self-mover according to *Physics* VIII.4, it is clearly a self-mover in that it is the necessary source and subject of its motion in and of itself. Given this, and given its central and singular position in Aristotle’s natural philosophy, the rotatory self-motion of the cosmos is unique, and hardly inconsistent with the overall theory of motion advanced in *Physics* VII and VIII. After all, as we have argued, the exercise of its ability to rotate is at every time a complete ἐνέργεια. As such, it obviates a regress of movers while satisfying the notion that every incomplete motion presupposes the prior presence of something already in actuality. Thus, there is nothing intrinsic to Aristotle’s thought—on matters of cosmology and natural philosophy—that compels the positing of an unmoved mover. Therefore, on considering the imperatives that drive the systematic development of his thought, we should not be too hasty in making the unmoved mover the necessary capping stone of his theory of motion. And in any event, we have not got definitive arguments to show that the unmoved mover supersedes the naturalism of *De Caelo* in providing an account of what makes the cosmos go around.

This brings us to question (3). If there are indications that the cosmos is alive and ensouled in *De Caelo* might this not indicate that Aristotle conceives it as ensouled in the spirit of ‘Platonic motion’ whereby souls are the only self-movers and the source of all other motions? We think not. Two passages need brief comment. In II.12, 292a19-23, Aristotle says that we think of the stars as soulless (ἐγγυμον) and as merely bodies. However, we ought to think of them ‘as if (ὡς) they partake of
activity and life' (292a21). This ως must be taken seriously with the in­
finite construction (υμομανθανειν). Aristotle is stating an analogy. In
fact, he says explicitly at 292b1-2 that we 'must suppose that the activi­
ity of the planets is analogous (τοιαοτην ως αναλο) to that of the ani­
mals and plants'. His point is this. If we think of the motions of the
heavenly bodies as if they had some of the features of ensouled things
which exhibit life and activity, it becomes easier to think of the inter­
related and ordered motions of the heavenly bodies in relation to the
motion of the cosmos itself. In this natural hierarchy the eternally ro­
tating cosmos with its regular and constant motion is the source of all
change and motion. Thus, in comparison to other moving things it is the
principle of perfection which they depend upon and emulate. So, given
the complex interrelations of the cosmos to its 'parts' and the 'parts' to
one another and to the cosmos itself, the cosmos can be thought of as if
it were an organic whole. It is not that the stars, etc., are alive, but
rather that their motions and the principles that explain them can be
acted as though they were analogous to the principles which explain
animate things. This interpretation is supported by another important
passage. At I.9, 279a24-29, Aristotle says that just as each thing has its
characteristic life-span or duration, so analogously the duration of the
cosmos is everlasting (αιτί) since it is immortal and Divine. But when he
goes on to say that all other things have their 'existence and life' in
dependence of the cosmos (279a30), this is not to say that the cosmos
itself is alive. It is merely to say that the causal presence of the cosmos
is everlasting, an attribute that befits the θειον σωμα of the Divine
body of the physical world. Thus, there is nothing in these passages
to suggest that the exercise of cosmic rotation is directed by a rational
δυναμεια, or that its rotation does not obey our principle of plenitude.

A central feature of our analysis is the claim that the doctrine of
the eternally rotating cosmos (The Great Clock) requires the sophis­
tication of Aristotle's theory of modality. We also argue that this theory
rests on the doctrines of nature and abilities, and the conditions under
which the latter are exercisable. This is significant. De Caelo I.12 makes
extensive use of these inter-related notions, and of what is said to be
necessary, possible or impossible in virtue of them. The evident connec­
tions between Metaphysics 6.8, 1050 b6-28 (see xxxviii), and the cosmo­
logy of I.12 (especially the claim that the cosmos is a self-mover whose
motion is actuality) alone justify this claim. But these connections indi­
cate something more. They reveal an intrinsic relationship between the
thought of the central triad of the Metaphysics--Books Z, H, and Θ--and
the doctrines of matter, form, ability and actuality used in the first
Book of the De Caelo. Certainly Books Z, H, and Θ contain a developed
account of these doctrines. But if, as we think, I.12 requires the sophis­
tication of Aristotle's basic theories, the conception of the cosmos it ad­
vocates is not one that necessarily remains valid for the early develop­
ment of his thought alone. After all, if it can be argued that the trans­
cendent prime mover presupposes the developed doctrines of ability and
actuality and is thus a late conception, with equal cogency one can
argue that the cosmos of the De Caelo and Meta. 6.8--that which rotates
in and of itself always and necessarily--presupposes the same doctrines
for its articulation and justification.
ENDNOTES

1 Aristotle uses ὁ κόσμος, ὁ οὐρανός, πρῶτος σώματος and τὸ πᾶν interchangeably. We shall use the term 'cosmos' to refer to the body that contains the whole of the Heaven. For Aristotle's discussion of the senses in which he uses the term οὐρανός see De Caelo I.9, 278b 10-22.

2 Some crucial texts are Prior Analytics I.13; De Interpretatione 9; Physics, Books I, II, and VIII; Metaphysics Δ.12, and Book Θ; and De Anima II.5.


4 For our views on the "dating game", see also the conclusion of the paper and note 68. We believe little use attaches to attempts to set the relative chronology of works in various fields; rather, it is determination of the conceptual structure and the interrelations of different aspects of Aristotle's thought that counts. These issues would remain open even if we possessed precise data concerning both relative and absolute dates of composition of the Aristotelian corpus.

5 The first section of this text (281a28-b1) claims literally that what has the ability to be for an unlimited time cannot also have the ability not to be for an unlimited time:

εἰ δὴ ἦστιν ἔννοια δυνατὰ καὶ εἶναι καὶ μὴ, ἀνάγκη χρόνον τινὰ ὑρίσαβι τὸν πλεῖστον καὶ τοῦ εἶναι καὶ τοῦ μὴ, λέγω δ' ἃν δυνατὸν τὸ πράγμα εἶναι καὶ δὲν δυνατὸν μὴ εἶναι καθ᾽ ὁποιανοῦ κατηγορίαν, οἷον ἀνθρώπων ἢ λευκῶν ἢ τρίπηχος ἢ ἄλλ' ὀτιοῦν τῶν τοιούτων. εἰ γὰρ μὴ ἦσται ποσὸς τες, ἀλλ' ἂεί πλείων τοῦ προτεθέντος καὶ οὐκ ἦστιν οὗ ἐκλάττων, ἂπειρον ἦσταί χρόνον τὸ αὐτὸ δυνατὸν εἶναι, καὶ μὴ εἶναι ἀλλ' ἂπειρον ἀλλὰ τοὺτ' ἀδύνατον.

For reasons set out in our discussion in note 7, we translate as follows:

If then there are some things able both to be F and not to be F, there must be a certain maximum time determining of their being F and their not being F: I mean a maximum time during which the thing is able to be F and a maximum time during which it is able not to be F, according to any category whatsoever; for example, being a man, or white, or three cubits long, or anything other of this sort. For if the time will not be some definite quantity, but is always greater than that which is set down and lesser than none, one and the same thing will be able to be F during an unlimited time, and able not to be F for another unlimited time; but this is impossible.
'To be F' means to be whatever the thing has an unlimited ability to be. 'To not be F' is to not be whatever that is. Henceforth in the translation of all passages, where appropriate, F will be a place-holder for the relevant predicate item. In the case with which we shall be concerned, it is impossible for the cosmos to have the ability both to rotate (the relevant predicate item) for an unlimited time and to not rotate for an unlimited time. Leo Elders takes this passage existentially, saying that it "presupposes a proportion between the essential structure of a thing and its actual duration, and implies a world in which finality dominates". See Aristotle's Cosmology: A Commentary on the DE CAELO (Netherlands: Royal Van Gorcum Ltd., 1965), Chap. XII, p. 164. He goes on to state explicitly that "the argument is based on a relationship between a capacity to exist and actual existence" (p. 165). Paul Moraux is silent on the issue. He does point out, however, that the ability of the cosmos to exist eternally is a physical, not a logical, modality. See his Aristote du Ciel (Paris: Collection Bude, 1965), Introduction, Section 5, pp. LXXV-LXXXI.

The second text (281b18-23) makes the same claim with regard to abilities not to be F for a limited time. Here Aristotle says it is impossible for one and the same thing to have the ability to be F for an unlimited time and to have the ability to not be F even for a limited time. Taken together, what has the ability to be F for an unlimited time cannot also have the ability to not be F for an unlimited time.

\[
\text{εἴ δὲ τι ἀπειρὸν χρόνον ἔχει πλείόνων δύναμιν, οὐκ ἔστιν ἐν ἀλλῷ χρόνῳ, ἀλλὰ τούθ᾽ ἀμα. οὕτ᾽ εἰ τι ἀπειρὸν χρόνον δὲ θεαρτὸν ἐστὶ, δύναμιν ἔχοι δὲ τοῦ μή εἶναι. εἰ δὲ ἀπειρὸν χρόνον ἔστιν, ἔστω ύπάρχον ὁ δύναται, μὴ εἶναι. ἀμα δρ᾽ ἔσται τε καὶ οὐκ ἔσται κατ᾽ ἐνέργειαν.}
\]

But if something has more than one ability for an unlimited time, it is not [realized] in another time [i.e., it is not realized successively], but that [ability] is [realized] simultaneously. So if something that is F for an unlimited time is perishable it must have the ability to not be F. Then, if it is F for an unlimited time, let that which it is able not to be (i.e., not-F) obtain [ἔστω ύπάρχον ὁ δύναται, μὴ εἶναι]; then, in actuality, it will both be F and not be F at once.

The categories are classes of predicates or features. As a discussion of features, it attempts to classify and to distinguish between the different sorts of things which a subject can be or have. As a discussion of predicates, it distinguishes kinds of terms linguistically predicated of grammatical subjects. For a discussion of the differences between these two enterprises, and the distinction between being and having, see Bogen, "Introduction", and Alan Code, "On the Origins of Some Aristotelian Theses about Predication", and Frank Lewis, "Form and Predication in Aristotle's Metaphysics", in James Bogen and J.E. McGuire, eds., How Things Are: Studies in Predication and the History of Philosophy of Science (Dordrecht: D. Reidel, 1985). Aristotle's concern is with things "said of" or "in" a subject (Cat. 2). What is neither said of nor in a subject is not a member of any category. Although nothing can be either said of nor in a subject which fails to exist (Cat. 15b12-35), existence itself is neither in nor said of any subject. Owen argues that, as
it is often used by Plato, the verb \( \varepsilon \nu \varphi \) should be translated as 'to be' with a place-holder to be filled with a predicate (e.g., 'Socrates is (short)) or a variable (e.g., 'Socrates is (such and such)), and that sentences of the form 'X is not' should be understood as claiming that X is not such and such. Accordingly, \( \varepsilon \nu \varphi \) is not to be understood as 'to exist'. See Owen, "Plato on Not Being", in Logic, Science and Dialectic, ed. Martha Nussbaum (Ithaca: Cornell University Press, 1986), pp. 104-37. This, we think, is how Aristotle uses forms of \( \varepsilon \nu \varphi \) in the texts we are discussing.

The notion that 'to be' or 'to have' or 'fail to be or to have' is filled out by an item from a category is stated again explicitly at Met. θ.10, 1051b31ff. Here 'being' and 'not being' are used in connection with kinds (schemata) of predication and abilities and exercises of abilities for opposites (\( \varepsilon \nu \varphi \nu \rho \sigma \alpha \varsigma \)). Aristotle adds truth and falsity to the list of what something (e.g., a belief) can be or not be (1052b1-2). But this provides no warrant for taking 'to be' to mean 'to exist'. In the examples that follow, a belief is true just in case the subject is or has the essence or accidental feature it is believed to have (1051b33ff).

See the second text of note 5. Aristotle says that if anything is F (where F is an item in any category) for an unlimited time, it cannot perish unless it has the ability to not F. Thus Stocks' and Guthrie's translations are incorrect. Aristotle does not say that, if anything exists for an unlimited time, it is destructible only if it has the ability to not exist. All \( \delta \nu \varphi \mu \varepsilon \zeta \)s are abilities to be or to have (to do or to suffer) something from a category. Since existence does not belong to any category, there can be no such thing as the ability to exist or the ability to not exist. Perishable substances do, of course, have abilities whose exercise can lead to their perishing. For example, the organs (or, perhaps, the flesh which is their matter) of a living thing have passive abilities to be affected in ways which will cause the perishing of the individual. And since (Meteorology, IV.12 and elsewhere) the death of an organism leads to the perishing of its organs (the fingers and eyes of a dead man are fingers and eyes in name only), what makes the organism perish makes the organs (and their matter as well, according to the Meteorology passage) perish as well. The brain has the ability to suffer changes which make it cool, and the organs responsible for nutrition may become unable to discharge their functions, and so on. But to say (as Aristotle believes) that such changes destroy the organism is not to say that the abilities to suffer the changes are abilities for non-existence. Similarly, whatever abilities it is whose exercise preserves the living organism, there are not abilities for existence. Instead, they are abilities to take in and metabolize food, to withstand or avoid what could otherwise cause destructive changes, etc. Finally, even someone who thought it plausible to speak of a \( \delta \nu \varphi \mu \varepsilon \zeta \) for existence ought to balk at the idea of a \( \delta \nu \varphi \mu \varepsilon \zeta \) for non-existence. The latter involves such bizarre notions as that our non-existent grandchildren continue to not exist by exercising their abilities for non-existence. But an ability requires that some existing thing have it. And so, a friend of abilities for non-existence would have to say that those non-existent grandchildren must exist in order to have and exercise their abilities for non-existence. Aristotle's theory neither requires, nor tolerates, any such rampant Meinongianism.

De Caelo I.12, 281b8-19, includes examples also found in Meta. θ.3.
Categories IV.9 include things done. Rotation falls under this heading.

Aristotle has no technical term he uses consistently for this. In *Meta.* 6.5, he uses the term πράγμα as we will use 'situation' in this paper, and ὁπέρχειν as we will use 'to obtain', μή δόντος is used here in something like the way we will use 'to not obtain'. But often Aristotle speaks of 'what is' and 'what is not' as being possible, necessary, etc. Thus there is no canonical term in Aristotle which corresponds to 'situation' or 'obtain' as we shall use them.

The term 'situation' will be familiar to readers of John Perry and Jon Barwise (Situations and Attitudes [Boston: Bradford-MIT, 1984]) and many other recent works in philosophy of language and metaphysics. 'To obtain' is used by some translators of Wittgenstein's *Tractatus* for what Sachverhalte do or don't do. The reader is warned and forcefully urged to ignore any connotations these terms may have acquired from such works. Aristotle has next to nothing to say about, and exhibits no apparent interest in questions concerning the ontological status of situations which have concerned twentieth century philosophers since the publication of the *Tractatus* and before. It would be anachronistic to read these into Aristotle and even worse to read in answers to them. Please don't.

There are a number of connections in which it is important for Aristotle to distinguish opposites (e.g., dark/light; hot/cold; up/down) from contradictories (e.g., dark/not dark; hot/not hot; up/not up). For example, when Socrates is alive, he can be will or ill, but before he was born, although it was true to say (given the correct placement of the negation sign) that he was not ill, it was not true to say that he was well or ill. Furthermore, Aristotle is concerned sometimes with the question whether one of two apparently opposed features is merely the privation of the other (e.g., whether illness is a privation of health, *Meta.* H.5). Our jargon does not represent such distinctions. For example, Thelonius playing is a situation which obtains just in case playing is what Thelonius is doing, and Thelonius being a man is a situation which obtains just in case a man is what Thelonius is. Although playing is an accidental feature and being a man is essential, we introduce no canonical device for marking the distinction. Thelonius being ill is the obtaining of a situation which our notation would mark in the same way regardless of whether illness is or is not a privation or a contradictory of health. And the same terms ('obtaining', 'not obtaining') used in connection with Thelonius playing will be used in connection with Thelonius not playing. This is because our purposes do not require a notation for situations and their obtainings and non-obtainings which marks the differences between contradictories and opposites, havings and privations, etc. Nor do they require a formal device to represent situations involving predicates from one category (e.g., substance) differently from those involving predicates from another category (e.g., doings). Thus our use of a uniform notation for situations of all sorts should not be taken as a sign that we don't accept or take seriously distinctions like those just mentioned. Instead, we don't think our purposes here require them to be marked in the jargon we use for talking about situations.

Although there is no room in this paper to set them out fully and defend them in detail, the following points should be mentioned concerning this:
(a) If Aristotle had been trying to define or explicate such modal terms as 'can', 'possible', 'necessary', the texts we discuss would be woefully inadequate. ενδέχεσθαι ('can', 'may', or 'is possible') cannot be defined or explicated without vicious circularity in the use of terms of such unashamedly modal notions as δύναμις, δυνατόν, etc. But there is no reason to suppose that the Prior Analytics 32a18, 32b4-11, and the rest were intended by Aristotle to provide definitions or explications. Instead, it seems clear that ενδέχεσθαι and δύναμις (along with δυνατόν, etc.) are used as primitives. Moreover, Aristotle's aim is to set out general principles concerning the notions they mark. Instead of trying to define modal notions in terms of non-modal notions, he is doing something like telling us what sorts of factors (some of them modal) determine whether situations are possible, impossible, necessary, etc. For example, although it would be circular to define 'possible' in terms of 'ability', it would be both non-circular and informative to show how the possibility of a situation depends upon the abilities of things, and the conditions for the exercise of those abilities (assuming, of course that Aristotle has informative things to say about abilities and their exercise). This is what we take him to be doing.

(b) As will be obvious, Aristotle's treatment of modalities is quite foreign in spirit to both the Kantian picture of necessity and possibility as features of judgments, and to the positivist and Quinian assimilation of 'necessary' to 'necessarily true', which are features of sentences or propositions. Aristotle believes that some situations obtain of necessity, that others are possible, and that others are impossible. Thus Aristotelian modalities have to do with situations, their obtainings and non-obtainings, and apply only deprivatively to the truth values of judgments, thoughts, propositions, or sentences. Further, where Kant thought modalities derived from laws of thought or psychology, and the positivists thought they were grounded in rules of logic or language, Aristotle's modalities are unabashedly naturalistic, depending on what sorts of things there are, and what they can and cannot do both by nature and in virtue of the situations they figure in. The contrast between Aristotelian and positivistic accounts can perhaps be indicated by saying that whereas a positivist theory or definition of necessity would look something like an axiomatized logical system (e.g., after the manner of Carnap), an Aristotelian account would look more like a theory in a natural science.

13 We are using 'exercise' as a technical term. We suppose that in ordinary speech, to exercise is to do something rather than to have something done to you, or to resist change. As we shall use the term, when such and such (e.g., heating something up, or being heated by something, or maintaining a constant temperature in the presence of a heating or a cooling agent) is what an ability is an ability for, we shall say that doing, suffering, etc., such and such is an "exercise" of the ability. A precedent for this is Aristotle's use of ἔργον (work or function) in Meteorology I.v.12, 390a15-19 in connection with both doing
Exercising a δύναμις, then, is something like the functioning of what has the δύναμις, where the thing's function may be to undergo a change, to change something else, or to withstand change. Notice also that as we use the term, the simple bodies (earth, air, fire, water, and aither), stuffs (flesh, silver, etc.), parts of things, etc., as well as animals, may be said to exercise abilities. Finally, we shall often use 'exercise' to translate the various forms of ἐνέργεια. For example, we shall often speak of the exercise of an ability instead of the "actualization of a potential", of exercise instead of "actuality", and so on.

14 The discussion of the second sort of ἀδύνατά is an attempt to answer a number of extremely helpful (and vexing) objections raised by Charles Young in a discussion of an earlier draft at a meeting of SCRAP (Southern California Readers of Ancient Philosophy) at Pitzer College.

15 At Meta. Δ.12, 1019b19-24, Aristotle says that some things are said to be ἀδύνατα not because they lack an ability (the sort of ἀδύνατα illustrated in the preceding passage by the immature boy and the eunuch) but in another way:

... τὰ δὲ ἀλλὰ τρόπον [ὅπον] δύνατόν τε καὶ ἀδύνατον, ἀδύνατον μὲν οὗ τὸ ἐναντίον ἐξ ἀνάγκης ἀληθές (ὅπον τὸ τὴν διάμετρον σύμμετρον εἶναι ἀδύνατον διὰ ψεύδος τὸ τοιούτον, οὗ τὸ ἐναντίον οὐ μόνον ἀληθές ἀλλὰ καὶ ἀνάκη ἀσύμμετρον εἶναι: τὸ ἀρα σύμμετρον οὐ μόνον ψεύδος ἀλλὰ καὶ ἐξ ἀνάγκης ψεύδος).

Taking the first ὅπον as 'namely', and the second as 'for example', this passage says that things which are ἀδύνατα (but not because they lack an ability of the kind just illustrated) are ἀδύνατα in another way:

... namely, [in virtue of] δύνατόν and ἀδύνατον [A situation] whose opposite (ἐναντίον) is true of necessity is ἀδύνατον, e.g., [for] the diagonal [of a square] to be commensurable [with a side] is ἀδύνατον. [We take μὲν in line 23 to indicate emphasis; there is no δὲ or other contrastive particle following to answer it]

The difficulty here is to see how ἀδύνατα can be nontrivially accounted for by δύνατόν and ἀδύνατον. The example of incommensurability has suggested to most commentators that Aristotle is thinking of things which are logically impossible. But nothing in the text requires this. Nor is it required by the characterization of this sort of ἀδύνατα in terms of the opposite being true of necessity. Aristotle thinks that in general, the truth or falsity of a sentence depends upon how things are (De int. 19a33) and shows little sign of thinking that truth can depend simply upon logical form if this is thought of as based in rules of language or of thought. In the example, the relevant opposites would be presumably ascriptions of commensurability and incommensurability. And it seems reasonable to think that these features (commensurability and incommensurability) fall under the characterization of opposites as pairs of features such that 'it is necessary for one or the other of them to belong to the things they naturally occur in or are predicated of' (Categories, 12a1). Thus some lines are such that they cannot fail to be divisible by a common unit, while others are such that no common unit
can be used to divide them without remainder. While we think of this as a matter of logical necessity, there is no reason why our views on this should be read into Aristotle, who tends to explain the necessity of one thing belonging to another in terms of their natures. Thus it seems natural to read the example as a case in which, because of the natures of squares (their sides and diagonals) and of what the units and the operations of division are, there are (can be) no abilities whose exercise can secure an even division of a side and a diagonal by the same unit. It is not that a specific ability (e.g., the ability to conceive a child) which could make the division is lacking. Instead, we take it, the sentence asserting incommensurability is true of necessity because there is no ability whose presence under any circumstances could make possible the relevant divisions. And this, we take it, is a general fact about all abilities and their exercises.

16 This may be extended to cover such cases as existence and nonexistence, coming to be and passing away, and other processes, states, etc., excluded from the categories. For example, the obtaining of a situation in which one and the same item both does and does not exist (come to be, etc.) at one and the same time with respect to the same things would require something (e.g., a bit of matter) to violate (MII) and Metaphysics Γ by coming to have and not have, or be and not be a single category item (e.g., features required for the matter to have the form it must have in order for the relevant item to exist or come to be) at one and the same time. We note also that as is generally agreed, the passage from Metaphysics Γ is not a statement of the law of non-contradiction; it is a claim about category items (qualities, quantities, etc.) and the things that have them, rather than a claim about the truth values, kinds (classified by logical form, for example) of propositions.

17 Theaetetus, 152A-E; 171B ff. We are indebted to Peter Machamer for suggesting that this background accounts for the presentation of the principle here in application to discourse.


19 The features an Aristotelian substance or body has by nature (and in particular, those in virtue of which it moves naturally) are to be accounted for by its form and its matter. (Phys. II.1). Normally, the explanation of natural motion lies primarily in its form. (Phys. II.1, 3-11). This is because it is in virtue of having a form that the matter of the substance or body is what the matter is able to be, and what a thing is explains its natural motion. But, as we shall see, the cosmos is a special case because its matter, the aither, always is and does what it can be (can do), and cannot therefore fail to rotate. Thus the explanation for the natural motion of the cosmos lies in its matter, and this is all we shall need to consider.

20 See APo II.19 and note 18 above. It should be noted that whatever the merits and the shortcomings of Aristotelian scientific methodology
may be, it is clear from the passages and commentaries mentioned in note 18 that despite the translators who render ἐναγωγή as 'induction', what Aristotle has in mind is quite different from Humeian induction. In particular, he is by no means committed to a simple minded inductive argument of the form: the cosmos has rotated every year for n years; therefore it always rotated before it was first observed, and will always rotate from the n + 1st year on. For a discussion of the uses of ἐναγωγή in the Analytics see Richard McKirahan, "Aristotelian Epagoge in Prior Analytics 2.21 and Posterior Analytics 1.1, Journal of the History of Philosophy, 21 (1983), 1-14. Robert Turnbull suggests in private discussion that the term is best translated as the 'assemblage' of kinds under a genus, and of a genera under a higher genus, etc.


Aristotle accepts the general view of his culture that what is divine is immutable and unchanging in its characteristics. For Aristotle the cosmos satisfies these criteria and is thus divine-like. While there is evidence that De Caelo admits divine, animate objects that are suitable as objects of religious belief, these play no role in the aetiology of cosmic motion. They are in fact un-moved non-movers.

Our principle of plenitude differs from those attributed to Aristotle both by Hintikka ("Necessity, Universality and Time in Aristotle") and some of the formulations of a related principle in Waterlow (Passage and Possibility). Without going into details which would have to be treated in an exegesis of Hintikka and Waterlow, here are some of the main differences. According to Hintikka, Aristotelian modalities are equivalent to, and can be explained in terms of, quantification theory with variables ranging over times. Thus, according to Hintikka, '# is possible' is true just in case # obtains at some (past, present, or future) time; # is necessary just in case # obtains at all times (Hintikka, 111); and # is impossible just in case there is no time at which # obtains (112). These claims (which Hintikka subsequently modified drastically) are clearly un-Aristotelian. De Int. 8 provides an example of something which is possible at a time even though it never obtains: it is possible at some time, t, for a coat to be cut up, but if it wears out first, it will not be cut up. As it happens, the coat wears out before anyone takes the trouble to cut it up. Thus, what never obtains (the cutting up of the coat) was possible until the coat wore out. (De Int. 10a19-22). The example is used to illustrate a principle which is fundamental to Aristotle's rejection of the Megarian doctrine that nothing but what is the case is possible. (Met. 6.3). As opposed to the Megarians (and to Hintikka) Aristotle holds that of things which are not always, it is possible for any # either to obtain or not to obtain. (De Int. 19a10). Thus, what is possible need not ever obtain, and what never obtains (e.g., the cutting of the coat) can be possible at some time. Our principle of plenitude holds that if at some t, the obtaining of # requires nothing more than the exercise of non-rational abilities whose exercise involves nothing ἀδύνατον and is not prevented, # will obtain. But by the argument of De Int. 9, if at t, it is the case that # will obtain, the obtaining of # after t is necessary, and according to Prior Analytics 32a18, 32b4-11, what is necessary is not possible. Thus where Hintikka's principle of plenitude holds that all possibilities are actualized, our
principle identifies a special group of situations which will obtain because their obtaining is necessary.

Waterlow begins with two of Hintikka's principles, (A') if it is possible that \( p \), then at some time it is the case that \( p \), and (B') if it is always the case that \( p \), then it is necessary that \( p \), (Waterlow, 2), and gradually modifies and complicates them, in order to account for the Aristotelian texts with which Hintikka's account conflicts. While we take the Aristotelian modalities to be features of situations which depend upon the abilities of things and the conditions which determine their exercise, Waterlow tends to take modality to be a feature of sentences to be accounted for by logic and linguistic rules. Thus she says that a proposition or sentence 'p', even if false at some time \( t \), is possible (i.e., possibly true) at \( t \) if and only if no contradiction is deducible from the premise "p will be true at some later time" conjoined with a description of the actual state of things at \( t \). (31) We reject this conflation of possibility with possible truths, and with features of sentences. We also reject the conflation of the rules by which situations and their obtainings are described (and by which inferences are drawn) with the naturalistic principles governing abilities and their exercises on which we claim that Aristotelian modalities depend. Waterlow's later version of A' and B', (161) is far more congenial to our approach, incorporating the idea that Aristotel's modalities are rooted [in the world of concrete substances], not among concepts or propositions, or the linguistic expressions of these...

We agree with a crucial feature of Waterlow's interpretation—the relativisation of modalities to times. (32) For us, as for her, '# is possible' is incomplete without being supplemented by references to time. Although we differ over details (to be set out in a forthcoming book) we agree with Waterlow's emphasis on such facts as that there can be times, \( t', t'', t''' \), such that for one and the same #, it can be the case at \( t'' \) that # can obtain at \( t''' \), even though at \( t' \), it is not possible for # to obtain at \( t''' \). Further differences and similarities between our's and Waterlow's interpretation will be mentioned later in this paper.

These senses are what Aristotle refers to as the strictest senses of the two terms (280b12-15; 280b32-35). There are, for example, three senses in which something can be \( \delta'\gamma\nu'\eta'\sigma'\omega' \): (1) the thing can just be ungenerated, i.e., the denial that the thing has become; (2) a thing is not now, but has the ability to be and had that ability to be for all times; (3) a thing is ungenerated in the strict modal sense if it satisfies the condition that at any time it is untrue that it is able to begin and thus to become.

Because the cosmos is the clock against which all things are timed (De Caelo 287a23-26) and the basic units of time are measures of its rotations, an unlimited stretch of time corresponds to an unlimited number of rotations of the cosmos. Thus two distinct but unlimited stretches of time would require the cosmos to move in a way in which nothing can move.

Because unlimited time, \( T \), corresponds to a linear series, each of whose members is a complete rotation of the cosmos, and because short durations of time correspond to fractions of single rotations, every short duration, \( t \), must belong to \( T \).
The text of De Caelo 281b3-19 accords with the interpretation just given up to the point at which we supply the argument from (MIII). 281b3-19 distinguishes between suppositions which are false because their truth requires the obtaining of a # which happens not to obtain, and suppositions which are false in the way that the claim that the diagonal is commensurable, or that the sum of the angles of a triangle is not equal to the angles of two right triangles, are false. These are examples of the kind of δυνατά distinguished in Meta. A.12. They involve #s whose obtaining would violate (MI). At 281b8-15, the distinction is applied to the example of an agent who has the ability to stand (or sing) and the ability to sit (or to refrain from singing). If Jones sits (refrains from singing) at time, t, it is false to say he stands (sings) at t; he could have stood (or sung)--he had the ability to do so--but he didn't. On the other hand, to say he stands while sitting (or sings while not singing) is to say what is impossible. It could be true only, if, in violation of (MI), an agent could exercise abilities so as to bring about the simultaneous obtaining and non-obtaining of one and the same #. Next Aristotle says that if a thing has more than one ability whose maximal exercise is unlimited, another time is impossible and the times must coincide. (281b18-19). The examples of sitting and standing, singing and not singing force the reading of 'more than one ability' as abilities whose simultaneous exercise would violate (MI). By the definition of 'unlimited time', there cannot be more than one unlimited stretch of time. And by (MI), what has opposed abilities cannot exercise both at the same time. So far then, the text conforms to our interpretation. The logical gap we fill by the principle of plenitude occurs in the passage which follows immediately. Here Aristotle tersely states and argues for (DCB). The numbers in parenthesis are ours.

Therefore if what is F for an unlimited time is perishable, it would have the ability of not being F. If (1) it is F for an unlimited time, let that which it is able not to be (i.e., not F) obtain. Then it will actually both be and not be F at one and the same time. Thus what is false would follow because what is false was assumed. But if (3) what was assumed had not been impossible (δυνατόν) (4) what follows would not have been impossible. Hence everything which is F always is absolutely imperishable. (De Caelo 281b19-25).

The impossible result (4) which follows from an impossible assumption (3) is that one and the same thing is and is not F at one and the same time. The impossible assumption (3) is that one and the same thing can have the ability to be F for an unlimited time and also have the ability to not be F (for an unlimited or a limited time). The impossibility of (3) can be established only if we suppose (1) that what has the ability to be F for an unlimited time actually exercises this ability (is F for an unlimited time); and (2) that if it also has the ability to not be F, it exercises that ability. Judson objects that there is no reason to suppose (2) because abilities need not be exercised. If he is right, the same objection can be brought against (1). This is the logical gap which needs to be filled, and the argument we supply from (MIII) incorporates the only Aristotelian doctrines we can find to fill it. All that Aristotle has to offer to prevent us from rejecting both (1) and (2) is that the ability to rotate and (if there were one) to refrain from rotating are non-rational abilities, and that non-rational abilities cannot fail to be exercised when there is nothing to prevent their exercise. As noted above, the same gap
needs to be filled in order to argue for (DCA). It occurs as well in several other passages in I.12, including 281b29-31, 282a24-5, and 283a26-28.

28 At Cat. 13b15-25, Socrates can be well or ill, sighted or blind only if Socrates exists. But if non-rotation involves privation of a natural function or ability (as do illness and blindness), then, by parity of reasoning, it is true to say that the cosmos rotates, and true to say that it fails to rotate only if the cosmos exists. This provides additional support for the claim that is based directly on the thesis that the having of any category item requires an existing subject.

29 A further objection to CA is that it does not provide a valid argument for imperishability. Conjoined with the Categories doctrine that something has a feature (e.g., rotation) only if it exists, the premise that the cosmos always rotates entails that the cosmos exists at every time. But, pace Hintikka, this does not entail that the cosmos is imperishable, i.e., that it is impossible for the cosmos to perish. Suppose that for any two successive times, t and t', the cosmos rotates at t', even though, at t, there was no fact of the matter as to whether it would rotate at t'. Then, even though the cosmos rotates and exists at t', it was not necessary at t that it would do so.

30 Aristotle assumes, without argument or explanation, that in addition to rotation, there are only 4 natural motions: the inward motions of earth toward the center of the universe, and of water to a place somewhere outside the center, and the outward motions of air towards one place, and fire toward another place away from the center. If the cosmos had a natural motion other than rotation, it would have to be one of these. But because no two simple bodies can have the same natural motion (260a32ff) the aither cannot have any of the 4 natural motions just mentioned. And because there are no other natural motions, except rotation, the cosmos can only have this as its natural motion. We are indebted to James Lennox for help with the interpretation of this, and the next argument.

31 Aristotle's argument for this seems to proceed in two stages. First, he assumes that a forced motion of a simple body must be the opposite (or perhaps, must have as components, motions, at least one of which is the opposite) of that body's natural motion. But only a rectilinear motion can have a rectilinear motion as its opposite. Because the natural motion of the cosmos is non-rectilinear, it cannot have a forced motion which is rectilinear (or which contains a rectilinear component). (269b35 ff) Thus, if the cosmos can be forced to move in some way other than that way it moves naturally, Aristotle assumes the forced motion would have to be (or to have as a component) rotation in the direction opposed to that of its natural rotation. The second stage of Aristotle's argument is intended to rule out this possibility. It is to be found in De Caelo I.4, and we leave it as an exercise for the reader to interpret it.

32 Following Guthrie and Stocks, we think the similarity in the contents of the Physics passage and the De Caelo summary is enough to establish the reference to Physics I.4-9. The same doctrine seems to be referred to at Met. A, 1069b2-9.

33 This is, of course, a complicated doctrine fraught with difficulties, and a complete sorting out of the complications of the relevant texts is
beyond the scope of this paper and the powers of its authors. But we need to defend our interpretation against two objections.

The first is the familiar doctrine that when a man dies, his corpse has neither fingers (or a face, or eyes, etc.) nor flesh and bone (Meteor. IV.12) Fingers, along with the other bodily parts, constitute the matter or the substrate of a man, and flesh and bone are the matter or substrate of the bodily parts. Contrary to what we (and Aristotle in the Physics) said, this makes it look as if the substrate of a man or of any other living thing does not survive the organism's destruction. We don't know how Aristotle would square this with the doctrine of Physics I.8-9. But there he says nothing to suggest that the substrate of non-living things cannot survive their destruction. Because the cosmos is not a living thing, no generalization drawn from the case of living organisms need apply to it. And since Aristotle applies the doctrine of the Physics straightforwardly and without qualification to the question of the cosmos perishing, the aither (which is its substrate) would have to survive the process through which it perishes.

The second difficulty we need to consider arises from the doctrine of the Categories (3b24ff) that neither a primary substance (e.g., a particular man) nor a secondary substance (e.g., animal) has an opposite. How then can perishing be understood as a substrate which is F becoming the opposite of F, F, as we (and Aristotle) said? We think this can be resolved along the following lines. For any individual (substance, bit of matter, etc.), i, there will be a substrate, S, and an essence, E, such that i exists just in case S is E, and perishes just in case S ceases to be E. Even though E should not (according to the Categories) be a member of any pair of opposites, we may suppose that for some opposite or opposites, F and F, S is E only if S is F, and that if S is F, S is not E. Thus the perishing of i can require S to go from F to F even though E does not itself have an opposite.

Aristotle does not argue that in order not to rotate, the cosmos would have to have and not have, or be and not be an item from the categories at the same time and in the same respect (MII).

Meta. I.4, 1055a 29ff, Cat. 2b36ff. We have simplified the conditions on opposites. In addition to characterizing opposites by conditions (a)-(d) above (as opposed features of things) Aristotle gives conditions for opposites with regard to abilities or faculties (καρα δύναμις) (I.4, 1055a30). We omit this, because it is not relevant to our argument. 'Genus', we think, should be understood informally to mean "kind" on any taxonomic level.

Aristotle gives no explanation of how 'difference' is to be understood in this connection. We shall follow his precedent. It is unlikely that he had any account to offer, and it seems that his use of this term in the characterization of opposites amounts to no more than a promissory note. However, the significance of the term εσωτερικα for Aristotle's thought is important, and it needs serious investigation.

We assume Aristotle would acknowledge that there are other things (wheels, for example) which can rotate in opposite directions. He is committed only to saying that there is no rotation possible for the cosmos except its unique natural rotation.
Hintikka, $T^*$ and $T^{**}$, p. 111. In effect, we think Hintikka has this backwards. If it is necessary for $\# \text{ to obtain at all times}$, it is immediate that $\# \text{ always obtain}$. But Hintikka thinks that the necessary obtaining of $\# \text{ follows from}$, and is to be accounted for by $\# \text{ obtaining always}$.

This point is made emphatically at Meta. N.2, 1088b15–26. Here Aristotle takes up the view (ascribed to the Platonists) that the eternal objects like numbers have elements. Adopting his own principles, he argues that if anything has elements, it is a compound of form and matter, and if it is immaterial it has the possibility of not existing. But no eternal object (number or otherwise) can have the possibility of not existing. And although it is possible that anything having the ability to not exist can in fact exist for ever, there is no warrant that it must necessarily last for ever. Thus Aristotle concludes that "what can fail to exist is not eternal, as we have had occasion to discuss in another work." His reference is probably to Meta 8.8, 1050b6–28. See our analysis of this passage in (xxxvi) below.

The following case illustrates the difference between the illegitimate inference from '$\# \text{ always obtains}' to 'necessarily $\#$', and the legitimate inference from necessarily to always.

Case 1: At $t$, Becky is digging a ditch, hoping that soon her foreman will give her a break so she can stop. Besides that, it's 120 degrees in the shade, she's been digging for hours, and even if the foreman doesn't come, she may soon stop from exhaustion. Thus, at $t$, it is not necessary that she will still be digging at a later $t_i$. As it happens, the foreman doesn't come, she gets her second wind, and so she is still digging at $t_i$ and so on, through a later time, $t_n$. We cannot infer that at any time between $t$ and $t_n$, her digging at the next time was necessary.

Case 2: At $t$, Becky exerts enough force on her shovel to send the sand in it flying through the air. Neither the sand, nor anything else present can prevent it from flying through the air for a short time from $t$ to $t_n$. If all of this is the case, we can infer that at every time between $t$ and $t_n$ it is necessary for the sand to move through the air at each next time before $t_n$. And from this we can infer that the sand moves at every time from $t$ to $t_n$.

The ensuing argument makes the case against the Timaeus that is promised at 1.10 "where he (Plato) says that the heaven has been generated, but yet will be for all future time" (280a28–35). For a recent general discussion of the Timaeus on this issue, and its historical setting, see Richard Sorabji, Time, Creation and the Continuum, (London: Duckworth, 1983), chapter 17, pp. 268–78.

Sarah Waterlow, Passage and Possibility, Chap. IV, 69.

Ibid., 69. Italics are Waterlow's. Prior to this analysis (and on the same page) Waterlow says that something's being able to F/not F always is for Aristotle to be characterized by an inherent temporal maximum. But (says Waterlow) in this case the "maximum must be: all time. 'All time', in other words, is here to mean an amount of time--the greatest amount".
43 Ibid., 69-71.

44 Ibid., pp. 73 and 77.

45 "For in general the unlimited is in virtue of one thing's always being taken after another, and what is taken is always finite, but ever other and other." (TII.6, 206a27-29). Aristotle means this conception of the unlimited to apply to time, to the generations of man, and to the division of magnitudes. In effect, the conception construes the unlimited iteratively in terms of finite, recursive steps of the appropriate kind.

46 Passage and Possibility, 77.

47 Ibid., 78. Waterlow discusses the proposition 'If it is always the case that p, then necessarily p' on pp. 74 and 75, and gives an argument to establish it in Chap. 7 which she claims "dispenses with the suspect De Caelo assumption that there is an infinite time, which is the maximal period for anything that lasts for ever" (p. 156). Using the principles of 'like comes from like' and the 'continuity of nature' Waterlow argues that in Aristotle's view, in the generation of natural organic substances the necessity that there always be an instantiation of the species does not follow alone from the temporal claim that there is no time at which an instantiation can fail to occur. Her argument is correct so far as it goes, but it is not needed as a substitute for the De Caelo account. We have argued (section (xviii)) and will continue to argue here, that the correct relationship between 'always' and 'necessarily' falls out from De Caelo 1.12, and that Aristotle's use of the notion of an unlimited temporal maximum is constitutive of his argument in 1.12.

48 At 206a18-25 Aristotle distinguishes possible being from actual being, arguing that what is infinite is possibly infinite. The possible being of what is infinite is explained by reference to the day and the Olympic games which are by "the constant occurrence of one thing after another" (206a11). But Aristotle points out that the games are successive both actually and possibly. Now, then, do we identify the potential being of the infinite with the actual being of a game or with possible Olympic being? We think the latter, recognizing that the possible successive being of the games is disanalogous in another important respect to the eternal rotation of the cosmos. The actual exercise of the cosmos' ability to rotate through an unlimited sequence requires a rotation at every time, but not (what is impossible) the completion of an unlimited number of rotations. Also the cosmos rotates always in the sense that that repeated exercise is constitutive of what it is, being actualized successively, each rotation preceded and followed by another rotation. Thus, the cosmic ability is always actual (i.e., it is always being exercised) and is never merely possible (i.e., there is never a time at which it can, but may not be exercised). But the games are sometimes possible, and sometimes actually going on. Moreover, their rules of conduct require a point before and after which they are not occurring, and a particular series may fail to begin. In our view, then, although Aristotle uses the analogy of the games, to explain the actuality of successiveness (and to suggest possible successiveness), he also has recourse to 'algorithmic' successiveness to explain the possible infinite. We thank SCRAP for the use of their reading notes, and Bob Turnbull and James Lennox for discussion.
This is in line with what Aristotle says about the unlimited at 206a14-18. After stating that 'to be' means either 'to be possibly' or 'to be actually', the infinite is said 'to be possibly'. AT 206a18 καινεται ὁδὲ δύναται εἶναι τὸ ἀπειρον is usually translated as saying that what is unlimited is potentially. But what does 'potentially' here mean? Not that what is unlimited is merely possible; for according to Meta. 6.8 cosmic rotation is actual and never merely possible (see section (xxxvi)). Here at 206a14-18 we read Aristotle as saying that something can be called unlimited in virtue of a δύναμις or ability. This indicates that the cosmos does what it does unlimitedly in virtue of what it is, and not that it is merely possible for it to be unlimited or that it is unlimited actually.

The context of the argument is this. Aristotle has already shown that there cannot be anything that can have simultaneously the ability to F and to not F for an unlimited time. Here he argues first that if both abilities are realized simultaneously opposites occur. This is absurd. But equally absurd is the claim that something can have the ability both to exist and not to exist when, per impossibile, it is in neither state, i.e., it is the case that if it is it might not be and that if it is not it might be. We accept with Allan the gloss "[for an unlimited time]".

For Aristotle, any explanation of the behavior of natural things must make reference to their individual natures and to the exercise of abilities intrinsic to their natures. Now while the exercise of these abilities can be conditioned or not conditioned by what occurs coincidently in the temporal order, what cannot occur naturally is an absolute coming into being at a specific time which is pre-programmed into the thing's individual nature. For a discussion of explanation and the natural order in Aristotle see Lindsay Judson, Op. Cit., note 3, especially section VI of his paper.


Physics III.5, 204a20-35. Aristotle's point is that if we treat the infinite as an actually independent substance any part taken will be infinite. But this forces us to consider the infinite that 'contains' the infinite 'parts' as a greater infinite than its infinite 'parts'. But on Aristotle's position it is impossible that one and the same thing be many infinities. Thus Aristotle implies that the notion of 'greater or smaller' applies neither to the infinite nor a fortiori to any relationship between the infinite and the finite.

Again, if the cosmos is merely able to be F it is possible that it obtains de facto always. But, under this description, there is no modal fact in virtue of its nature to ground that obtaining. See note 39.
This is a large exegetical problem that falls into the context of Aristotle's struggle to demarcate the simple bodies as natural-movers from self-movers which are also natural-movers. Aristotle carefully distinguishes the knower's ability to exercise a skill if not prevented, and the knower's actually exercising that skill when not prevented. Then he says immediately (255b5): 

\[ \omega\iota\omicron\iota\omicron\upsilon\varepsilon\varepsilon\tau\alpha\omicron\upsilon\iota\varepsilon\chi\epsilon\iota\varsigma\varsigma\iota\pi\tau\upsilon\nu \phi\upsilon\sigma\iota\kappa\omicron\nu \]  

"It is the same in regard to natural things". What follows is a discussion of the behavior of the simple bodies (when not prevented) according to the same distinctions applied earlier to the knower's possessing (being able to exercise) a skill, and the knower's actually exercising that skill. Now it is true that the knower's exercise of the skill is the exercise of a rational ability, and that a heavy thing's exercising its ability to fall if not prevented is not. Nevertheless, in stressing the analogy Aristotle is focussing attention on a principle he discusses elsewhere (APo. 95a10-b1): namely, that strictly speaking a cause is concomitant with its effect. This is relevant to the actual fall of a heavy thing, since it is then no longer in contact with either its generator or releaser. When a simple body is in this state, the relevant cause concomitant with the effect (i.e., the thing actually undergoing a downward motion) is the actual exercise of its ability to move to its natural place. But again, this argument sits uneasily with Aristotle's claim (255b13-30) that it is just in the nature of simple bodies to undergo motion passively when not prevented.

Although actualities like seeing, thinking, and flourishing persist through time, time is not integral to their definition, as each of these acts is always complete, or complete at all times. Motions, on the other hand, are in time and for an end, because only in time can they attain their ends. Motions therefore demand time, while actualities are intelligible without time. Actualities are ever unchanging and complete, e.g., it makes no sense to say someone is in the process of coming to see. At any time it is true that to see is to have seen. For a recent discussion of this and related points see Edward Halper, "Aristotle on Knowledge of Nature" Review of Metaphysics, 37, (June 1984) 811-35.

In other words, the ability-to-rotate-always is a necessary constituent of the cosmic nature. Thus, the notion that the maximal time for cosmic rotation is unlimited in time, is itself part of the definition of something (the cosmos) which is able to rotate always. So considered, the cosmos is not just always exercising its ability to rotate; rather it is at every time exercising its ability-to-rotate-always.

penses entirely with the notion of a transcendent mover (see Von Arnim especially Chapters 2, 3, and 4, 10–21). However, in his discussion of the earlier De Philosophia Ross maintains (correctly) that there is no trace in De Caelo of the thesis that the heavenly bodies must be moved either by nature or by force or by will. On this point see Elders, 20–3, and Von Arnim, Chap. I, 1–9.

Just as an act of seeing now lacks nothing that will complete it later, so at any given time the exercise of the cosmos’ ability-to-rotate-always lacks nothing that will complete it later. In rotating the cosmos is ever changing. But it is a changeless change, since in always changing in the same manner, it is always the same. And although its motion is in time, the actuality of its change is atemporal precisely because it is a changeless change. Thus in always changing in the same way, the rotation of cosmos is both regular and unchanging in respect to that action. It is therefore the paradigm of what is natural and eternal and hence knowable.

Richard McKirahan points out (in conversation) that the changeless motion of the cosmos is what is required of the motion by which all else is timed (by the argument of Physics 223b12ff). Aristotle requires that the motions of the clock against which other things are timed must be perfectly uniform. But no motion or change which consists of something going from one opposite to its opposite can be perfectly uniform. This is because the motion or change stops once the second opposite is reached. And if the thing which moves or changes from F to its opposite, F₀, continues to move or change, it would go from F₀ back to F. Accordingly, there would be short periods during which its change or motion is different in sense and direction and hence not uniform over these periods. Aristotle apparently believes that the eternal, circular motion of the cosmos meets the requirement of uniformity because there is no point at which the rotation stops or changes directions. Because rotation is an ἐνέργεια of the sort is is, the cosmos is moving in exactly the same way at every time during which it moves. But (unlike seeing, and other exercises of second ἐνέργεια) it is eternal; there is no stopping point in the sense of a motion after which there is no further motion. Thus eternal motion lacks a τέλος.

Motion is "the actuality" (ἐνεργεία) of what is in potentiality as such "or" as "potential" (201a10–11). The circularity is well recognized. For example, if motion is considered as the actuality of the potentiality to become an end state, circularity occurs since motion is considered with respect to a potentiality defined with reference to motion itself. In an unpublished paper "Aristotle on the Unity of Material Substance", Mary Louise Gill argues that the definition is not circular if an object has the ability for just one sort of end, i.e., for being the product. She points out that the definition allows that a subject can manifest its potential qua potential simply by being potential, a state-of-affairs consistent with its being at rest. Gill rightly suggests that Physics III.3 addresses this inadequacy. Motion is the actuality "of what is potentially active and of what is potentially passive as such" (202b26–27). Here the actuality that motion is, is the realization of both an active and passive δύναμις, which obtains only if and when the agent is acting. Thus, the potentiality manifested by the 'motion-actuality' is here distinguishable from the potentiality manifested in the subject by its merely being at rest. As is clear from note 61 and our text, these distinctions do not apply to eternal motion, the actuality exhibited through the continuous
exercise of the cosmos' ability-to-rotate-always. Harold Cherniss has argued in Aristotle's Criticism of Plato and the Academy (Baltimore: The Johns Hopkins Press, 1944) Vol. 1, Appendix X, 581-588, that circular motion is not reconcilable with the definitions of Physics III. If motion is the passage of a subject between opposite termini different in kind, circular motion is outside its scope. Furthermore, if motion is understood with reference to a thing's ability to be a product, something moving in eternal circular motion (or as something undergoing a process of actualization) is again not captured as it lacks potential to be or to become what it is not as yet, and manifests that of position or direction alone. Cherniss does not hold, however, as does Waterlow (see note 67), that circular motion is a κίνησις only if it is dependent on a separate agent. In fact, he recognizes that the eternal, circular motion of the cosmos is a kind of self-motion, and hence a type of motion.

63 It might be said that the cosmos is the ἀρχή and τέλος of its own motion, so long as it's understood that it lacks a distinct τέλος or πέρας; such an ascription would, of course, abrogate its eternality. A related objection to our claim that the necessary and eternal rotation of the cosmos does not require an additional unmoved mover is this. Suppose that all natural motions (the rotation of the cosmos included) must have a final cause (οὗτος ἐνέκεια). Now on this supposition the aither, (the necessary material ground of rotation in De Caelo can itself never be sufficient to account for what something is or does; in addition this fact must be explained by reference to the goal for the sake of which the aither exists or acts. Therefore, the objection concludes—in addition to the aither and its nature—an appeal to the unmoved mover of Metaphysics Α is necessary.

We reject this on the basis of Meteor IV.12 which shows, we think, that an appeal to a divine unmoved-mover is not required to provide an explanation for the movements of the simple bodies, including the rotation of the aither. The argument of that chapter is this.

348b27-390a4 argues that all natural substances are as they are in virtue of their matter (οὐν) and their form as given by their account (λόγος). A body is uniform if every part of it is of the same kind as the whole. For example, flesh is homeomerous because a bit of flesh is flesh, and every part of it is also flesh. By this definition, earth, air, fire and water are homeomerous (as Aristotle states explicitly at 390a3), and so too should the aither.

The distinction between form and matter is clearest, Aristotle says, in things that have homeomerous parts, but are themselves non-homeomerous, and have ends (οὗτος ἐνέκεια). His examples are a man, the hand of a man, and flutes. A stone flute is a flute in name only; and a corpse a man in name only (389b31-390a1). This suggests strongly that to be man (i.e., to have the form and logos of a man), the substance must do whatever it is for the sake of which a thing is a man (thinking, moving, reproducing, etc.). In contrast, that which cannot do what men are for the sake of is not a man, what cannot do what hands are for is not a hand, and so on. But the form/matter distinction is less clear in the case of flesh and bone, and less still in the case of fire and water (390a2-3). Furthermore, the matter/logos distinction is clearest in instrumental things, and least clear where what something is for is least clear, i.e., where things are mostly matter. A reason for reading 390a2-3 this way is that the unclarity of the final cause is the reason Aristotle gives for
thinking that the presence of, and the distinction between, form and matter is harder to discern in both the uniform and the simple bodies. Thus, the distinction between logos-being and matter is less clear for the simple bodies, because the ό ἕνεκα is less clear in things that are mostly matter.

Now Aristotle goes on to state that all natural things are both matter and logos-being, because each thing (including the simple bodies) falls under the δύναμις/ἐργον distinction. And once he shifts to this vocabulary, he makes no identification of ἐργον with ὀ ἕνεκα. So considered, minerals produced in the earth, and mist or cloud in the atmosphere, have a function (ἐργον). They do not, however, have an intrinsic ὀ ἕνεκα as a defining part of their logos. In other words, the individual functions permissible to the simple bodies, say, do not as such need to constitute a limiting case of an end or ὀ ἕνεκα. And Aristotle concludes by introducing ends explicitly at the level of organs and organisms. (390a14ff).

If this is right, it could be maintained that the simple bodies have a ὀ ἕνεκα but that there is no simple answer to what it is. We wish to put the emphasis otherwise. Organs are for specifiable ends, and each one is for a definite end. Homeomerous bodies are not all for something; but those that are (e.g., flesh) are always for a specifiable end. Similarly not all the simple bodies collectively are for something; and no particular one (say earth) is always for something, though some one of each elemental kind is. Thus, the account of what an individual organ is, states for what it is; the account of flesh also states its for what; but neither the account of the simple bodies, as such, nor of 'earth' or 'water' will state for what (though of course the earth of bones is for bones). But all of these natural substances have both active and passive δύναμις that should be stated in the logos of their being. And some of these will be teleological.

Although the aither is not mentioned in these passages it is the fifth simple body of Meteor I.3. Thus like the other simple bodies it is matter with a function. That is, the aither has by nature a characteristic ἐργον according to which it acts in a specific way, i.e., it rotates eternally in one direction only. There is no external thing or process in which the aither has the ability to participate. And since rotation around the earth at a fixed distance is the exercise of its natural ability, that rotation is its intrinsic function. No further item of any kind need be postulated to supply a ὀ ἕνεκα or the aither—let alone an immaterial, living and thinking unmoved-mover. We are grateful for discussion with James Lenox, and for his allowing us to see his forthcoming paper, "The Matter of Meteorology IV".

It is generally agreed that De Caelo rejects the Platonic view that only a self-moving soul can be the source and cause of all bodily self-movement. See Phaedrus 245c; Laws 894c–895b; and Phaedo 99a. Plato is emphatic that the primary cause of motion must be that which qua self-mover, can move other things. This he identifies with the soul, and credits souls as the carriers of the heavenly bodies. When we say 'adoption', this is not meant to imply that Aristotle consciously transformed the Platonic doctrine of self-motion into the notion that nature is an intrinsic source of motion even in bodily things. The situation is obviously more complex than that. But clearly there is a definite remnant of the Platonic sensibility (however naturalized) in Aristotle thesis that
the primary body—the aither—is a divine body possessing a unique, natural ability to move itself eternally and necessarily. This is not to say, however, that Aristotle unconsciously returns to the Platonic conception of a kinesis of mover effecting a kinesis of σώμα in his notion of the self-mover cosmos of De Caelo. In De Caelo, κυκλοφορία, not psychic κίνησις, is essential to the defining nature of the cosmos.

At 285a29-31, Aristotle says that direction defined in terms of function is true of whatever has a source of motion, and since the "heaven is alive and has a source of motion" (ὅ δ' οὐρανός ἐμψυχὸς καὶ ἐκείνης ἄρχην) it also has upper and lower parts and a right and left. This statement does not provide grounds for thinking that Aristotle here conceives the cosmos as an organism. In the first place, the reference to the cosmos being 'alive' should be compared with 292a21 where we are told that the stars can be conceived "as if they partake of activity and life" (see the Conclusion of this paper). Also there is no unambiguous warrant to suppose that Aristotle is here invoking the Phys. VIII.4 doctrine that only animate movers are self-movers; rather, the II.2 doctrine that φύσις is the immanent source of motion in all things (the inanimate included) is perfectly consistent with the tenor of the argument here. Nor is 285b31-35 evidence against this. There Aristotle says that only living things are self-movers and thus possess intrinsic functions which define their topology. But this does not affect the thesis we are arguing, i.e., that the cosmos is an unique and eternal self-mover whose directionality must be defined relative to an external topological framework. After all, if, as we argue, the cosmos possesses a unique one-way ability enabling it to rotate always, the 'either animate or inanimate' dichotomy does not apply given that the first motion involves volition and intention. Second, Aristotle tells us repeatedly (PA 656a13, Juv 468a5 and IA 705a2-30-1) that it is only in human beings that what determines the biological upward is also that which determines the cosmological upper part. Even if one transfers this relation literally (and not merely analogically) to the cosmos, it provides a small basis on which to say that Aristotle conceives the cosmos as a biological organism. In any event, the overall thrust of De Caelo II.2 is against any such conception of the nature and function of the cosmos. Also at IV.3, 310b23-26 Aristotle plainly argues that even the sublunary bodies have ἐν αὐτοῖς ἐκείνης ἄρχην τῆς μεταβολῆς in a manner that attributes to them an inner source of motion according to the criteria of Physics II. Clearly, if this is the case with the sublunary simples, there is further indirect evidence of Aristotle's commitment to the view that the cosmos is the unique source and subject of its own motion.

The importance of the phenomenalistically given in Aristotle's methodology should not be overlooked. What we experience directly are cases of things being borne along, that is, undergoing motions in relation to other things. For Aristotle the issue is not the fact of their behavior but the 'reasoned fact', the explanation or cause of the behavior. Now, of course, we cannot experience phenomenalistically (and as a whole) the eternal, rotating motion of the cosmos. Nevertheless, it is a state-of-affairs that can be imagined and conceptualized, and it is a datum that demands explanation in terms of principles appropriate to the nature of the cosmos. Thus, the explanatory account appropriate to things moving linearly and locally is inappropriate to the unique, rotating motion of the cosmos itself. In this connection it is well to recall the beautiful passage from De Partibus Animalium I.5, 644b22-645a36. There Aristotle distinguishes the nature of the imperishable and eternal things...
of the Heavens from the perishable plants and animals, knowledge of which is abundantly provided through sensory experience. He makes it clear that knowledge of the eternal is "furnished but scantily by sensation". Nevertheless, it is not only knowledge, but knowledge of the highest excellence. See also note 61, which bears on the discussion here. The same point concerning the fitting of things to their appropriate principles of explanation occurs at De Caelo III.7, 306a9-12: "For surely the first principles which concern sensible things must conform to the sensible, those which concern eternal things to the eternal, those which concern perishable things to the perishable: in general, principles must be conformable to their subjects".

67 In her Nature, Change and Agency in Aristotle's PHYSICS (Oxford: The Clarendon Press, 1982), Sarah Waterlow argues that eternal rotation is a \( \kappa \iota \nu \pi \sigma \iota \zeta \) only if it satisfies the definition of \( \kappa \iota \nu \pi \sigma \iota \zeta \) in III.1. According to Waterlow natural motions are \( \kappa \iota \nu \pi \sigma \iota \zeta \) because (a) they are agent dependent and (b) incomplete, requiring an actualization by a prior or actuality and a culmination as III.1 demands. (See Chap. 5, especially 253–55.) She goes on to argue that the incomplete/complete criteria of Meta. J.6 fit eternal rotation badly. "There remains one path of escape from the obvious conclusion, and Aristotle in my view has taken it. This is to convert agent-dependence from a necessary consequence of kinetic status into a criterion for the same ..." (p. 255). Thus, it is only because eternal rotation has a distinct agent (i.e., the unmoved-mover) that Aristotle can class it as a \( \kappa \iota \nu \pi \sigma \iota \zeta \). Moreover, if we continue to suppose that the cosmos is the self-sufficient cause and source of its motion (as does Guthrie) "we automatically put that motion outside the class of \( \kappa \iota \nu \pi \sigma \iota \zeta \)" (p. 255). In her Appendix to Chapter V (where she discusses briefly the views of Guthrie, Cherniss, and von Arnim on De Caelo) she goes so far as to deny that the cosmos is natured to rotate on the grounds that that would exclude a distinct agent and the right to class eternal rotation as an 'incomplete actuality' as III.1 demands (p. 261). It is clear that our view of eternal motion differs from Waterlow's with respect to the account of both its nature and its cause.

68 This is of importance in the light of the probability that De Caelo has been put together by Aristotle's school, rather than by Aristotle, though a compilation by Aristotle himself cannot be ruled out. (See Elders' note 60, pp. 59–68, for a discussion of the arguments favoring these views.) Moreover, it is not unlikely that Theophrastus' Physics influenced the composition made by the ancient editors. Books III and IV are closer to the De Gen. et Corr. than the first two books, and the first two contain the subject matter that answers to the traditional title, On the Heaven. Moreover, the first two books form a unity that compares favorably with most of the other treatises of the Corpus Aristotelicum. In the Corpus the De Caelo follows the Physics and precedes the De Gen. et Corr. Since the reference at 275b23-24 is essential to the sustained argument, it is neither a later insertion by Aristotle nor an addition by the redactors. It is certainly hazardous to attempt any relative dating of De Caelo and its parts by using criteria stylistic or otherwise. We are forced to consider the imperatives impelling the systematic development of Aristotle's central doctrines and the relation of this development to Plato's thought. From this perspective it seems to us (as we've argued in this study) that the first two books of De Caelo presuppose the availability of the following: (a) the principles of Aristotle's logic; (b) the theory of abilities and the conditions of their exercise; and (c) the theory of modality, itself based on the theory of abili-
ties. Given that the central arguments for the eternality and modality of the cosmos depend essentially on (a)-(c), it seems unlikely that Aristotle (or his editors) added these elements later to writings from his earlier period. It seems to us, then, that the first two books can be considered as an integral expression of the thrust of Aristotle's developed thought, though not necessarily in its finally articulated form.

Op. cit., note 60, p. 170. Ross, on the other hand, sees these arguments as referring directly to a mover of the heavenly bodies. In fact he sees these and De Caelo II.12, 292a19-23 as arguing that the movements of the heavenly bodies are due to "the action of immanent souls or powers". See Aristotle's PHYSICS, Introduction II, p. 98. Not surprisingly, he accepts Guthrie's thesis that the "Unmoved Mover, when it did appear on the scene, appeared only to put the coping-stone on the previous construction, not to shake its foundation" (op. cit., note 60, p. 171).


This is not the place to consider Aristotle's religious sentiment (expressed especially at I.9 and II.1) in the light of the socio-religious context in which De Caelo was written. On this see Elders, Aristotle's Cosmology, Introduction IV, 34-42; and W.J. Verdanius, "Traditional and Personal Elements in Aristotle's Religion", Physis (1960), pp. 57-60. But let us note again that in ascribing divinity to the cosmos Aristotle is marking its immutability and everlastingness. There is no question of his endowing the cosmos with an agent-deity or an individualized soul. For a discussion of Aristotle's early religious development, see Werner Jaeger, Aristotle: Fundamentals of the History of His Development, tr. Richard Robinson (Oxford: The Clarendon Press, 1948), Chap. VI, pp. 123-66. Jaeger makes much of I.9, 279a24-29, to show that De Caelo is early despite its doctrine of the self-moving aither. Jaeger believes this passage preserves the religious rhetoric of the De Philosophia, a literary work written in direct reaction to Plato and under the spell of the Academy. See Chap. VI, 300-301. And he goes so far as to believe that Aristotle's works on cosmology and physics are essentially discussions within the Academy. The passage itself may be early. Which, ironically enough, tells against those who see the first-mover in the reference to ῥαξεῖ. But this is an absurd reading anyway, as ῥαξεῖ is plural, and Aristotle is here talking of beings and principles, not movements. Moreover, the notion that formal principles beyond the sensible world imply a mind to contemplate them provides no argument for the prime mover.

Jaeger, Ibid., Chap. VIII, pp. 194-227; Elders, Aristotle's Cosmology, Intro. III, p. 33, and Intro VI, p. 66. G.E.R. Lloyd, however, suggests that the developed doctrines of actuality and ability do not require the conditions of the Lyceum for their formulation. See Aristotle: The Growth and Structure of His Thought (Cambridge: The University Press, 1968), p. 298. Jaeger argues that the notion of a prime mover (In Platonic guise) appears in De Philosophia together with the notion of the aither as the outer κυκλοφορία. See Chap. VI, 140, pp. 142-144. Certainly the notion of a prime mover is developed in the later corpus; namely, the transition from the ensouled, self-moving first mover of De Philosophia to unmoved mover of Phys. VII and VIII and Meta. This does