ARISTOTLE'S *Physics*

A Critical Guide

EDITED BY

MARISKA LEUNISSEN

CAMBRIDGE
UNIVERSITY PRESS

CHAPTER II

Physics V–VI *versus* VIII: *Unity of change and disunity in the* Physics

Jacob Rosen

Introduction

You toss an apple straight up into the air and let it fall back into your hand. The apple moves up, and then the apple moves down. There is an upward motion of the apple and then a downward motion of the apple. Do these two motions compose a single whole motion? Is there such a thing as the up-and-down motion of the apple?

Another question. You read *Physics* V–VI, with its general theory about changes and continua. Then you read *Physics* VIII, with its cosmological arguments about the eternity of motion and the existence of a first unmoved mover. Have you just read a single text, something we could call a 'continuous treatise on movement' (Ross 1936: 3)?

The first question matters to Aristotle's cosmology. Aristotle believes he can show, in *Physics* VIII.8, that the answer is 'No'. He purports to prove that when something moves back and forth along a straight line, its successive motions in opposite directions do not compose a single motion. This result, together with other theorems of his physics, entails that there cannot be an eternal motion along a straight line. From this he infers that the only possible eternal motion is circular motion. Since, independently of this, he thinks he has proven that there needs to be an eternal motion, he can assemble a demonstration for the existence of eternal circular motion. His candidate for such a motion is the motion of the heavenly sphere in which the stars are fixed. Ultimately, then, his argument in *Physics* VIII.8 offers a measure of confirmation for certain astronomical theories of his day, and a sort of explanation for the existence and rotation of the outermost heavenly sphere which is posited by these theories.

The second question matters to the history and interpretation of Aristotle's writings. Its answer admits of degrees. It will affect, among other things, the extent to which we use passages in one book to elucidate

passages in another, and the extent to which we may combine doctrines from the different books and then offer up the resulting whole as a view held by Aristotle.

In this chapter I will develop some thoughts about the second question, the one about the text, by way of considering how Aristotle reaches his answer to the first question, the one about the apple. Aristotle offers several arguments in *Physics* VIII.8 for his thesis that, when something moves back and forth, it does not undergo a single motion. These arguments occur against the background of a sophisticated theory, expounded in *Physics* V–VI, of the basic structure of motions and of other continuous entities such as times and magnitudes. The arguments in *Physics* VIII.8 stand in a surprisingly complex relation to that theory. On the one hand, Aristotle evidently relies on the theory in a number of crucial steps.[1] Yet in other steps he seems to contradict or misapply the theory. This situation offers the occasion to examine Aristotle's views about some fundamentals in the metaphysics of motion, while also raising questions about the unity of the text which has come down to us as the *Physics*.

Let me signal in advance one of the questions we will encounter. In one of the arguments of *Physics* VIII.8, Aristotle introduces a thesis about continua that we may call the Potentiality Doctrine. According to this doctrine, a continuous entity has no actually existing proper parts and no actually existing middle-points. Rather, it has parts and middle-points only *potentially* or in capacity. The Potentiality Doctrine is not affirmed in *Physics* V–VI. To the contrary, Aristotle often refers in these books to parts and middle-points without ever suggesting that they are only potentially there. It is natural to wonder whether we may attribute to Aristotle a single overall theory of continua in which the Potentiality Doctrine is combined with the theory of Books V–VI. The answer will depend on many considerations, but an important one is this: when we come to Aristotle's *argument for* the Potentiality Doctrine in *Physics* VIII, we will see that it rests on an assumption that is contradicted by a theorem in *Physics* VI.5. That is reason to doubt whether the Potentiality Doctrine is going to combine successfully with the theory of *Physics* V–VI. At the least, it speaks

[1] For example, Aristotle's rejection of eternal rectilinear motion in *Physics* VIII.8 tacitly relies on the following two theorems from *Physics* VI: (1) no motion traverses an infinite straight line (*Phys.* VI.10, 241a26–b10); and (2) no motion takes an infinite time to traverse a finite distance (*Phys.* VI.2, 233a31–34, and VI.7, 237b24–25). These theorems imply that if something moves forever along a straight line, it must sometimes turn around; *Physics* VIII builds on this by arguing that what turns around does not undergo a single motion.

against regarding these three books of the *Physics* as a single, continuous exposition of such a combined theory.

In all, there are many points of agreement and more than one point of tension between Books V–VI and Book VIII. I will begin by presenting a few fundamental points of agreement. Then I will argue that there are (at least) two tensions. First, in *Physics* VIII.8, Aristotle assumes that any single motion must be homogeneous (in a sense to be explained), whereas according to *Physics* V–VI a motion is not homogeneous. Second, in *Physics* VIII.8, Aristotle assumes a beginning of change (in a sense to be explained), whereas in *Physics* VI.5 he proves that there is no such thing. These tensions both undermine Aristotle's justification of the Potentiality Doctrine and affect his strongest arguments against the existence of eternal rectilinear motion. We will thus need to ask where these tensions leave us in assessing the unity and success of Aristotle's project in the second half of his *Physics*.

I Common ground

Let us begin with three doctrines about change that are endorsed by Aristotle both in *Physics* V–VI and in *Physics* VIII. The first is the thesis that there are changes. The second concerns the way in which changes occupy time. The third concerns the conditions under which a given change is 'one' (full stop), or 'one with' a given change.

The most fundamental commonality between the different texts is their commitment to the existence of such objects as changes and motions.[2] This is a substantial theoretical commitment, going beyond the more modest claim that things move and change, or that there are moving and changing things. (Davidson posed the question: 'Things change; but are there such things as changes?'[3] Aristotle's answer, like Davidson's, is 'Yes.') Aristotle writes:

> It is necessary that if a motion is present, then something moves, and that if something moves, then a motion is present.[4] (*Phys.* VI.1, 231b25–26)

I should mention that this biconditional is preceded in the text with an 'if indeed' and followed by a 'then . . . '. It is the antecedent of a conditional

[2] In my translations of Aristotle, I will use the word 'motion' and its cognates to translate κίνησις and its cognates, and use 'change' and its cognates to translate μεταβολή and its cognates. Every motion is a change, but not *vice versa*. The distinction between motion and change is not important for this chapter, and I will not be careful about it.

[3] Davidson 1970: 25. [4] Translations are my own.

claim, not something that Aristotle asserts on its own. Still, it is beyond doubt that he endorses it. A sign of this is his easy way of switching back and forth between verbs predicating of things that they move or change, and nouns denoting motions or changes. He does so both in *Physics* V–VI and in *Physics* VIII.[5]

As it stands, Aristotle's biconditional is fairly weak. It merely says that something moves if and only if there exists a motion. It does not explicitly say whether there is a motion *of each thing* that moves; or whether a motion is present *at every time when* something moves. Nor does it specify whether motions have particular kinds and characters, corresponding to *how* things move. (For example, is it the case that something moves fast if and only if there is a fast motion? Or that something moves to Venice if and only if there is a motion to Venice?) We must return to the last question later, but the first two have natural, obvious answers, and it seems clear that Aristotle accepts these obvious answers. He assumes that a subject S moves if and only if there is a motion *of S*, and that something moves during time T if and only if there is a motion of it *occupying T*. So I will take it that in *Physics* V–VI and VIII, Aristotle endorses the following principle:

> NOUN–VERB TRANSLATION PRINCIPLE: S moves during T iff there is a motion of S that occupies T.

A second point of agreement between *Physics* V–VI and VIII is their understanding of the way in which changes are temporally extended. Aristotle in both texts conceives of changes as spread out in time like sails. By this I mean that, where a change occupies a given time, it has different parts occupying different parts of the time.[6] (*Physics* VI contains an analogous claim involving spatial extension, namely that, where a change belongs to a given body, it has different parts belonging to different parts of the body.[7]) We should appreciate that this is not the only possible philosophical view Aristotle could have taken. In principle he might have conceived of a change as a continuant: something that endures through time in much the way that substances are naturally thought to do. Thus, he might have thought that a change is wholly present in every part of the time for which it exists. I have heard it said that Aristotle sometimes regards

[5] See, for example, *Phys.* VIII.8, 265a7–12.

[6] See, for example, *Phys.* VI.4, 235a18–24; VIII.8, 263a27–29, 264a24–26. As already mentioned, according to VIII.8 a change has these parts only potentially, not actually (whatever exactly that means).

[7] *Phys.* VI.4, 234b21–24 and following. This claim is neither affirmed nor contradicted in *Physics* VIII, to my knowledge.

changes as continuants in this way. I do not know whether that is true, but in any case he does not so regard them in the texts I am discussing.

The third point of agreement between the texts is a shared framework for addressing issues of unity for changes. Recall that Aristotle's question in *Physics* VIII.8 is whether there can be a *single change* of a certain sort (namely, a single change back and forth along a straight line). In order to answer it, he builds upon a discussion of criteria for oneness of change that was presented in *Physics* V.4. (He refers back to this discussion at VIII.8, 262a1.) Aristotle there discussed three main ways of being one: being one *in genus* (*genei*), being one *in kind* (*eidei*), and being one '*simply*' or '*without qualification*' (*haplôs*).

The last, and strongest, way of being one is the topic of Aristotle's concern in *Physics* VIII.8. On the surface, at least, he adopts the same criteria for it as were laid down in *Physics* V.4. According to both texts, a change's being one without qualification depends upon three factors: what changes (i.e. the subject of change), when it changes (i.e. the time of change), and that 'in which' it changes (i.e. the path of change, if I understand rightly).[8] A change is one without qualification if and only if (i) its subject is one, (ii) its time is one and without gaps, and (iii) what it is in is 'one and indivisible' (V.4), or 'undifferentiated in kind' (VIII.8).[9] The third criterion appears to be the same as the criterion for a change's being one in kind.[10] This explains Aristotle's statement that 'necessarily, a motion that is one (namely, without qualification) is also one in kind, although it is not necessary for a motion that is one in kind to be one without qualification' (*Phys.* V.4, 228b9–10).

In the next section I will discuss a problem in Aristotle's treatment of oneness in kind in *Physics* VIII.8. But before I can do that, there is a point that requires clarification.

Interlude: One-place oneness and two-place oneness

Aristotle's discussion is subject to a complication that will be crucial in the next section of this chapter. The complication is that he shifts between what we may call a 'two-place' use and a 'one-place' use of the notion of oneness.

A two-place statement of oneness has the form 'change A is (or is not) one with change B'. For example, Aristotle tells us that every locomotion is

[8] *Phys.* V.4, 227b23–26; VIII.8, 262a1–4.
[9] *Phys.* V.4, 227b29–228a3; VIII.8, 262a1–2.
[10] *Phys.* V.4, 227b6–7, 19, 27–28.

one in genus with every other locomotion (*Phys.* V.4, 227b5). He tells us that every whitening is *one in kind with* every other whitening (227b11). And he tells us that one man's restoration to health is not *simply one with* another man's restoration to health (228a1–3). He gives reasonably clear explanations of what he takes such claims to mean.

A one-place statement of oneness has the form 'A is (or is not) one'. It is sometimes, but not always, clear what Aristotle means to say with a sentence having this form. A fairly clear case is when the term substituted for A signifies a *type* of change. In this case the sentence can be understood as equivalent to a certain two-place oneness claim: it means that each change of the type is *one with* each other change of the type. For example, Aristotle says that *learning* is, to a degree, one in kind (227b13), and this seems to mean that every learning is one in kind with every other learning.

Another sort of case is trickier, although the basic intention behind it is still recognisable. This is the case where the term substituted for A purports to refer to an individual change, and the sentence either affirms or denies that the term's referent is one without qualification. Consider an example (in this passage it is clear from context that 'one' means 'one without qualification'):

> The motion is not one but many, if there is rest between them. Consequently, if a motion is separated by stationariness, it is not one or continuous. (*Phys.* V.4, 228b4–6)

What makes these sentences difficult is that the term 'the motion' or 'a motion' seems as though it must refer to a single thing, if it refers at all. And yet the term is used to say such things as 'the motion is not one' or 'the motion is many'. Are such claims capable of being true? Aristotle seems to be struggling somewhat to express himself properly; indeed he mixes grammatically singular and plural forms in a way that tests the rules of syntax. For example, in his phrase 'the motion is not one but many' there is a predicate ('many', *pollai*), which does not agree in number with its subject ('the motion', *hê kinêsis*).

Nevertheless, Aristotle's basic intention seems reasonably clear. The idea is that there are some changes (plural) that we are interested in, and we are interested in whether or not these changes compose a single change. In order for them to do so, there are some conditions which they jointly must satisfy: for example, they must jointly occupy a time that has no gaps in it. A term such as 'the motion', although grammatically singular, can be used to say things plurally about the changes of interest. Thus, for example, 'the motion is separated' is made true not by the fact that any single individual

is separated, but by the fact that the motions in question (plural) are separated. (The plural predication here is like what we use when we say of some people, 'they are crowded together', or 'they are arranged in a square'. Such sentences do not say something about each person individually – they do not say that any individual person is crowded together or arranged in a square – nor do they posit a whole item, composed out of the people, which is a crowded or square item. They simply attribute a predicate to some people plurally.)

II Oneness in kind and homogeneity

As we saw above, Aristotle holds that oneness without qualification implies oneness in kind. Oneness in kind is among the criteria for unqualified oneness.

This point is fairly clear when we deal with two-place statements of oneness. Suppose that my face simultaneously heats up and turns red, and we want to know whether the heating is simply one with the reddening. Well, the subject of the heating is one with the subject of the reddening, and the time of the heating is one with the time of the reddening. Two of Aristotle's three criteria are met. However, his third criterion is not met: the heating is not one in kind with the reddening. Hence the heating is not unqualifiedly one with the reddening, because it differs from it in kind.

When we turn to one-place statements of oneness, we encounter a difficulty. Suppose we now ask whether my face's heating and its reddening are, i.e. compose, a single change (we could put this by asking whether my face's *growing flushed* is unqualifiedly one). Or, returning to our old example of the apple, suppose we ask whether the apple's motion from the apex of its arc down to your hand is simply one. (Do its motion from apex to the level of your eyes and its motion from there to your hand come together to compose a single change?) To answer such questions we will need to apply Aristotle's three criteria in new ways. We will need to know what it means to say that a change's subject or its time 'is one': not one *with* something, but just plain one. And we will need to know what it means to say that a change 'is one in kind': again, not one in kind *with* something, but just plain one in kind.

Above I suggested that we can reconstrue such claims in a plural form. We can look at the components of a putative single change and ask of them, plurally, whether *they belong to one subject*, whether *they occupy one time*, and whether *they are one in kind*. But understanding these plural-form questions is not straightforward. We should notice, to begin with,

what the sentence 'they occupy one time' does *not* mean. It does not mean that each of the changes in question occupies *the same time as* each other change. For example, assuming that the apple's motion from apex to eyes and its motion from eyes to hand compose a single motion from apex to hand, we will need to say that they occupy one time. But the motion from apex to eyes does not occupy the same time as the motion from eyes to hand. One occurs after the other. The thought behind Aristotle's criterion, presumably, is that the times occupied by these two motions 'add up' to a single, continuous time.

I want now to focus on the criterion involving oneness in kind. In *Physics* VIII.8, I will suggest, Aristotle interprets this criterion precisely along the lines that we have just rejected for the criterion involving time. That is, he appears to hold the view that if a change is unqualifiedly one, then each of its parts must be one in kind with each other part. Then I will argue that this view is inconsistent with the theory of *Physics* V–VI.

II.1 Homogeneity in Physics VIII.8

Let us say that a change is *homogeneous* if and only if each part of the change is one in kind with each other part of the change. In *Physics* VIII.8, Aristotle apparently holds that a change is one without qualification only if it is homogeneous.

We find this view at work in Aristotle's first argument for the thesis that, if something moves back and forth along a straight line, it does not undergo a single motion. The argument begins:

> For it turns back, and that which turns back on a straight line undergoes contrary motions (261b32–34)

And he concludes:

> but contraries differ in kind, and are not one. (262a5)

In this argument, Aristotle notes that a supposed single back-and-forth motion would have two contrary motions as parts; he observes that these contrary motions differ in kind from each other; and he infers that there is no single back-and-forth motion. This appears to be an application of the view that a single motion must be homogeneous.

Aristotle gives further indication of the homogeneity of changes later on in the chapter. The context is the following claim: if something undergoes a motion which it was not always undergoing, then the motion is preceded by the sort of rest which is opposed to it. (Rest at A is opposed to motion

from A to B.) Thus, for example, for some period before you walk from your office to the beach, you are at rest in your office. Now, Aristotle recognises that his claim must be restricted. For motions have smaller motions as parts, and Aristotle does not want to say that all these smaller motions are preceded by periods of rest. On your way from the office to the beach you pass a lemonade stand and an ice-cream booth, and there is a part of your walk by which you traverse the distance between them. Aristotle does not think that this part of your walk must be preceded by a period of rest in front of the lemonade stand. So, he restricts his claim in such a way that it does not apply to motions that are parts of larger motions. He states his restriction in the following way:

> I mean those motions that are different in kind, and not if it is some part of the whole motion. (264a25–26)

Aristotle here contrasts motions that are parts of motions with motions that are different in kind. This suggests that the parts of a motion are one in kind with the wholes of which they are part, and with the other partial motions that precede and succeed them.

II.2 Heterogeneity in Physics V–VI

According to the theory of *Physics* V–VI, by contrast, an unqualifiedly single change will not be homogeneous. The reason is this. Every change is a change from something and to something;[11] let us call these its starting-point and its end-point. A change is one in kind with another change only if it has the same end-point as it. (There are further conditions, too: it must also have the same starting-point, and indeed the same path from starting-point to end-point, as the other change.)[12] But the different temporal parts of a single change have different end-points. For example, the apple's whole downward motion, from its apex to your hand, is unqualifiedly one change. But one of its parts is a motion from the apex to a place before your eyes, and another of its parts is a motion from there to the place in your hand. These parts have different end-points, so they are not one in kind with each other. Hence the apple's whole downward motion is not homogeneous.

A thought along these lines finds explicit expression in *Nicomachean Ethics* X.4 (complete with an apparent cross-reference to *Physics* V–VI).[13]

[11] *Phys.* V.4, 225a1; VI.4, 234b11 and 5, 235b6. [12] *Phys.* V.4, 227b14–20.
[13] *NE* X.4, 1174a31–b5. Aristotle uses this line of thought in order to argue that pleasure is not motion.

What matters to us here, and what I would now like to show, is that the line of thought brings out a genuine consequence of the doctrines of *Physics* V–VI.

According to Books V–VI it is clear that, where a motion occupies a given time, the motion has a part in each part of the time. These parts are themselves motions.[14] And in the lesser times occupied by these lesser motions, the moving thing moves (*kineitai*) or traverses (*dierchetai*) lesser magnitudes. Thus, we find statements such as the following:

> It is evident that the magnitude is continuous if the time is, since in half the time it traverses half the distance, and in general a lesser distance in a lesser time. (*Phys.* VI.2, 233a13–16)[15]

Suppose, for example, that there is a motion from A to C, and that B lies between. Then the motion from A to C has, as parts, a motion during which the thing traverses magnitude AB and a motion during which the thing traverses magnitude BC. It is reasonable to think that these latter motions are, respectively, a motion from A to B and a motion from B to C. Aristotle himself does not have occasion to describe them in precisely this terminology, but arguments can be given to show that this is what they are.

The main thing needed in order to show this is a supplementation to the Noun–Verb Translation Principle stated earlier. We need to add a correlation between a characteristic of a moving thing, namely that it *moves from A to B*, and a characteristic of a motion, namely that it is *a motion from A to B*. If we are justified in doing this, then we may attribute to Aristotle the following expanded principle:

> Expanded Noun–Verb Translation Principle: S moves from A to B during T iff there is a motion of S from A to B that occupies T.

There is good evidence for such an expanded principle in *Physics* V–VI. Here, for example, are two passages from V.1:

> Every motion is from something and to something, for that which primarily moves is different from that to which it moves and that from which it moves. (*Phys.* V.1, 224b1–2)

> (a) Since every change is from something to something . . . (b) that which changes could change in four ways: either from a subject to a subject, or

[14] See for example *Phys.* VI.4, 235a18–24. At *Phys.* VI.1, 232a8, an assumption for *reductio* has the consequence that 'the motion would not be composed out of motions', and this is treated as an unattractive consequence.

[15] See also *Phys.* VI.2, 232b7–8, a34–b2, 6, 236b34–237a3, and 7, 237b23–24.

> from a subject into not a subject, or not from a subject into a subject, or not from a subject into not a subject . . . (c) Consequently, it is necessary from what has been said that there are three changes: that from a subject to a subject, that from a subject to not a subject, and that from not a subject to a subject. (*Phys.* v.1, 224b35–225a10)

It seems clear in the first of these passages that Aristotle is equating what *a motion is from and to* with what *a thing moves from and to*. The equivalence is especially clear in the second passage. The details of interpretation of this passage, for example the question what exactly Aristotle means by 'subject', need not concern us. What is noteworthy is Aristotle's switch back and forth between saying that *a change is* from and to something, in points (a) and (c), and saying that *a thing changes* from and to something, in point (b). Aristotle's inference from (b) to (c) shows that he regards the two ways of speaking as equivalent. In other passages in Books v and vi as well, Aristotle switches fairly casually between speaking of what a change is from and to, and of what a thing changes from and to.[16]

Given the expanded translation principle, it only remains to convince ourselves that, during the different parts of a motion from A to C, a thing moves from A to B and moves from B to C. Here we must pause to note an ambiguity in the verbal form 'moves', or rather in the corresponding Greek present tense form. On the one hand, the form can be understood as having perfective aspect. So understood, the statement that S *moves* from A to B during a time implies that, at the end of the time, S *has moved* from A to B. (This in turn implies that S is at B at the end of the time, *Phys.* vi.5, 235b7–8.) But, on the other hand, the form could be understood as having imperfective aspect, equivalent to 'is moving'. The statement that S *is moving* from A to B during a time does not imply that S has moved to B by the end of the time. For example, if it takes you a whole day to walk to Thebes, then it is not true that you *walk* (perfective) to Thebes in the morning, but it is true that you *are walking* to Thebes in the morning.

The question is which verbal aspect figures in the translation principle? Is a motion from A to B a motion during which something *moves* (perfective) from A to B, or a motion during which something *is moving* (imperfective) from A to B? If it turned out to be the latter, then perhaps motions would be homogeneous after all. For it is plausible that a thing *is moving from A to B* during every part of a motion from A to B.

[16] See, for example, *Phys.* v.1, 224b7–10, 12–15; vi.4, 234b10–13 and 10, 241a26–b11 (esp. b9); see also vi.5, 235b13–14, 236b2–4.

In my view, it is more natural on the whole to adopt the perfective reading of Aristotle's present tense 'moves'. This reading is also supported by certain considerations of detail.[17] If you accept my view of the matter, then you will join me in drawing inferences from claims made by Aristotle in the perfect tense, such as the following:

> Let AB have moved from B to C primarily . . . If BC is divisible, there will be something before C to which AB has changed, and another in turn before that. (*Phys.* VI.5, 236b11–14)

Here Aristotle says that, before having changed from one point to another, a thing *has changed* to an intermediate point. I infer that the thing *changes* to an intermediate point, and, applying the translation principle, conclude that it undergoes *a change* to an intermediate point.

Fortunately, there is one passage in which Aristotle himself uses the present tense, so that we may apply the translation principle directly, without settling questions of verbal aspect or the relation between present and perfect tense forms. In this passage, Aristotle supposes that something has changed from C to D. He argues that CD is not indivisible. Then he proceeds:

> Necessarily, what is in between is a magnitude and is infinitely divisible. Consequently, it changes to those beforehand. (*Phys.* VI.6, 237a33–34)

Here Aristotle says that, before having changed from C to D, the thing changes to the various points between C and D (i.e. the points at which CD can be divided). He says this using the present tense. Applying the translation principle, it follows that the thing undergoes a change to each of the intermediate points. Each of these changes is, to review, different in kind from the others, and they are all parts of the change from C to D. Consequently, the change from C to D is not homogeneous.

To conclude, some of Aristotle's arguments in *Physics* VIII.8 against the possibility of eternal rectilinear motion are based on the principle that a change must be one in kind in order to be unqualifiedly one. This principle is common to Books V and VIII. But Aristotle interprets the principle to mean that if a change is unqualifiedly one, then each of its parts must be

[17] Here are two considerations. (1) At *Phys.* V.6, 230a4–5, Aristotle says that if something stands still at A, then a motion to A is or coincides with a coming-to-rest. His claim seems plausible only on the assumption that at the end of a motion to A the thing *is* at A (so that it will rest immediately after the motion). This assumption is validated by the perfective, but not by the imperfective, reading of the translation principle. (2) At *Phys.* VI.5, 235b6–8, Aristotle juxtaposes present and perfect tense claims, in a way that suggests (even if not, I grant, strictly entailing) that what a thing *changes to* and what it *has changed to* are the same for any given change.

one in kind with each of its other parts. This contradicts the theory of *Physics* V–VI, according to which a single change has, as parts, changes to different endpoints, with the result that its parts differ in kind from each other.

III The potentiality doctrine and the beginning of change

Aristotle has other arguments in *Physics* VIII.8 that are based on another of his criteria for unity of change. In these other arguments, he appeals to the principle that a change, in order to be one, must occupy a single time without gaps. He thinks he can show that this criterion is failed by back-and-forth motion: when something moves back and forth along a straight line, it must rest for some time at the point where it turns around. (Indeed, he thinks you can *see* that it rests there, *Phys.* VIII.8, 262a18.)

In the course of developing these arguments, Aristotle introduces a new general doctrine about continua, which I will refer to as the Potentiality Doctrine. This is the claim that a single continuous thing, such as a motion, line, or time, has parts and middle-points only potentially or in capacity, not in actuality. On the other hand, he argues, when something moves back and forth, the point where it turns around is *in actuality* a middle-point of its motion. Since its motion has an actual middle-point, it follows that its motion is not one. Along the way, he also uses the Potentiality Doctrine to answer one of Zeno's paradoxes of motion (263a4–b9).

Aristotle seems conscious in *Physics* VIII.8 that the Potentiality Doctrine is a new thesis relative to the theory presented in Books V–VI. At least, he thinks that the doctrine provides a new and better response to Zeno.[18] There were gestures in the direction of this doctrine in earlier books, during Aristotle's discussions of infinity and of time (*Phys.* III.6, 206a14ff., IV.11, 220a10ff.). But it is nowhere endorsed in Books V–VI. This is somewhat surprising, given that many of Aristotle's proofs in *Physics* V–VI appeal to the existence of parts and of intermediate points.[19] One would expect it to make a difference to these proofs whether or not the parts and middle-points actually exist, as opposed to being mere *possibilia*, and yet he says nothing about the question.

The Potentiality Doctrine is rather difficult to understand, but it is clearly important to Aristotle. It is closely connected with some claims

[18] He claims to improve on the solution given 'in the first discussion of motion' (ἐν τοῖς πρώτοις λόγοις τοῖς περὶ κινήσεως, *Phys.* VIII.8, 263a11), apparently referring to *Phys.* VI.2, 233a21ff.

[19] See, for example, *Phys.* VI.2, 232a32ff., 232b27ff., 4, 234b23ff., 6, 236b32ff., and 10, 241a8ff.

about potentiality found in the *Metaphysics*, in particular the doctrine that no substance is composed out of actually existing substances (*Metaphysics* Z, 13 and 16). (The doctrines are related but not the same, since motions, lines, and times are not substances.) Aristotle seems to need it in order to combine his belief in the existence of continua with his denial of the simultaneous actual existence of infinitely many things.[20] Commentators often regard it as one of his central doctrines about continuity.[21]

What, then, should we make of the Potentiality Doctrine's absence from *Physics* V–VI? Here are two opposed and extreme views. On a unitarian view, we might simply infer that Books V–VI are not intended as a complete, self-sufficient treatment of continua. Part of their job is to build up to Book VIII, and they were written with the intention of their being supplemented by further refinements such as the Potentiality Doctrine. On an opposite view, we might infer that Books V–VI were written in isolation, independently from the concerns of the rest of the *Physics*. Issues about causation, potentiality and actuality, and infinity are simply not on their agenda. They are a more or less mathematical text (relating perhaps to a part of mathematics in the way that optics relates to geometry),[22] plonked into the middle of a more natural-philosophical one.

Presumably the truth lies somewhere between these extremes, and I will not try to determine where precisely. But I would like to point out two issues that are relevant to the question. The first issue is whether Aristotle's argumentation in *Physics* V–VI is even *compatible* with the Potentiality Doctrine. Do his proofs go through when we add the premise that none of the parts and middle-points appealed to therein have actual existence? There is no space here to settle this issue, since it depends on both a detailed interpretation of the Potentiality Doctrine and a detailed analysis of Aristotle's proofs. I am optimistic that the central proofs of Books V–VI can be recast so as to be compatible with the Potentiality Doctrine.

The second issue concerns the argument that Aristotle gives in support of the Potentiality Doctrine in *Physics* VIII.8. The argument is unsound. Worse, the flaw in Aristotle's argument for the Potentiality Doctrine

[20] See Coope 2005: 10. Aristotle's main target in his discussion of infinity (*Physics* III.4–8) is the question of infinitely extended magnitudes. But he also speaks of number, and he seems to deny any simultaneous, actually infinite number of things at III.7, 207b11–15.

[21] See, for example, Ross 1936: 68.

[22] The relation in question I have in mind is described by Aristotle as 'being under'. See *APo.* I.13, 78b32ff. for this relation both within mathematics and across the boundary between mathematics and natural science.

appears to rest precisely on a failure to appreciate a significant theorem from *Physics* VI.5.

III.1 The argument of Physics VIII.8

When you threw the apple into the air and let it fall back into your hand, there was a point where the apple turned around. That point was an actual middle-point of the apple's movement up and down. It served as the end-point of the apple's motion up and the starting-point of the apple's motion down. The apple arrived there from your hand and departed from there back to your hand. For Aristotle in *Physics* VIII.8, these claims imply that the apple rested for some time at the point, and hence that it did not undergo a single motion up and back.

The point where the apple turned around is different from a point before your eyes which the apple passed through on its way down. At the point before your eyes, the apple did not rest for any time. It did not arrive there or depart from there. The point did not serve as the end-point of a motion or as the starting-point of a motion. It was not an actual middle-point of the apple's downward motion. A single motion has no actual middle-points.

Aristotle can parlay his result about middle-points of motion into a general doctrine about parts and middle-points of continua. For, first, Aristotle presumably thinks that a motion has an actual middle-point if and only if it has actual parts: if there is a middle-point, then there are parts that meet at the middle-point, and if there is a part, then there is a middle-point where the part meets its remainder. This explains why, having argued that a continuous motion has no actual middle-points, he later asserts that it has no actual halves (VIII.8, 263a28–29). Second, Aristotle seems to think that a motion has actual parts if and only if the *time* occupied by the motion has actual parts, and if and only if the *magnitude* traversed by the motion has actual parts (compare *Phys.* VI.4, 235a15–17ff.). This explains why he is prepared to assert that continuous lines and times, in addition to motions, have only potential parts (VIII.8, 263b3–9).

Let us follow Aristotle through his argument about middle-points of motion. The central passage is *Physics* VIII.8, 262a19–b8, with the argument then being carried on at 262b17–263a3. Aristotle's first premise is this: if a point is (actually) a middle-point of a motion, then it is (actually) the end-point of a motion (namely, of the part of the whole motion of which it is the final boundary) and the starting-point of a motion (namely, of the

part of the whole motion of which it is the initial boundary). He expresses this as follows:

> There being three things, beginning, middle, and end, the middle is both in relation to each. (*Phys.* VIII.8, 262a19–20)

Aristotle's next two premises are these. If a point is actually the starting-point of a motion, then at some time the moving thing *has departed* (*apogegone, apelêluthe*) from the point. And, if a point is actually the end-point of a motion, then at some time the moving thing *has come to be* (*gegone*) at the point. Thus he writes, of something which has undergone a motion from A to C:

> It has departed from point A, i.e. the beginning, and has come to be at C, when it finishes and stops. (*Phys.* VIII.8, 262b7–8)

From these premises it follows that, if a point is actually a middle-point of something's motion, then at some time the thing has come to be at the point, and at some time the thing has departed from the point. So far, Aristotle's reasoning is tenable. What comes next, however, is not so good:

> It is impossible for A simultaneously to have come to be at B and to have departed. Hence it does the one in one point of time, and the other in another. Hence there will be a time in the middle, and consequently A will rest at B. (*Phys.* VIII.8, 262a32–b2)

Aristotle adds a further detail to his argument a little later (by which time point B has been replaced by D):

> It is not the case that it simultaneously has come to be at D and has departed from D: for it would simultaneously be there and not be there in the same instant. (*Phys.* VIII.8, 262b26–28)

In these passages, Aristotle assumes that if A has come to be at a point and has departed from the point, then there is such a thing as the instant, or point of time, when A has come to be at the point, and such a thing as the instant or point of time when A has departed from it. At the instant when A has come to be at the point, it *is* at the point, and at the instant when A has departed from the point, it *is not* at the point. Given the Principle of Non-Contradiction, it follows that the instant when A has come to be at the point is different from the instant when A has departed from the point. Between any two instants there is a period of time. So, there is a period of time between these two instants, during which A has come to be at the point and has not yet departed from the point. Throughout this time, A is at the point. Hence, A rests at the point.

From the perspective of *Physics* VI.5, many of the steps in this argument are acceptable.[23] But there is a crucial error, namely, Aristotle's assumption that there is such a thing as *the instant when* A has departed from the point. It is, of course, sometimes true to say of A that it has departed from the starting-point of its motion. But for every instant at which it is true to say this, there is an earlier instant at which it is also true to say this. There is no first, primary time or instant in which A has changed some, in which A has departed from the starting-point of its motion. This is argued at some length in *Physics* VI.5 (236a13–27), and corollaries are derived from it in the remainder of that chapter (236a27–b18).

When we hold this lesson in mind from *Physics* VI.5, we can see that the argument of VIII.8 does not go through. True, there is such a thing as the instant when A has come to be at the middle-point, and yes, at this instant A is at the point. Every instant at which A can be truly said to have departed from the point is indeed different from, not simultaneous with, the instant at which it has come to be there. So, yes, for any given instant at which A has departed from the point, there is a period of time separating it from the instant at which A had come to be there. But no, such a period is *not* a period during which A has come to be at the point and *not yet departed* from the point. For, prior to any instant you choose at which it is true that A has departed, there is always an earlier instant at which it is already true that it has departed. (There is a last instant at which it has not departed, and every instant thereafter is one at which it has departed.)

As far as *Physics* V–VI is concerned, nothing seems to rule out the possibility that the apple you threw and caught never rested anywhere between leaving your hand and arriving back in your hand. What is more, as far as I can see, nothing in those books rules out the possibility that it underwent a single motion up and back. Related to this, Books V–VI seem to be consistent with the proposition that a single motion has actual middle-points. Now, *Physics* V–VI do not purport to deliver the whole truth about motion. Perhaps Aristotle could derive the results he wants by introducing some further independent principle – something consistent with, though not entailed by, the theory of *Physics* V–VI. But that is not what he does in *Physics* VIII.8. His argument in *Physics* VIII.8 rests on a tacit premise that is inconsistent with *Physics* VI.5. Thus, the argument that Aristotle actually gives for the Potentiality Doctrine, along with the

[23] For example, the connections between having departed and not being there, and between having come to be and being there, appear in VI.5 (235b14–16, 235b7ff.). Similarly, the claim that there is a time between any two instants is ubiquitous in V–VI.

associated argument against the existence of eternal rectilinear motion, is incompatible with the theory of *Physics* V–VI.

IV Conclusion

Let me close with three questions.

The first question is, did Aristotle have a single basic understanding of continua, or did he rather have multiple overlapping fragments of theories? In particular, where does the Potentiality Doctrine belong in his understanding of continua? I have argued that his attempt to establish this doctrine is defeated by *Physics* VI.5. Given this, we should not, without further ado, read the Potentiality Doctrine into the theory presented in *Physics* V–VI. Further research is called for here. A minimal condition on attributing a combined theory to Aristotle would be to show that the Potentiality Doctrine (setting aside Aristotle's attempted proof of it) is consistent with the doctrines and proofs given in *Physics* V–VI.

Second, what should we think about the unity or disunity of the second half of the *Physics*? The tensions we have seen go beyond, I think, what we normally find as a result of mistakes or oversights within a single philosophical work. They indicate that Books V, VI, and VIII were not all written in one sitting. This impression is reinforced by differences in technical terminology between the books.[24] On the other hand, the texts do not seem wholly independent of each other, and it is plausible that Aristotle himself assembled them together. It would be useful to have a more complete map of the interconnections and any additional tensions between the texts, so as to make an informed hypothesis about the manner of their composition.

Finally, do the tensions we have seen amount to a major problem for Aristotle's physics and cosmology? I have argued that some of Aristotle's arguments against the possibility of eternal rectilinear motion in *Physics* VIII.8 are inconsistent with V–VI. Are *any* of his arguments consistent with the earlier books? I count six arguments in all. Two seem to rely on the

[24] In most books of the *Physics*, including V–VI, a point is called a στιγμή (*Phys.* V.3, 227a27, 28, 31, 4, 227b16; VI.1, 231a25, 26, 30, 231b7, 9, 13, 10, 241a3, 7, 10, 12, 13, 19; there is an exception at VI.9, 240b3). In Book VIII a point is called a σημεῖον (VIII.8, 262a23, 29, 262b2, 4, 7, 12, 25, 263a24, 31, b10, 12, 264a3). Furthermore, in *Physics* V–VI the starting-point and end-point of a change are normally referred to using the prepositions ἐκ and εἰς, respectively (e.g. V.1, 225a1), while in Book VIII Aristotle uses ἀπό for the one and ἐπί or πρός for the other (e.g. VIII.8, 262a7, 9–10, b10–12, 19, 264a29–31).

mistake I described about the beginning of change (262a19–263a3, 264b1–6). Two seem to rely, more or less directly, on the 'homogeneity' interpretation of oneness in kind (261b32–262a6, 264a21–b1), which I have argued is incompatible with *Physics* V–VI. One is brief, cryptic, and *prima facie* irrelevant to the desired conclusion (264b6–9). This leaves only one argument which, I think, could be made to work (264a7–21). And this argument seems more suggestive than demonstrative, resting on somewhat uncertain linguistic intuitions rather than clear scientific principles. (Roughly, the intuition behind the argument seems to be that there is something wrong with saying of a thing, 'it is moving back and forth between A and B'. Instead, you should say, at some times, 'it is moving to A', and, at other times, 'it is moving to B'.)

In the first book of *On the Heavens*, Aristotle treats it as a previously established fact that circular motion, and only circular motion, can be eternal (*Cael.* 1.2, 269b6–9). We have not questioned Aristotle's positive arguments in the *Physics* for the possibility of eternal circular motion. But it is troubling that his most powerful-seeming arguments on the negative side, against the possibility of eternal rectilinear motion, are all defeated by *Physics* V–VI. When we take away these arguments we weaken his case for the priority of circular over rectilinear motion (cf. *Phys.* VIII.9, 265a24–26), and we hamper his effort to make the stars' circular motion intelligible (why is there an eternally rotating sphere rather than, say, an eternally swinging pendulum?). Still, we should not exaggerate the trouble. Aristotle has other arguments for the priority of circular motion (*Phys.* VIII.9, 265a16–17, b11–12; *Cael.* 1.2, 269a18–21). And he has other resources for denying the existence of eternal rectilinear motion. For example, he could mobilise his doctrines about natural and unnatural motions in *On the Heavens* I. According to these doctrines, any simple body that moved back and forth in a straight line would sometimes be moving unnaturally, and no body would do that sort of thing forever.

CHAPTER 12

Perfection and the physiology of habituation according to Physics VII.3

Mariska Leunissen

Introduction: Habituation as a factor in moral development

In his ethical treatises, Aristotle singles out three factors that play a role in the moral development of men, namely nature, habit, and reason.[1] Although a complete understanding of Aristotle's moral theory will thus involve an analysis of all three factors, this chapter focuses mostly on Aristotle's discussions of habit and the process of habituation. Specifically, I aim to offer an interpretation of Aristotle's "physical" discussion of the acquisition of character virtue in *Physics* VII.3 by drawing from his physiological treatment of habituation in the ethical treatises.

In the *Nicomachean Ethics*, Aristotle argues – famously – that character virtues do not come to be by nature (for instance, in the way that humans realize their perceptive capacities),[2] but rather that they are dispositions (ἕξεις) that we acquire "through habits" (*EN* II.1, 1103a17: ἐξ ἔθους)[3] and "by first activating them" (*EN* II.1, 1103a31: τὰς δ' ἀρετὰς λαμβάνομεν ἐνεργήσαντες πρότερον). Virtues thus come to be as the result of the repeated performance of virtuous actions, whereby the quality of the action is said to determine the quality of the disposition that comes to be (*EN* II.1, 1103b6–25). In the *Politics,* Aristotle claims that also practices such as bodily conditioning and exercise, imitations in play, and musical instruction during childhood are productive of the character virtues, and are therefore forms of habituation (ἐθισμός).[4] Together, these practices aim to change the appetitive soul-capacities of men in such a way that they become correctly disposed towards undergoing the appropriate

[1] *EN* X.9, 1179b20–21; *Pol.* VII.13, 1332a38–40 and 15, 1334b6–28; and *EE* I.1, 1214a14–25.

[2] See especially *EN* II.1, 1103a17–b2 and 6, 1106a9–10: "we have the capacities by nature, but we do not become good or bad by nature."

[3] See also *EE* II.2, 1220a39–b1 and *MM* I.6.2.

[4] *Pol.* VII.13, 1332b10–11; VII.15, 1334b8–9; VII.17, 1336a18–19; and VIII.4, 1339a7–10.