THE UNIVERSITY OF CHICAGO

EVERY CHANGING THING:

NATURAL CONTINUA IN ARISTOTLE'S PHYSICS VI

A DISSERTATION SUBMITTED TO

THE FACULTY OF THE DIVISION OF THE HUMANITIES

IN CANDIDACY FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY

DEPARTMENT OF PHILOSOPHY

BY

ARNOLD ROBERT BROOKS

CHICAGO, ILLINOIS

AUGUST 2021

To Agnes, Ben, Macabee, Abe, and Izzy

Contents

Table of Figures iv
Acknowledgments v
Introduction 1
Chapter 1: A Fault Line in Aristotle's *Physics* 12
Chapter 2: *Physics* 6.4 234b10-20, The Partwise Argument 54
Chapter 3: Part-by-part Change 86
Chapter 4: What Is A Primary Time? 105
Chapter 5: Divisibility and Infinity 137
Bibliography 181

Table of Figures

Figure 1: state-time isomorphism 65
Figure 2: modalities of change 80
Figure 3: part-by-part locomotion.....91
Figure 4: division of a body in two dimensions 92
Figure 5: locomotion in two dimensions.....93
Figure 6: 234b20-235a10 in diagram.....133
Figure 7: homogeneous events 135
Figure 8: motion-magnitude isomorphism.....155
Figure 9: motion-magnitude-moving isomorphism.....156
Figure 10: divisions in changing.....165
Figure 11: the primary time in which something has changed.....168
Figure 12: arriving and departing 176

Acknowledgments

I would like to thank my committee members for their help and indulgence. Christopher Shields, for his consistent and insightful advice, and whose friendship has made our regular meetings a pleasure. Thomas Pashby, for his help in contextualizing Aristotle's mathematical insights in modern mathematics and physics. And Gabriel Lear for a decade of patience and instruction in how to become a better philosopher. I owe her a debt for every piece of writing and every stage of my career as a graduate student.

I also thank the Ancient Greek and Roman Philosophy Workshop and its participants, who have read commented on many drafts of the chapters herein. I wish to thank Sarale Ben Asher, Rory Hanlon, Joshua Mendelsohn, Ermioni Prokopaki, and Joshua Trubowitz for their friendship and for their many contributions to my work. I am greteful to Benjamin Morison, Marko Malink, Christopher Frey for reading early drafts of the present work, and especially to Pieter Sjoerd Hasper for helping to guide me through a difficult text with an expert's eye.

I thank my wife, Agnes Callard, for listening to many confused thoughts about the *Physics* and for her advice and love, and for believing in my project from its very hazy beginnings. I thank Benjamin Callard, for his interest, his encouragement and for his brotherhood. I thank Abraham, Macabee, and Izzy for being that "other" against which my work could attain limit and definition—and for giving me something to be happy about when Aristotle would not cooperate with me.

Finally, I want to thank my parents and my brothers, for their endless enthusiasm for the course I've chosen, sometimes contrary to prudence.

Introduction

> By a "continuum" is understood a system or manifold of terms possessed in varying degree of one or many properties A in such a way that, between any two terms which show a finite difference with respect to A, an infinite number of other terms may be interpolated, of which those that are immediately adjacent to one another exhibit only infinitely small differences with respect to the property A. There can be no objection to such a system, considered as a fiction merely, or as a purely arbitrary ideal construct. But the natural scientist, who is not exclusively concerned with the purely mathematical point of view, is compelled to inquire whether there is anything in nature that corresponds to such a fiction."—Ernst Mach, *Principles of the Theory of Heat*

Zeno of Elea deserves the honor of being the first philosopher in the Greek tradition, in our record, to consider seriously the mathematics and physics of the continuum. But Zeno's foray into this line of thinking, which would prove so important to the development of ancient physics and metaphysics, was entirely negative: the continuum was a physical absurdity. Zeno made use of the concept of a continuum exclusively to show that motion, and perhaps also continuous physical bodies, were impossible.

And so while Aristotle cannot claim to be the first philosopher to study the continuum, he does have the honor of being the first to positively answer Mach's question: are there natural continua? But he only approached this question through a series of false starts, and, I will show, his considered theory emerged only relatively late in his career. Aristotle ultimately concludes that time, change, spatial distances, and bodies are all continuous—divisible into divisibles—and that the explanation of this common structure is the structure of the changing body itself.

This dissertation is an effort to understand Aristotle's theory, not of mathematical, but of natural continua. But many obstacles must be cleared before we can achieve a clear view of this theory. First and foremost is the text in which Aristotle's theory is presented: Physics 6. This text is undoubtedly one of the strangest and most obscure corners of the Aristotelian corpus, at least from the perspective of modern scholarship.

There are three major modern works about Physics 6 that attempt in some way to give an account of the book's assumptions, argument, and purpose as a whole. These are as follows: David Bostock's "Aristotle on Continuity in Physics VI," a 1991 paper now republished in the 2006 collection Space, Time, Matter, and Form, Essays on Aristotle's Physics; the latter half of Sarah Broadie's (née Waterlow) third chapter in Nature, Change, and Agency in Aristotle's Physics, A Philosophical Study; the third chapter of Pieter Sjoerd Hasper's 2003 doctoral dissertation The Metaphysics of Continuity. There are other important works that I will discuss, but those focus on particular topics within Physics 6 without attempting to put together any synoptic picture of that book. Though there has been no modern book-length study of Physics 6, Hasper's dissertation chapter (at 120 pages) comes the closest.

However, all of the three of these works just mentioned are pessimistic about the prospects of finding anything like a coherent project in *Physics* 6. All three find that the book is both inconsistent with itself, and with other parts of Aristotle's corpus in which similar questions are taken up.

Concerning the philosophical prospects of *Physics* 6, no one is more unhappy than Waterlow, who writes that the analysis of change in *Physics* 6 "fails" and that the book is "remarkable for the degree to which it combines intense precision of reasoning with a pervasive ambivalence concerning the fundamental concepts involved." The book is, in her view "incurably incoherent."

Bostock also complains that "Aristotle's discussion in fact leaves a number of important gaps, is at times seriously muddled, and contains some plain mistakes." It is Hasper, however, who confronts in the finest detail the many difficulties, rhetorical as well as philosophical, a reader confronts in trying to find their way through this book: "There are a large number of incongruities which seem to throw into doubt the very unity of the book. These fall into three groups: there are passages which are just inconsistent with other passages; there are theses argued for twice; and there are passages which suggest an ongoing argument, but on a closer look appear to be without argumentative connection."

Some of this frustration is well justified. However, the book need not remain the *terra incognita* that it is today: we can bring substantial order *Physics* 6 by addressing the flaws in modern scholarship about this book. But, first, it is worth appreciating some of the difficulties *Physics* 6 presents, starting with those internal to the text, and then moving on to those having to do with its relation to the rest of Aristotle's work.

First, there are several apparent redundancies in the text. Aristotle frequently uses redundant arguments, but when he does so he acknowledges this by presenting together, often separated by the phrase "And again" (ἔτι δὲ). The redundancies in *Physics* 6, however, are more suggestive of an anomaly in the production or editing of the text. For example, in *Physics* 6.2, Aristotle argues that if magnitude is divisible and continuous, then time must be as well. This follows a brief argument for the same conclusion at the end of 6.1, which however argues from the divisibility of both motion and magnitude. We see another argument for the divisibility of time in 6.4, this time from the divisibility of motion, while "magnitude" has gone missing. He also argues in 6.2 that if the time or magnitude of a motion is infinite in extent, then the other will also be infinite. Again, Aristotle apparently argues for the same thesis in 6.7. I say that these redundancies are

suggestive of some kind of anomaly because these texts evince no awareness of the repetition: he does not qualify his earlier arguments, or refer back to them.[1]

There are also discontinuities in the text. At 6.1 231b18-20, Aristotle says that he will show "in what follows" that motion, time, and magnitude are all mutually divisible or composed of indivisibles. No such argument follows. Instead, the remainder of 6.1 consists of an argument that assumes this thesis at the outset, and then goes on to try to show that motion, time, and magnitude cannot be composed of indivisibles. The promised argument does not appear until 6.2[2].

Physics 6 seems to be committed to conflicting positions on its central questions. Throughout Physics 6, Aristotle insists that every change takes time, and is infinitely divisible.[3] On Waterlow and Bostock's understanding, this entails that every change is from some *terminus a quo* to some *terminus ad quem*, and that these bound infinitely many intermediate stages, which they take to mean infinitely many *termini ad quos*.[4] Think, for example, of the points or positions between the two termini of a locomotive change. But at 6.4 234b10-20, Aristotle says that there is in general a "first" result of a change, and in 6.5 235b13-19 he argues as if changes between contradictory terms, between which an intermediate is impossible, can be taken as a sort of paradigm of change. Indeed, how are contradictory changes supposed to be continuous at all? What could a half-way point in a change from not-F to F be?

---

[1] See Hasper, Pieter Sjoerd. *The Metaphysics of Continuity: Zeno, Democritus and Aristotle*. PhD diss., University of Groningen, 2003: 110-115 for a detailed account of the redundancies in *Physics* 6. I do not endorse or discuss all of those he finds, because they are at a tangent to my purposes and (sometimes) because I think a better interpretation removes the appearance of redundancy.

[2] Cf. Hasper, *Continuity*, 103-105

[3] See *Physics* 6.3 and 6.6 237a17-b3

[4] See Bostock, David. *Space, time, matter, and form: Essays on Aristotle's Physics*. Oxford: Oxford University Press, 2006: 176, and Waterlow (Broadie), Sarah. *Nature, change, and agency in Aristotle's Physics: a philosophical study.* Oxford: Oxford University Press, 1988: 135-136, 145-146. I am not coining the plural of this phrase, which appears in R. P. Antonio's 1629 commentary on Aristotle's *Physics* 6. The plural of *terminus ad quem, termini ad*

Physics 6 seems to deviate from Aristotle's approach to its topical questions elsewhere. Nowhere in this book does Aristotle make use of any of is usual metaphysical apparatus: we find no talk of actuality or potentiality, matter or form, cause or principle, agent or patient. This is especially surprising when we consider that he uses these concepts, even develops them, in relation to some of the very same things discussed in *Physics* 6. For example *Physics* 6 is deeply concerned with the infinite, with questions of divisibility, and with the situation of the changing thing as it is changing. But here Aristotle does not try to give any analysis of infinity in terms of potential and actual, as we would expect if we had just read *Physics* 3, or 8.8, or *Metaphysics* Θ.6. He does not try to understand the changing thing as matter or substratum, as we would expect if we had just read *Physics* 1.7, nor does he analyze change in terms of potentiality and actuality or agent and patient as we would expect having read *Physics* 3.1-3[5].

We also find some outright conflicts between book 6 and other parts of the corpus. Aristotle says in *Physics* 1.3, 8.3, and in *De Sensu* 6 that some changes may happen instantaneously and in all parts of a thing at once. But his position in *Physics* 6.4 seems to be that every change takes some positive amount of time, and that the parts of a thing never all change at the same time.[6] In *Physics* 4.11, Aristotle says that time and motion are continuous and divisible because magnitude (meaning the spatial path of the motion) is continuous and divisible. While in 6.4, it is the body of the changing thing itself that explains the structure of time and change. There are also a number of well recorded conflicts between *Physics* 6, particularly 6.5, and Aristotle's long

---

quos, appears to have fallen out of use since its heyday in the 17th and 18th centuries, in which it was important to both commentaries on Aristotle's work and to maritime insurance law.

[5] See Waterlow, *Nature*, 132 who sees *Physics* 6 as an attempt, a failed attempt, to resolve difficulties with the account of change in *Physics* 3.1-3, one which he ultimately abandons by returning to the book 3 conception in book 8.

[6] Cf. Bostock, *Space*, 175, Waterlow, *Nature*, 154-155, who both take the *Physics* 8 view that some changes happen instantaneously to be Aristotle's considered opinion.

argument about the continuity of locomotion in *Physics* 8.8[7].

These difficulties led both Bostock and Waterlow to conclude that *Physics* 6 represents a relatively early and ultimately abandoned attempt to produce an analysis of change[8], particularly in relation to *Physics* 8. This appears to be supported by a reference at *Physics* 8.8 to the discussion of Zeno's paradoxes in 6.2, in which Aristotle talks about his own approach in 6.2 as incomplete precisely because it leaves out the distinction between actual and potential divisions in a continuum.[9] At the same time, the assumption that 8.8 antedates *Physics* 6 has caused no end of trouble, since *Physics* 8.8 is crude precisely where *Physics* 6 is sophisticated, and is silent precisely where *Physics* 6 takes up the demands of argument. For example, *Physics* 6.5 includes a detailed (if difficult) argument to the effect that there is no such thing as the beginning, in time, of a change. *Physics* 8.8 casually assumes, without any hint that this is a problematic thesis or one that requires any defense, that there is an instant at which something begins to change.[10]

Both Bostock and Waterlow adopt the assumption that the books of the *Physics* were written roughly in order, and conclude that *Physics* 6 represents a deviation or digression from the metaphysically richer strategy in *Physics* 3 and 8—books which by contrast cohere well together.[11] Though both also explicitly acknowledge that the order of authorship is unknown, and that the assumption that 6 was written between 3 and 8 is little more than a heuristic default. But we can at any rate say that Waterlow and Bostock see *Physics* 6 is a text apart, one which does

[7] See Bowin, "Unity,"Bowin, John. "Aristotle on the Unity of Change: Five Reductio Arguments in Physics viii 8." Ancient Philosophy 30, no. 2, 2010: 319-345 and Rosen, Jacob. "Physics V-VI versus VIII: Unity of Change and Disunity in the Physics" in *Aristotle's Physics: A Critical Guide* Ed. Mariska Leunissen. Cambridge: Cambridge University Press, 2015, whose articles are devoted entirely to bringing these texts into some communication with one another. See also Waterlow, *Nature*, 149-158, and White, Michael J. *The Continuous and the Discrete: Ancient physical theories from a contemporary perspective*. Oxford: Clarendon Press, 1992: 102-106, who first brought this conflict into focus.

[8] Waterlow, *Nature*, 132

[9] ibid. 155

[10] *Physics* 8.8 262a26-b8

not substantively share in the spirit of the *Physics* as a whole.

Here is my position. Many of the conflicts between *Physics* 6 and the rest of the *Physics* are real, and this is a consequence of the fact that Aristotle wrote a *part* of *Physics* 6, namely 6.4-6, in order to deliberately revise his views about natural continua. *Physics* 6 itself is not an entirely coherent text, but one edited together out of several smaller texts, which have related but distinct subject matter. This explains the redundancies in the text. However, the most serious conflicts that Bostock and Waterlow identify *within Physics* 6 are largely imagined, in particular the conflict between the continuity of change and the possibility of a "first thing" to which something changes, is imagined: a better interpretation of the relevant passages shows that these positions are (counter-intuitively) consistent.

The evidence for the revisionary aims of 6.4-6 and its lateness in relation to *Physics* 3-4 is substantive, and I discuss this in detail in my first chapter. I will make a further suggestion in my fifth chapter about the composition of *Physics* 6: 6.1-2 are probably "early" and part of the same philosophical stratum as *Physics* 3-4. This early text also shows some signs of development and editing: the discontinuity mentioned above in 6.1 is plausibly explained as the insertion of an argument into 6.1 (consisting of 231b21-232a22) designed to deal with a theory of indivisible magnitudes, like that discussed in the pseudo-Aristotelian text *On Indivisible Lines*. This division of *Physics* 6 into an early text, 6.1-2, and a late text, 6.4-6, is sufficient to explain most of the anomalies we find in the book.

I also discuss in my fifth chapter the back-reference to *Physics* 6.2 in 8.8. The relationship between *Physics* 6.4-6 and 8.8 is fraught. Aristotle says in 6.5 that there is no instant in which a change begins, yet in 8.8 he argues on the unremarked upon assumption that there is. This is

[11] Bostock, *Space*, 159; Waterlow *Nature*, 132

made all the more confusing by the assumption that book 6 is a continuous text: if Aristotle's reference to book 6 in 8.8 indicates that 8.8 was written later, why does Aristotle so completely ignore his own doctrine in 6.5 about the instant at the beginning of a change? On my picture, the difficulty does not arise: 8.8 refers back to an early part of book 6 (i.e 6.2), and in 8.8 Aristotle ignores his doctrine of 6.5 about the beginning of a change because 6.5 belongs to a later part, and hasn't been written yet.

I will summarize the contents of this dissertation:

Chapter 1: A Fault Line in Aristotle's Physics

I argue that there is a kind of fault line in the *Physics*, identifiable by two points of conflict, both of which implicate *Physics* 6.4. Both have been described above: 6.4 conflicts with other texts in the *Physics* on whether instantaneous, all-at-once changes are possible, and it conflicts with these on what explains the continuity and divisibility of change and time. I show that these conflicts are real, and that a passage in Generation and Corruption 2.10 suggests that 6.4 represents later view, one written with the aim of revising his position.

Chapter 2: The Partwise Arguiment

In my remaining chapters, I set out to explain the theory presented in 6.4-6. I begin in this chapter with what I call the "partwise" argument in *Physics* 6.4. The standout feature of this argument is the implication that every change happens "part-by-part," propagating through the body of a changing thing. An important premise in this argument is that there is always a first result in any change. Bostock takes this to be an unaccountable error on Aristotle's part, and a view in plain conflict with his commitment to the infinite divisibility of change in the surrounding texts.

I show that Bostock has misread Aristotle's argument, because he has attributed to Aristotle the assumption that any continuous change from some state A to another state B must involve infinitely many intermediate states (e.g. infinitely many intermediate positions or shades or temperatures). I show that this assumption is not Aristotelian, and that Aristotle has not made any mistake here. A proper understanding of this argument is vital to the interpretation of the rest of 6.4-6, and I believe these chapters have remained opaque precisely because the "partwise" argument has gone unappreciated. I also discuss the unity of part-by-part changes, and the possibility of infinitely divisible changes between contradictory states.

Chapter 3: Part-by-part Change

I explore the notion that every change happens part by part, with the aim of filling out an underlying kinematic theory. I aim to show how a kinematic theory can tolerate the requirements of part-by-part change as Aristotle understands it, in an effort to meet the skepticism to which Aristotle's theory is subject among contemporary scholars. These are:

-The states from and to which something changes constitute a finite series, and so there is always a "first" state to which something changes.

-The states from and to which something changes are restricted to: qualities, quantities, places, being, and non-being.

-Every changing thing is infinitely divisible into spatially differentiated parts.

-When something is changing, it is partly in its original state and partly in the first or next state.

Given Aristotle's own division of changes into five species—locomotion, alteration, growth/diminution, generation, and destruction—I approach each species individually, drawing

the following lessons. First, the parts implicated in something's changing are relative to that change. They are relative both to the species of change (such that a locomotion will involve different sorts of parts than a generation) and within these species (locomotions in different directions will implicate different parts). Second, when in the midst of a change to F, some part of a whole has become F, this may mean F *simpliciter*—as when a body of water becomes a body of air—or this may mean that a part of it becomes such as it will be when the whole is complete—as when a foundation stone is set into place, or a part of a painting is finished.

Chapter Four: What is a Primary Time?

Much of 6.5-6 is structured around arguments having to do with whether or not some event has a "primary time." These arguments have been subject to some recent scholarship in which a serious difficulty has emerged in interpreting the meaning of "primary" in this context. I criticize two of these recent scholarly works—Benjamin Morison's 2013 paper "Primary Time in Aristotle's *Physics* 6" who takes a "primary time" to be a most precise time, and Nico Strobach's 1991 book The Moment of Change who takes a "primary time" to be an indivisible time. I offer an alternative approach, on which a something has a "primary time" when it can be used as a unit of temporal measurement. I also show that on my reading the primary time arguments can be better integrated into their argumentative context, as they can be read as an extension of Aristotle's discussion about the co-divisibility of time, change, the changing thing, etc. in *Physics* 6.4.

Chapter Five: Divisibility and Infinity

The main obstruction to the understanding of *Physics* 6 is a lack of clarity about Aristotle's

goals therein. In this chapter, I undertake to explain the overarching argument of 6.4-6, under guidance from the signposting passage at 6.4 235a35-b5. I divide Aristotle's argument into two parts, one having to do with divisibility in 6.4, and the other having to do with "infinity"—meaning something like infinite divisibility—in 6.5-6. I situate 6.4-6 in relation to 6.1-2, which represents an earlier approach to these problems. I take Aristotle's argument to be as follows. Every aspect of change (time, change, the changing thing, the distance traveled in the case of a locomotion, and so on) are subject to the same divisions, so that if one is divisible, all the others will be as well.

But the changing thing is special: it can be shown (via the "partwise" argument in 234b10-20) to be divisible categorically, without referring to the divisibility of anything else. Hence all the aspects of change are mutually divisible, but the changing thing is divisible in a direct or immediate way, and the divisibility of the other aspects of change follows from the divisibility of this. In 6.5-6, Aristotle aims to make an analogous point in terms of infinity, but his approach is very different. Aristotle attempts to show that one of the co-divisible aspects of change, the "changing" of the changing thing, is an homogenous event, such that if it is divisible anywhere, it is divisible everywhere. He then infers that since it is co-divisible with the time, the change, the changing thing, and so on, all must be divisible everywhere.

Chapter 1: A Fault Line in Aristotle's *Physics*

One of the most persistent interpretive puzzles in Aristotle's *Physics* concerns an apparent conflict in his theory of change. In the first two arguments of *Physics* 6.4, Aristotle commits himself to the view that all changes—locomotion, alteration, growth/diminution, generation and destruction—take place part-by-part. Imagine, for example, a length of wood becoming blue part-by-part as it is lowered into a bucket of paint. We could divide the change into stages according to how much of the piece of wood has become blue at any given time. This view of change apparently conflicts with several passages, in *Physics* 1.3, 8.3, and *De Sensu* 6, where Aristotle describes some changes as happening "all-at-once" (ἀθρόος), meaning that they happen instantaneously, or in all the parts of a thing simultaneously, or both.[1] Freezing is his preferred example of this kind of change.

In his 4th century C.E. commentary on Aristotle's *Physics*, Themistius reports that concerns about this conflict go back to Aristotle's own contemporary, Theophrastus:

> But in cases in which it sometimes turns out that transformation is , in what way is it necessary that, [for example], one [part] be in white, the other in black? Theophrastus explicitly raises this problem in his *On Motion*, Book 1 and has provided confusion for the commentators (Themistius 191.30-192.2).[2]

In nearly every commentary on *Physics* 6 up to and including that of Thomas Aquinas in the 13th

[1] As I will explain, the meaning of the Greek adverb "ἀθρόος" is itself a matter of some contention (cf. Gregory, Andrew. "Aristotle, dynamics and proportionality." Early Science and Medicine 6, no. 1, 2001: 12-13). I think that it is misleading (and in some cases, nonsensical) to translate the term "instantaneously." I opt instead for the weaker "all-at-once" with the understanding that if something changes instantaneously, then necessarily it changes in all its parts simultaneously, and so "." It is worth noting at the outset that ἀθρόος is used by Aristotle to mean "all-at-once" in cases where it is unambiguous that the motion is not instantaneous. E.g. *Progression of Animals* 705a4, 708a28, where Aristotle uses the word to describe leaping with one's whole body, as opposed to stepping, with one foot first.

[2] ἐφ' ὧν δὲ συμ βαίνει ποτὲ ἀθρόαν εἶναι τὴν μεταβολήν, πῶς ἀναγκαῖον τὸ μὲν ἐν τῷ λευκῷ εἶναι, τὸ δὲ ἐν τῷ μέλανι; τοῦτο δὲ ὁ Θεόφραστος ἀπορεῖ διαρρήδην ἐν τῷ Περὶ κινήσεως πρώτῳ καὶ τοῖς ἐξηγηταῖς ὄχλον παρέσχεν.

century, this puzzle was a central subject of discussion. Yet no consensus emerged as to its solution. Nor even was there a consistent understanding of the problem. This much was agreed upon: Aristotle implies (but does not say outright) in *Physics* 6 that all changes must happen part-by-part, yet elsewhere he seems to accept that some changes do not happen part-by-part—rather, they happen all-at-once. Later commentators, apparently starting with the Arabic reception of the *Physics*, took "all-at-once" to mean not only that all the spatial parts of a thing change simultaneously, but that the change happens instantaneously.[3] This produces another point of conflict, for Aristotle maintains throughout *Physics* 6 that all changes take a positive amount of time. This puzzle exercised ancient commentators both because it has significant consequences for understanding Aristotle's theory of the structure of change, and because it raises questions about the coherence of that theory in his work. Modern commentators on the *Physics* have sometimes taken this conflict as evidence that the relevant claims in *Physics* 6 (that changes must happen part-by-part, that changes must be continuous) constitute an early, obsolete theory, or a mistake.[4]

In section one, I discuss the context of the passages implicated in the conflict over instantaneous changes. I give a brief overview of the ancient and modern history of attempts to find a solution, and I evaluate these attempts. I will suggest that the most plausible reading of the "all-at-once" passages (*Physics* 1.3 186a15–16, 8.3 253b19-26, *De Sensu* 6 446b28-447a3) is one

---

Translation is from Themistius. *On Physics 5-8*, Tr. Robert Todd. London: Bloomsbury, 2014.

[3] Here and throughout this chapter, something happens "instantaneously," when it takes no positive amount of time. For example, if we mark a horse-sized place along a horse track, a horse running continuously around the track will line up with the horse-sized place only instantaneously: the horse will spend no positive amount of time in the place unless it comes to a rest there. See *Physics* 6.8 239a23-b4.

[4] Bostock, *Space*, 175: "As a matter of fact this claim seems to be abandoned later in the *Physics*, in chapter 3 of book VIII. For it is there claimed that a thing may change size by losing a whole particle of matter all at once—and though the particle is divisible it does not follow that it was detached bit by bit—and similarly any change of quality (such as freezing) may happen all at once (253b14–26; cf. also 186a15–16)." Cf. also Waterlow, *Nature*, 139-144, especially 139n34.

on which Aristotle thinks that all-at-once changes are *also* (perhaps necessarily) instantaneous. I therefore suggest that the most plausible reading of these passages is one on which there is the deepest conflict between them. I may seem to be prescribing a drug harsher than the disease. But so long as the solution the ancient commentators aimed at is not forthcoming, I think we have good reasons to prefer a reading that treats *Physics* 1.3, 8.3 and *De Sensu* 6 charitably, but on which *Physics* 6 is inconsistent with them. Such a reading sheds significant light on Aristotle's intentions in *Physics* 6.

In section two, I turn to the second conflict, which has to do with what explains the continuity (in the sense opposed to "discreteness") of change. Aristotle believes that changes are not fundamental elements of nature. Changes are dependent for their existence and character on the things (substances or parts of substances) that undergo changes, as well as the situations (places, qualities, sizes) from and to which these things change. Thus, the properties of changes, such as their continuity, call out for explanation in terms of something more fundamental. At the end of *Physics* 6.4, Aristotle says that the infinite divisibility of change is explained by the infinite divisibility of the changing thing. This apparently conflicts with his explanation of the infinite divisibility of change in *Physics* 3.7 207b21-4 and of the continuity of change in *Physics* 4.11 219a10-21, 4.12 220b24-32. In all three of these passages, Aristotle says that the infinite divisibility or continuity[5] of the magnitude[6] (μέγεθος) of a change explains why change and time are infinitely divisible or continuous. By "magnitude" Aristotle means the spatial path of moving

[5] For Aristotle, infinite divisibility is a necessary but not a sufficient condition on continuity. For a detailed discussion of Aristotle's understanding of infinity, continuity, and their relationship, see Bostock *Space* and White *Continuous*.

[6] By "magnitude" Aristotle almost always means a size or distance in the literal, spatial sense. For example, he sometimes uses "magnitude" to refer to a body having volume, sometimes to a geometrical object in the abstract ("magnitudes are always divisible into magnitudes"), and sometimes to the (spatial) path over which something moves. Possible exceptions to this rule are Physics 3.7 207b21-4, 5.2 232a23-24, and 6.9 239b9. For a discussion of the idea of a "path" of motion see Coope, Ursula. *Time for Aristotle: Physics IV. 10-14*. Oxford: Oxford University

body. As we will see, Aristotle understands these to be not merely different, but conflicting ways of understanding the structure of time and change.

In both these cases, there is much work to be done just to show that the conflicts I've described are really there. The longstanding practice of scholars is to avoid attributing conflicting views to Aristotle, for good reason: all veneration of the Philosopher aside, checking for consistency is a vital tool in narrowing the number of possible interpretations. But, of course, it is possible that a given conflict is real, and in these cases the assumption of consistency becomes a danger, asking us to mutate Aristotle's views in order to find obscure means of reconciliation. In this case, I can do nothing to decisively rule out readings on which the relevant passages are consistent. But I can argue that the appearance of a conflict in these passages is best explained—and the relevant passages are most charitably read—on the hypothesis that Aristotle revised his views. The basis for this hypothesis is a passage that comes to us at the end of *Generation and Corruption* 2.10:

> Is motion continuous[7] because the changing thing is continuous or because that in which it moves (I mean, for example, place or quality) is continuous? Clearly it is because of the moving thing. For how could a quality be continuous except because the thing of which it is an accident is continuous? But also, if motion is continuous because of that in which something moves, then this [i.e. being what explains the continuity of motion][8] belongs

---

Press, 2005: 49-50.

[7] "Continuous" (συνεχὲς) here means roughly "infinitely divisible into divisibles and without gaps." That is, it describes a topological feature of something. But the term is also used, by Aristotle and in Greek generally, to mean "eternal." It is important in discussions like—where astronomy and the eternality of motion are at issue—to be careful about which sense is meant. I explain my decision to read "continuity" in the topological sense in section three.

[8] Cf. Joachim's translation in Barnes, Jonathan (ed.) The Complete Works of Aristotle. Princeton: Princeton University Press, 1984: 552: "But if the continuity of 'that in which' makes the movement continuous, this is true only of the place in which; for that has magnitude," This compressed sentence ("But also…only to place") presents some interpretive difficulties. "Continuity" (συνεχὲς, 337a29) is the most natural antecedent of "this" (τοῦτο

only to place. For it has some magnitude.[9] (*GC* 2.10 337a25-30)

Aristotle is here deciding between two different explanations for the continuity of motion. On the one hand, there is the continuity of "that in which something changes" (τὸ ἐν ᾧ κινεῖται), examples of which are place and quality. On this theory, a walk is continuous because the *spatial path* over which one walks is continuous. On the other hand, one could say that the continuity of the *changing thing* (τὸ κινούμενον) explains the continuity of change. Think again of the piece of wood dipped into paint: its change of color is continuous because the piece of wood itself is a continuous body. Aristotle opts for the changing body, as an explanation for the continuity of change. He appears to prefer this explanation on the grounds that it allows him to bring alterations, and not only locomotion, under his theory.

Aristotle is explaining, I will suggest, the rejection of his own theory in *Physics* 4.11 in favor of the theory found in 6.4. *Physics* 6.4 can thus be read as or as part of a revision in Aristotle's views. Rather than explaining the continuity of change by appeal to spatial magnitude (which leaves open the possibility of discontinuous alterations), Aristotle instead explains the continuity of change in terms of the continuity of the changing *thing.*

337a30). But the resulting sentence makes no argumentative sense. The sentence begins with "also," and so we should expect it to support the thesis that "it will be the moving thing" that explains the continuity of motion. The sentence consists of a conditional that has as its antecedent a proposition Aristotle is arguing against. So the consequent of the conditional must therefore be something Aristotle takes to be false. However, "continuity belongs only to place" is not false, by Aristotle's lights, since of the examples of things in which something might change (place and quality), continuity does indeed belong only to place. So whatever it is that belongs "only to place," it cannot be "continuity", and we should look for an alternative. The sense of the sentence must be something such as this: "if we try to explain the continuity of motion by reference to that in which something moves, then this will work only for place because only places are continuous." This would support a thesis that the changing thing must instead explain the continuity of motion, by way of a disjunctive syllogism. Hence 'what belongs only to place' (on the condition of the antecedent) must be the power to explain the continuity of a motion.

[9] Συνεχὴς δ' ἡ κίνησις πότερον τῷ τὸ κινούμενον συνεχὲς εἶναι ἢ τῷ τὸ ἐν ᾧ κινεῖται, οἷον τὸν τόπον λέγω ἢ τὸ πάθος; δῆλον δὴ ὅτι τῷ τὸ κινούμενον· πῶς γὰρ τὸ πάθος συνεχὲς ἀλλ' ἢ τῷ τὸ πρᾶγμα ᾧ συμβέβηκε συνεχὲς εἶναι; εἰ δὲ καὶ τῷ ἐν ᾧ, μόνῳ τοῦτο τῷ τόπῳ ὑπάρχει· μέγεθος γάρ τι ἔχει… For the Greek text of the *Physics*, I use Ross, William D. *Aristotelis Physica.* Oxford: Clarendon Press, 1967, with modifications where noted. Translations of Aristotle are mine unless otherwise noted. In my translations of passages from the *Physics*, I am indebted to R.P. Hardie and R.K. Gaye in Barnes, *Complete*, 315-446.

All-at-once or Part-by-part

Physics 6, *All Changes Happen Part-by-Part and All Changes Take Time*

In *Physics* 6.4 234b10-20, Aristotle argues that every changing thing is divisible, by appealing to the assumption that all changes happen part-by-part. Aristotle begins by saying that when a changing thing is changing, it cannot be (entirely) in "that from which" (ἐξ οὗ μετέβαλλεν) nor "that to which" (εἰς ὃ μετέβαλλεν) it is changing. He then infers that the changing thing must be *partly* in that from which, and *partly* in that to which it is changing. The conclusion of this argument is that the changing thing, *a fortiori*, must have parts. Because the idea that changes all happen part-by-part is implicit in the first argument of 6.4, it is sometimes assumed that Aristotle hadn't given much consideration to the idea that *all* changes happen this way.[10] First because this just seems empirically implausible (what about a rug bleaching in the sun?), and second because Aristotle seems to admit of changes that happen all-at-once later in the *Physics.*

But the next set of arguments, in 6.4 234b21-235a10, makes it clear that Aristotle is aware of the significance of saying that all changes happen part-by-part. There, he argues that a change can be divided according to the changes of the parts of the changing thing. Imagine that I dip a stick of wood into a bucket of blue paint, until it is entirely blue. One way to distinguish the first from the second half of the change would be to imagine a mark half way along the length of the stick. The first half of the whole change is the change by which the bottom half of the stick becomes blue.[11] The second half of the whole change is the subsequent change by which the top

[10] Coope, *Time*, 53; Murphy, Damian. "Alteration and Aristotle's Theory of Change in *Physics* 6." *Oxford Studies in Ancient Philosophy* 34, 2008: 185-218, 192, 209-12; Waterlow, *Nature*, 139n35; Bostock, *Space*, 175-6.
[11] Ross, *Physica*, 646-7 reads this passage quite differently. He says that, for example, the motion of a car can be

half becomes blue. Hence we have divided the change by which the whole stick becomes blue according to the successive changes of its parts. One may wonder about a case where someone walks a mile: surely Aristotle does not mean that they can be divided into quarters, each of which moved a quarter mile? The answer is that this argument must be understood under the qualification introduced at 6.4 234b17-18: "that to which" something changes must be thought of as the first thing to which it changes. In the case of a person walking a mile, the first thing is the person-sized place into which the person walks first. And indeed, in this case, the motion into that place will be half-way over when half the person is inside that place.

Any change to which this method of division applies must occur part-by-part, and Aristotle is explicit at the end of the passage that this form of division applies everywhere. He says: "This, then, is the mode of division according to the changes of the parts, and it [i.e. this mode of division] must apply for everything having parts"[12] (*Physics* 6.4 235a9-10). We only have to recall the conclusion of the first argument in *Physics* 6.4—that every changing thing has parts—to see that Aristotle means for this kind of division to apply to every change.

Finally, I will take this opportunity to mention Aristotle's claim, maintained throughout *Physics* 6, that all changes are continuous. This entails that all changes take a positive amount of time and that they are infinitely divisible into stages. It is easy to find this claim mentioned both as the result of an argument (6.3 234a24-5, 6.4 235a10-12, 6.6 236b19) or as the basis for one (Physics 6.2 232b20-1, 6.7 237b23-4, 6.8 239a23-4, 6.10 241a15-19). It will be useful to note Aristotle's argument in 6.6:

---

divided into the motion of the seats, the frame, the lights, etc.. He comes to this conclusion after deciding that the mode of division I've suggested is incoherent, though he grants that his alternative is quite awkward. I think Ross is too quick to give up on the natural reading of this passage, because he tests this reading on a case of where something does not move in place as a whole. I take Aristotle to be explaining something to which he's already committed himself (somewhat inexplicitly) in 6.4 234b10-20. I discuss this passage, and Ross' interpretation in chapter 3.

> For everything that has changed from something and to something has changed in a period of time. For suppose that something has changed from A to B in a now. It cannot have changed in the same now as the now in which it is in A (for in that case it would be in both A and B at the same time). For it has been demonstrated previously [6.5 235b6-32] that what has changed, when it has changed, is not in that from which it has changed. If, on the other hand, it [i.e. having changed] is a different now [than the now in which it was in A], then there will be a period of time between the two [nows]. For the nows were not consecutive. Since, then, it has changed in a period of time, and every time is divisible, in half the time it will have completed another change, and again in half of this, another, and so on always.[13]

Aristotle's thought is that since A and B are the termini of a single change, they must be mutually exclusive (being either contraries or contradictories). And so given that the changing thing cannot be in both A and B at the same time, it must be in A and in B at different times. Aristotle assumes that there is a last moment at which the thing is in A and a first moment at which it is in B.[14] Moments are indivisible (cf. 6.3 233b33-234a24), and indivisibles on a continuum cannot be contiguous (cf. 6.1231a21-b18). There must, therefore, be a period of time between the last moment when something is in A and the first moment in which it is in B. Therefore, the change from A to B must take a positive amount of time, and must be (infinitely) divisible into stages.

---

[12] αὕτη μὲν οὖν ἡ διαίρεσις κατὰ τὰς τῶν μερῶν κινήσεις ἐστίν, καὶ ἀνάγκη παντὸς εἶναι τοῦ μεριστοῦ αὐτήν·
[13] ἅπαν γὰρ τὸ ἔκ τινος εἴς τι μεταβεβληκὸς ἐν χρόνῳ μεταβέβληκεν. ἔστω γὰρ ἐν τῷ νῦν ἐκ τοῦ A εἰς τὸ B μεταβεβληκός. οὐκοῦν ἐν μὲν τῷ αὐτῷ νῦν ἐν ᾧ ἐστιν ἐν τῷ A, οὐ μεταβέβληκεν (ἅμα γὰρ ἂν εἴη ἐν τῷ A καὶ ἐν τῷ B)· τὸ γὰρ μεταβεβληκός, ὅτε μεταβέβληκεν, ὅτι οὐκ ἔστιν ἐν τούτῳ, δέδεικται πρότερον· εἰ δ' ἐν ἄλλῳ, μεταξὺ ἔσται χρόνος· οὐ γὰρ ἦν ἐχόμενα τὰ νῦν. ἐπεὶ οὖν ἐν χρόνῳ μεταβέβληκεν, χρόνος δ' ἅπας διαιρετός, ἐν τῷ ἡμίσει ἄλλο ἔσται μεταβεβληκός, καὶ πάλιν ἐν τῷ ἐκείνου ἡμίσει ἄλλο, καὶ αἰεὶ οὕτως·

Physics *8.3, Some Changes Happen All-at-once and Instantaneously*

In *Physics* 1.3, 8.3, and in *De Sensu* 6, Aristotle says that alterations can (and often do) occur "all-at-once" (ἀθρόος), and in the latter two passages he gives freezing as an example of an all-at-once alteration. I begin with *Physics* 8.3 253b19-26, which is adequate to frame the interpretive puzzle at hand. I will turn to *De Sensu* 6 at the end of part one, since my interest in it is partly to connect the issue of all-at-once changes with what I've called the "second" conflict, concerning the explanation of the continuity of change.[15]

Physics 8.3 253b19-26 comes to us in the midst of an argument against the Heraclitian claim that everything is always changing[16], even if the change sometimes escapes our notice. Aristotle compares the Heraclitian's view to one he names only by an example: drops of water wearing away a pit in a stone over a long time. This is, I think, a modern intuition as well: is not everything always eroding a little bit? does not that entail that everything is always changing a little bit? The theory goes as follows: if over the course of a given period of time some amount of the stone has broken away, then in half the time, half the stone will have broken away. Since the stone removed is infinitely divisible, this division in the change can go on indefinitely. So even over the course of a few minutes some very tiny amount will have broken away. Suppose for example, ten cubic centimeters of stone has been removed over the course of ten years. From this it follows that 1/525600th of a cubic centimeter was removed over the course of one minute. This would surely escape our notice, and the stone would appear (though merely appear) to be unchanging. Hence, it is possible that everything, even apparently unchanging things, are always

[14] This is a substantive assumption, but it is beyond the scope of this chapter to examine it.
[15] I will not discuss *Physics* 1.3 186a13-16 in detail, since the interpretive difficulties surrounding this passage, in reference to the details of Melissus' theory, are significant, and since it adds nothing, for my purposes, to what we find in *Physics* 8.3 and *De Sensu* 6.
[16] I call this the "Heraclitian" view, but it seem likely that Aristotle is actually arguing against an Academic tendency to treat the natural world in a Heraclitian way, cf. *Phaedo* 78d-e. Whether this is a fair characterization of

undergoing some very gradual change.

Aristotle denies the central inference of the theory just mentioned: it is not the case that if so much stuff has been removed in a period of time, then half has been removed in half the time. He compares this to the hauled ship. A ship is hauled onto a beach, and it begins to rain. As water fills the ship, the weight of the ship overcomes the static friction between the ship and the beach, and the ship slides back into the water. But though a million drops may set the ship sliding ten meters into the water, it does not follow from this that one drop sets the ship sliding 1/100000th of a meter. Nor does it follow from the fact that three hours of rain sets the ship sliding ten meters that one minute of rain sets the ship sliding 1/18th of a meter. He then applies this reasoning directly to the case of erosion cited by the Heraclitian:

> What is broken off is divisible into many parts, but none of these was moved separately; rather, they were moved at the same time. It is evident then that it is not necessary that something is always breaking away, just because destruction is infinitely divisible. Rather, a whole breaks away at some particular time. And similarly also for any sort of alteration. For it is not the case that, just because the altering thing is divisible into infinitely many parts, the alteration is so as well. Rather, it often happens all-at-once (ἀθρόα), just as in the case of freezing[17] (Physics 8.3 253b19-26).

We are to imagine, I think, a cliff face collapsing and crashing into the sea. The erosion of many years of rain is the cause, but the breaking away of the stone happens suddenly, and all-at-once. Thus, the erosion is a divisible change, but it does not follow from this that all the parts of the

---

Plato's or any academic's views, it is nevertheless Aristotle's impression of them in *Metaphysics* A 6 197a29-b1.

[17] διαιρεῖται μὲν οὖν τὸ ἀφαιρεθὲν εἰς πλείω, ἀλλ' οὐδὲν αὐτῶν ἐκινήθη χωρίς, ἀλλ' ἅμα. φανερὸν οὖν ὡς οὐκ ἀναγκαῖον ἀεί τι ἀπιέναι, ὅτι διαιρεῖται ἡ φθίσις εἰς ἄπειρα, ἀλλ' ὅλον ποτὲ ἀπιέναι. ὁμοίως δὲ καὶ ἐπ' ἀλλοιώσεως ὁποιασοῦν· οὐ γὰρ εἰ μεριστὸν εἰς ἄπειρα τὸ ἀλλοιούμενον, διὰ τοῦτο καὶ ἡ ἀλλοίωσις, ἀλλ' ἀθρόα γίγνεται πολλάκις, ὥσπερ ἡ πῆξις.

cliff face are changing in every stage of the change. Some may be eroding away, but others are changeless.

Then follows the crucial dialectical step, for our purposes. Aristotle identifies a general principle on the part of his opponent:

-If something is infinitely divisible, then its changes are infinitely divisible.

Aristotle is diagnosing his opponent's error: if someone accepts the above principle, they will conclude that if one ton of rock breaks away, then the change by which it broke away is divisible into stages in which, say, a half ton of rock broke away and then another half ton. But, Aristotle thinks, this principle is false: it is possible for infinitely divisible bodies to undergo non-infinitely divisible changes. All he needs in order to refute this principle is a counter-example.

change, and freezing[18] in particular, is supposed to be this counterexample: a case where a body that is infinitely divisible into parts undergoes a change that is not infinitely divisible into stages. Hence, the dialectical context of the mention of all-at-once changes seems to demand that the all-at-once changes Aristotle has in mind here, such as freezing, are instantaneous changes or are composed of instantaneous changes. For it is on this condition that they could fail to be infinitely divisible.[19]

There appear, therefore, to be two points on which Aristotle's argument here conflicts with his own theory of change in *Physics* vi. First, Aristotle here seems to say that some changes do

[18] The word I've translated as "freezing", the Greek πῆξις, might also mean "curdling" or more generally "solidification" (but not "cooling"; the word is used also to talk about solidification due to heating, see *Meterologica* iv 6 382b31). I take "freezing" to be the intention here because the very similar passage from *De Sensu* 6, discussed below, is explicit that the subject of solidification is water.

[19] I will flag an alternative reading here that avoids attributing to Aristotle an acceptance of instantaneous changes. Perhaps Aristotle only means that the fact that an altering body is infinitely divisible does not entail that the alteration is infinitely divisible *just in the sense that the alteration is divisible according to the parts of the changing thing.* The alteration may still be infinitely divisible in time. I think that this reading is not supported by the text, and I also stress that it does not eliminate the appearance of a conflict, since in any case the change concerned does not happen part-by-part.

not happen part-by-part, that is, that some changes are not divisible into stages corresponding to changes of the parts. Second, he seems to say that some changes are not divisible into stages, that is, that they happen instantaneously.

I caution that I do not mean to suggest that "ἀθρόα" in the above passage should be translated by "instantaneously," nor do I infer that Aristotle is accepting the possibility of instantaneous changes on the basis of the semantics of this word. I also do not intend to suggest that freezing is always instantaneous, on Aristotle's view; he certainly thinks that a process of freezing can take some positive amount of time.[20] But Aristotle does say that water alone does not thicken as it solidifies[21], so there is no intermediate condition between liquid and solid in the case of water. This may be the reason why Aristotle chose freezing water as his example here and in *De Sensu* 6: if there is no qualitative intermediate between liquid and solid in the case of water, then a divisible process of freezing would have to be divisible in virtue of happening part-by-part. If so, then whenever something freezes , it freezes instantaneously.

The Ancient Commentators

Themistius reports that Theophrastus was the first to raise questions about the possibility of all-at-once changes, though it is not clear from his and Simplicius' indirect reports whether Theophrastus was raising a problem of interpretation, or a doubt about Aristotle's claims. In his discussion of *Physics* 1.3, Simplicius (107.12-16) quotes Theophrastus as maintaining that some changes happen , but he does not make clear what Theophrastus therefore intends to say about *Physics* 6.4. Whatever happened, he sparked a quiet, but millennia long debate over whether

[20] See *Meterology* i 12 348b20-3, though this may simply be because freezing sometimes happens part-by-part.
[21] See *Meterology* iv 3 380a34. *Pace* Murphy, "Alteration," 214, who suggests that freezing might be a divisible change because water gets thicker before it becomes solid.

Aristotle should or did require that all changes happen part-by-part, and whether Aristotle should or did permit some instantaneous changes. I briefly discuss the various solutions put forward by the ancient commentators up through Thomas Aquinas in the 14th century.

A note before we proceed. There is a long-standing modern habit of translating "ἀθρόος" as "instantaneous". This obscures the fact that Aristotle's early commentators (Alexander, Themistius, Simplicius) explicitly discuss the meaning of "ἀθρόος" and deny that it necessarily suggests instantaneousness.[22] This suggests both that they were alive to the distinction in meanings, and aware that "ἀθρόος" is sometimes taken to mean "instantaneous." By contrast, later commentators (Ibn Bâjja, Ibn Rushd, and Aquinas) seem to take it for granted that when Aristotle describes a change as happening "ἀθρόος," he means that it happens instantaneously. Aquinas goes so far as to say that the Aristotelian school is famous for its belief in the possibility of "non-temporal" (that is, instantaneous) changes (Aquinas 798).

"Some People"

Themistius (192.10-12) and Simplicius (967.4-8) both report that a common approach to this puzzle is to say that Aristotle's argument that all changes happen part-by-part in *Physics* 6.4 pertains only to locomotion, while all-at-once changes are limited to alterations. As I will discuss in connection with *De Sensu* 6, this is a well founded suggestion: Aristotle does indeed limit all-at-once change to alterations. These anonymous commentators may also be moved by the argument found in *Physics* 6.10 240b20-241a6, which follows the argument from 6.4 closely, and is framed in terms of a locomotive change. However, Themistius (192.10-12) and Simplicius (967.8-31) both also note that this is not a plausible reading of Aristotle's text at 6.4 234b10-20:

[22] For Alexander, see Simplicius *Simplicius: On On Aristotle Physics 6* Ed. Richard Sorabji. Tr. David Konstan

Aristotle not only puts the argument in very general terms, without making any special reference to locomotion, but he uses an example of a change of color as an illustration.

Alexander of Aphrodsias, 3rd century C.E.

Alexander's commentary on *Physics* 6 is lost, so his solution only comes to us through the reports of Simplicius (968.15-30, 979.1-9). Alexander reportedly thought that all changes must take a positive amount of time, and that all changes must happen part-by-part. What then, does he make of the "all-at-once" passages? Alexander suggests that while all changes happen part-by-part, the *beginning* of a change happens to some part of the changing thing all-at-once. Note that he does not mean to say that the initiation of a change is instantaneous, just that it does not happen part-by-part. Alexander is presumably observing the way Aristotle puts the claim that a change might happen : "rather, [the alteration] often happens " (ἀλλ' ἀθρόα γίγνεται πολλάκις). One may instead read "happens" (γίγνεται) as "comes to be" or "begins," such that Aristotle is only claiming that some changes *begin* all-at-once and proceed part-by-part after that (Simplicius 1199.16-20). Specifically, he thinks that the part of the changing thing that is in contact with the agent of change changes all-at-once (Simplicius 968.24-30). Suppose you place an ice-cube on a warm frying pan. The whole ice-cube will melt part-by-part, but perhaps the part of the cube that makes direct contact with the metal will melt all-at-once.

Simplicius argues (969.5-13) that this solution does not preserve Aristotle's argument in *Physics* 6.4: the change of a part is itself a the change of a divisible subject, and if it happens , then not all changes happen part-by-part.

(London: Bloomsbury 2014: 1199.16-20. Themistius, *Physics* 197.2-4 and Simplicius, *Physics 1.3-4,* 106.33-107.1

Themistius, 4th century C.E

Themistius stands opposite Alexander: Themistius says that some (complete) changes may happen , and that this is obvious from sense perception. Concerning Aristotle's reasoning in 6.4, Themistius suggests that Aristotle's reasoning only applies to things that do change part-by-part. *Physics* 6.4 234b10-20 aims to demonstrate that any changing thing has parts. So Aristotle does not need an argument for cases of all-at-once change, since if something changes in all its parts at once, it must in any case have parts (Themistius 191.30-192.22).

Themistius may be read as thinking that Aristotle admits of instantaneous changes. Robert Todd, who first translated Themistius' commentary into English, translates ἀθρόος as "instantaneous". He is also clear that he attributes to Themistius the view that Aristotle endorsed the possibility of instantaneous changes. But[23] it appears to me that Themistius distinguished between a change happening "all-at-once" (ἀθρόος) in the sense of happening simultaneously in all of something's parts, and a change happening in no positive amount of time. He does so explicitly in his discussion of *Physics* 6.6:

> I am using 'instantaneously' here not in the sense of just the parts in their entirety but in the sense of [a transformation coming about] not in a time period (οὐκ ἐν χρόνῳ) over which [the process of] being transformed is earlier than [the state of] having been transformed (Themistius 197.2-4).

Note that when Themistius is explaining his solution to the problem of 6.4 234b10-20, he says:

> For if we say that those things, all the parts of which are also either altered or increased with respect to one time period (καθ' ἕνα χρόνον), are transformed , clearly such transformation applies to things that possess some parts.

[23] See. Todd's introduction at *Themistius* 2.

The Greek word translated as “time period” (χρόνος) denotes a period as opposed to an instant (νῦν). It seems likely to me, therefore, that Themistius was aware that "all-at-once" need not mean “instantaneously”. When he said that some changes happen all-at-once in his discussion of *Physics* 6.4 234b10-20, he may have meant only that all the parts of something change simultaneously, not that the change happens in an instant. If that is so, then Themistius’ view is not that some changes happen instantaneously, but rather just that some changes happen , though they take time. He thinks that Aristotle ignores these changes in 6.4 because it is obvious that anything that changes all-at-once has parts.

Themistius does not seem confident about this reading: “Now the following struck us as helping the argument…”, and it is easy to see why. First, Aristotle gives us no grounds to think that he is limiting his argument in 6.4 to what changes part-by-part, or that there is any alternative to this. Second, what could possibly motivate Aristotle to argue that the subset of things that change part-by-part have parts, while letting it go without saying that things that do not change part-by-part have parts?

Simplicius, 6th century C.E.

Simplicius is our source for Alexander’s solution, and he also quotes and discusses Themistius on the matter. Simplicius’ discussion of the problem is extensive, but he appears to have given no solution of his own, nor does he explicitly endorse any of those he discusses. As I mention above, he criticizes Alexander, and he ends his discussion of 6.4 234b10-20 with Themistius’ solution. I conjecture, therefore, that Simplicius intended to (perhaps tentatively) endorse the solution of Themistius.

Philoponus, 6th century C.E.

Philoponus only deals with the issue briefly, citing the puzzle and saying that Alexander had solved it. But the solution he endorses actually belongs to Themistius (Philoponus 649.24-650.8).

Ibn Bâjja (Avempace) 12th century C.E.

Ibn Bâjja assumes that in the "all-at-once" passages, Aristotle is talking about *instantaneous* changes. He distinguishes between strict changes (locomotions, alterations, growth, generation, and destruction), which must take time and happen part-by-part, and changes in some broader sense, which might be instantaneous and all-at-once. He then suggests that the termination of a change is itself a change in this broader sense, and therefore can happen instantaneously. And so when Aristotle says that some alterations happen , he is referring to the terminations of strict changes.[24]

Ibn Rushd (Averroes), 12th century C.E.

He adopts Ibn Bâjja's view exactly, though he attributes another view to Ibn Bâjja, and so takes himself to be the originator. Ibn Rushd regards all generation and destruction as terminations, rather than divisible changes in their own right, and so he takes these to happen instantaneously. Ibn Rushd is apparently motivated by the metaphysical problem suggested by the claim that all changes are continuous: a change is continuous only if there is some intermediate between the initial and final conditions of the change. But contradictories have no intermediates, and so changes between contradictories could not be continuous in their own

[24] Lettinck, Paul. Aristotle's Physics and its Reception in the Arabic World. New York: Brill, 1994: 486-88. Ibn Bâjja does not consider the possibility that the *initiation* of a change could also be an instantaneous change (in the broad sense). This is because Aristotle argues specifically that there is no such instantaneous initiation of a change at

right.[25]

Aquinas, 13th century C.E.

Like the Arabic commentators, Aquinas unambiguously takes Aristotle to endorse the possibility of instantaneous (*momentanea*) changes. He follows Ibn Rushd in thinking that these are characteristically generations, or "the induction of form in matter" (Aquinas 34).

Aquinas criticizes Ibn Rushd's solution, however. He says that Aristotle's argument in 6.4 does not take the divisibility of change as a premise. Rather, Aristotle intends to prove that changes are divisible by reference to the divisibility of the changing thing. Therefore, we cannot accept a reading of 6.4 234b10-20 on which some discrimination between divisible and indivisible changes is presupposed (Aquinas 800).

In order to square the possibility of instantaneous changes with the argument of 6.4, Aquinas says that even though some changes are instantaneous (such as generations), nevertheless they are connected to and entail changes that are divisible and happen part-by-part.

Aquinas deals separately with the possibility of changes in which all the parts of something change together, and proposes a solution similar to that of "some people" above. All-at-once changes are possible, but these are always alterations, while *Physics* 6 is focused on locomotion. But Aquinas adds (1009) that this is because *Physics* 6 concerns change generally, and when speaking generally, change has to be understood according to its archetype, namely locomotion. Locomotions, he says, are always divisible and part-by-part. Aristotle's comment about all-at-once alterations in, e.g. *De Sensu* 6, on the other hand, concerns "*determinata mobilia*," or concrete changing things. This is difficult to understand, but I believe Aquinas means to say that

---

Physics 6.5 236a13-27.

the claims of *Physics* 6 have the status of "always or for the most part" generalizations, as we might say that dogs have four legs "always or for the most part," acknowledging exceptions due to chance. Such generalizations may be true and yet admit of exceptional cases.

The difficulty with this reading is that Aristotle gives no indication that the claims in *Physics* 6 can be understood as claims that hold either only of locomotion (Aristotle illustrates his claims with alteration and generation throughout the book)[26] or that they hold of changes only "for the most part." Aristotle's arguments that changes are always divisible, such as the ones found at *Physics* 6.1 231b21-232a17 and 6.6 237a17-b9 (discussed above) do not seem to be such as to admit of any exception.

So we find that ancient commentators fell into three camps:

-**The Greek solution** (Themistius, Simplicius, Philoponus) says that in the "all-at-once" passages, Aristotle is asserting the possibility of continuous changes in which all the parts of something change simultaneously. Concerning 6.4 234b10-20, the Greek solution says that the argument there is limited to changes that happen part-by-part, with the thought that whatever changes all-at-once needn't be mentioned because it obviously has parts.

-**The Arabic solution** (Ibn Bâjja, Ibn Rushd) says that all-at-once changes are instantaneous and possible, but are not changes strictly speaking. Rather, these are the terminations of changes. Generations (though not necessarily substantial generations) consist of terminations, and so these are always all-at-once changes.

-**The Latin solution** (Aquinas) says that both instantaneous and continuous all-at-once changes are possible. The argument of 6.4 234b10-20 does not discuss these because, concerning the instantaneous ones, these always entail divisible changes, and concerning

[25] Lettinck, *Reception,* 496-98. Cf. Bostock 1991, 173 for a modern articulation of this concern.

the continuous ones, *Physics* 6 concerns change in general, and so is put in terms of its archetype, locomotion. The claims Aristotle makes about change in general hold only for the most part, and therefore admit of exceptions, such as continuous all-at-once changes.

We can see that each solution deals with the appearance of conflict by either saying that the argument in 6.4 is limited in scope (the Greek and Latin solutions) or by granting that 6.4 discusses all changes, and saying that the "all-at-once" passages aren't discussing changes strictly speaking (the Arabic solution). I've already mentioned some of the interpretive difficulties with saying that 6.4 is limited in its scope. The Arabic solution faces some similar problems: in the "all-at-once" passages, Aristotle uses the same terms he uses to describe strict changes in *Physics* 5 and 6, namely "alteration" (ἀλλοίωσις) and "change" (μεταβολή), and nowhere does he qualify this usage or indicate that he means to talk about terminations.

The Modern Commentators

I will approach the modern discussion of this problem schematically. As among the ancient commentators, the appearance of a conflict between *Physics* 6 and the "all-at-once" passages is widely recognized. The modern discussion of this conflict is characterized by pessimism about the coherence of these passages.

This modern pessimism amounts to the thought that we cannot produce an interpretation of these texts on which Aristotle has not made a mistake or changed his mind. What debate there is about the nature of this conflict amounts to a question of scope. The scope of the conflict might be broad: if Aristotle means that all-at-once changes are instantaneous, then in the "all-at-once" passages he contradicts the central and consistent thesis of *Physics 6,* that all changes are

[26] *Physics* 6.4 234b18, 6.5 235b6-19, 6.6 237b9-22, 6.10 240b20-2.

infinitely divisible. Or it might be narrow: if all-at-once changes can be continuous (as the Greek commentators, and perhaps Aquinas thought), then perhaps when Aristotle says that some changes happen , he is not therefore committed also to saying that they happen instantaneously. Think for example of a rug bleaching in the sun: the change is gradual, but at any time in the change, every part of the rug is as bleached as every other part. Both camps tend to see *Physics* 6 as containing the error, rather than finding fault with the "all-at-once" passages.[27] Those who see a narrow conflict may blame *Physics* 6.4 234b10-20, and single it out as a confused bit of argument. Those who see a broad conflict must reject much of *Physics* 6, as Waterlow does when she says that *Physics* 6 represents an early and failed attempt at a theory of the structure of change.[28]

In what follows, I argue against the "narrow" reading of the conflict between *Physics* 6 and the "all-at-once" passages. In my discussion of *Physics* 8.3 above, I've already suggested that the dialectical context of this passage makes it likely that Aristotle is committed there to the possibility of instantaneous changes. Regardless of whether Aristotle would accept the possibility of continuous, all-at-once changes[29] he could not have intended to make use of this in

[27] Before the turn of the century, there was consensus that the conflict between *Physics* 8.3 and *Physics* 6 was broad: see Bostock *Space*, 175-6; Graham, Daniel. *Aristotle Physics VIII*. Oxford: Clarendon Aristotle Series, 1999: 7, 68; Heinaman, Robert. "Alteration and Aristotle's Activity-Change Distinction," *Oxford Studies in Ancient Philosophy* 16, 1998:243, 252; Strobach, Niko. *The Moment of Change. A Systematic History in the Philosophy of Space and Time*. Dordrecht: Kluwer Academic Publishers, 1998: 59, 255n39; Wardy, Robert. *The Chain of Change. A Study of Aristotle's Physics VII.* Cambridge: Cambridge University Press, 1990: 330n41; Waterlow *Nature*, 97, 55. Since then, several scholars have argued that the conflict is narrow: see Gregory "Dynamics," 12-3; Hasper, *Continuity*, 158n210; Murphy "Alteration"; Bowin, John. "Aristotle on the Unity of Change: Five Reductio Arguments in Physics viii 8." *Ancient Philosophy* 30, no. 2, 2010: 319-345: 333-5. I am indebted to Hasper (ibid.) for his discussion of the history of this question.

[28] See footnote 10. Waterlow's reasons for thinking this are not, in the first place, about this puzzle. Waterlow thinks that *Physics* 6 is problematic centrally because it does not offer any account of the teleological unity of a change. It contains no explicit teleological language and no reference to matter, form, cause, principle, actuality, potentiality, or substance.

[29] I do not think Aristotle could have accepted the possibility of all-at-once continuous changes. Briefly, Aristotle argues in *Physics* 6.10 that nothing without parts can change in any way. But something that changes in all its parts together is no different, from the perspective of these arguments, than a partless thing. Moreover, an all-at-once continuous change would be exhaustively described by the state of the changing thing at any moment. But no

Physics 8.3. I will also show that the Alexandrian understanding of "all-at-once" events (as the initiation or termination of changes, rather than changes themselves) in *Physics* 8.3 is also unlikely to have been Aristotle's intention.

I begin by quoting the crucial line from *Physics* 8.3:

> For it is not the case that, just because the altering thing is divisible into infinitely many parts, the alteration is so as well. Rather, it often happens all-at-once (ἀθρόα), just as in the case of freezing[30] (253b23-26).

We may frame the question thus: what sort of thing does "freezing" (ἡ πῆξις) refer to? I see three possibilities:

> A) "freezing" refers to an infinitely divisible alteration in which all the spatial parts of a body of water solidify together over time, rather than one part solidifying after another (this being the view of the narrow conflict readers).
>
> B) "freezing" refers to an instantaneous alteration (this being the view of the broad conflict readers).
>
> C) "freezing" refers to only the instantaneous termination of an infinitely divisible change. This is to say, "freezing" is not strictly speaking a change at all, but the termination of a change.

In my exposition of 8.3 above, I argued that the dialectical situation in this passage is as follows: Aristotle's line about "all-at-once" alterations is an argument against the Heraclitian principle: if something is infinitely divisible, then its changes are infinitely (temporally) divisible. Aristotle refutes this principle by saying that not all alterations of divisible bodies are infinitely divisible

---

continuum can, for Aristotle, consist of indivisibles (see *Physics* 6.1 231a21-b18). For a defense of the possibility of all-at-once continuous changes (though not against the concerns I've just raised), see Murphy "Alteration."

[30] οὐ γὰρ εἰ μεριστὸν εἰς ἄπειρα τὸ ἀλλοιούμενον, διὰ τοῦτο καὶ ἡ ἀλλοίωσις, ἀλλ' ἀθρόα γίγνεται πολλάκις, ὥσπερ

and citing freezing as an example—that is, as an example of a change that is not infinitely divisible.

This makes (A), suggested by the Greek solution and some modern commentators,[31] a very problematic reading. If by "freezing," Aristotle means to refer to an infinitely divisible change, then it is not the counterexample he is looking for, and it does no work in responding to his opponent: the Heraclitian will be happy to accept that a thing freezes in all its parts together, if we grant him that freezing is an infinitely divisible change. For then the Heraclitian can hold on to the claim that things can freeze (or undergo any other sort of change) imperceptibly slowly and perpetually.

So if we insist on reading (A) for the sake of preserving the consistency of this text with *Physics* 6, then we do so at the cost of attributing to Aristotle a serious and simple confusion. It is not plausible that Aristotle intends "freezing" to refer to an infinitely divisible change, regardless of whether it takes place part-by-part or all-at-once. It is worth noting also that Aristotle does not think that water thickens before solidifying, nor would he use "πῆξις" (translated "freezing" above) to refer to a process of *cooling*. So if this is supposed to refer to a divisible, all-at-once change, it is difficult to see what the intermediate stages of such a change would be.[32]

(C) is more promising. Perhaps we are to imagine a continuous process of cooling that is terminated by the moment at which some water freezes. Ordinarily, Aristotle would be unwilling to say that cooling and hardening could be parts of the same change,[33] but perhaps he is speaking

---

ἡ πῆξις.

[31] Specifically those arguing for a "narrow" reading of the conflict, cited in footnote 10.

[32] See footnote 18.

[33] A motion is one in an unqualified sense when, among other conditions, "that in which" the change occurs is one. "That in which" something changes is, e.g. color, temperature, size, etc. So a change that involves both cooling and solidifying could not count as one (in the unqualified sense) change. *Physics* 5.4 227b20-228a2.

loosely here. But as the Arabic commentators have observed, the terminating event of a change cannot, itself, be a change[34], strictly speaking. Perhaps Aristotle is using the word "alteration" broadly, so as to include terminating events? I think that this is a possible but uncharitable reading of Aristotle's argument. His interlocutor wishes to assert that the changes of infinitely divisible bodies are always also infinitely divisible, and infer from this that changes might go on forever. But this is entirely consistent with the thesis that the terminating events of those changes (at which we will never arrive) are indivisible. So on this reading, Aristotle's argument is a *non-sequitur*: it does not follow from Aristotle's rebuttal that the interlocutor's position is false. We may of course supply Aristotle with additional premises, perhaps drawn from other texts,[35] but at that point we have ceased trying to make sense of the argument that Aristotle wrote.

The remaining position is (B). On this reading, "freezing" in this passage refers to an instantaneous change, and this produces a straightforward and charitable reading of Aristotle's argument. If certain changes in divisible bodies are instantaneous, such as freezing, then "it is not the case that, just because the altering thing is divisible into infinitely many parts, the alteration is so as well." The difficulty with (B) is just that *Physics* 8.3 then seems to be inconsistent with the core theses of *Physics* vi.

I therefore conclude that the modern pessimism about the coherence of these texts is warranted: Aristotle either made a mistake or he changed his mind. Of course, I can offer nothing dispositive on this point. But I have tried to show that if we try to maintain the coherentist reading at which the ancient commentators aimed, we cannot give a plausible reading of the passages considered on their own. I have also argued that the conflict is broad, in the sense that

[34] Aristotle observes that if changes had to come to be or cease to be via changes, an infinite regress would follow. See *Physics* 5.2 225b33-226a23.

[35] Aristotle does argue, in *Physics* 6.7 237b34-238a19, that it is impossible that we should never arrive at the

Aristotle is committed to the impossibility of instantaneous changes in *Physics* 6, and to their possibility in *Physics* 8.3.

De Sensu 6

Let us turn then to *De Sensu* 6. In *De Sensu* 6 446b28-447a3, Aristotle again discusses the possibility of all-at-once change, and again uses freezing as an example. I take this passage to be further evidence that Aristotle accepts the possibility of all-at-once (proper) changes, and that these changes are instantaneous. Additionally, I aim to show that in regard to the question of whether or not changes can happen instantaneously and , Aristotle draws the very distinction between alteration and locomotion to which many of the ancient commentators refer. In *De Sensu* 6, Aristotle appears to think that locomotions are infinitely divisible as a matter of necessity, while alterations needn't be. This will be important to connecting this conflict with the one I discuss in part two.

In *De Sensu* 6, Aristotle is considering whether light travels through its medium before reaching our eyes, as sounds and smells do before they reach our ears and noses. When you are standing closer to the source of a sound than I am, you will hear the sound before I do. Is this also true of light? Not necessarily, Aristotle says. A body of air or water can become lit , rather than part-by-part. This is because "light is due to the presence of something, but…" unlike sound, "…it is not a change" (τῷ ἐνεῖναι γάρ τι τὸ φῶς ἐστιν, ἀλλ' οὐ κίνησίς τις).[36] He then goes on to explain that, in any case, we shouldn't even infer that *changes* must always reach an intermediate before coming to an end. It is here that we find Aristotle again using freezing as an example of an all-at-once change.

termination of a change. I discuss this chapter at the end of this chapter.

> But with regard to light there is another account. For light is due to the presence of something, rather than being some kind of change. And in general, neither does alteration work the same way as locomotion. Locomotions, it is well said, reach an intermediate first (and sound, it seems, is a change of something locally moved), but so far as something alters, things are not the same. For it is possible that something alters all at once, and not one half first, for example a body of water may all freeze simultaneously.[37] (*De Sensu* 6 446b28-447a3)

The point of the contrast between locomotion and alteration in this passage is to show that unlike locomotions, alterations needn't reach a *spatial* intermediate before reaching any given state of completion. But what difference justifies this distinction between locomotion and alteration? The difference is this: locomotions are changes of place, and place is *per se* divisible and continuous. By contrast, alterations are changes of quality, and qualities are not *per se* divisible or continuous. Instead, qualities are only accidentally continuous, because the things of which they are predicated (i.e. bodies) are continuous.[38]

Does Aristotle also suggest here that all-at-once alterations are instantaneous changes? He offers no explicit answer to this question. But all-at-once alterations are invoked as an analogy with the aim of defending Aristotle's thesis that light comes to be present in a medium *instantaneously*[39], as Aristotle makes clear at the end of *De Sensu* 6:

> It is well said that what is between the sensory organ and its object are not all affected at

---

[36] Cf. *De Anima* 2.7 for a fuller discussion of the idea that light is the activity of the transparent *qua* transparent.
[37] περὶ δὲ τοῦ φωτὸς ἄλλος λόγος· τῷ ἐνεῖναι γάρ τι τὸ φῶς ἐστιν, ἀλλ' οὐ κίνησίς τις. ὅλως δὲ οὐδὲ ὁμοίως ἐπί τε ἀλλοιώσεως ἔχει καὶ φορᾶς· αἱ μὲν γὰρ φοραὶ εὐλόγως εἰς τὸ μεταξὺ πρῶτον ἀφικνοῦνται (δοκεῖ δ' ὁ ψόφος εἶναι φερομένου τινὸς κίνησις), ὅσα δ' ἀλλοιοῦται, οὐκέτι ὁμοίως· ἐνδέχεται γὰρ ἀθρόον ἀλλοιοῦσθαι, καὶ μὴ τὸ ἥμισυ πρότερον, οἷον τὸ ὕδωρ ἅμα πᾶν πήγνυσθαι.
[38] This doctrine is a point of agreement between De Sensu (cf. also Metaphysics v 13.1020a26-29) and Physics 6, and he states the view more clearly in the latter, at 6.4.235a13-18.
[39] See Sorabji, Richard. "Aristotle on Colour, Light and Imperceptibles," *Bulletin of the Institute of Classical Studies*

> once (ἅμα πάντα πάσχε), except in the case of light on account of what has been said, and for the same reason in the case of seeing. For light produces sight[40] (447a8-11).

Of course a medium may become gradually lit in this sense: it may go from dimly lit to brightly lit as the light source intensifies. But this is consistant with the idea that the medium takes on a given intensity of light instantaneously. Aristotle is thinking of a case analogous to hearing a sound at a distance from its source. Imagine, then, someone lighting a candle 100 feet away. How long does it take for the intervening medium to become lit by the candle? No time at all, because light is not a motion nor due to the motion of something. And given the similarity of this passage to Physics 8.3 253b19-26, both with regard to the claim being made and of the language used to make it, I think it is likely that Aristotle has in mind here that every all-at-once alteration is instantaneous[41].

If this is right, then we arrive at a surprising and important principle, which if true reveals a longstanding and systematic misunderstanding of Aristotle's conception of the continuity of change. I think the most natural reading of both *De Sensu* 6 and *Physics* 8.3 passages is that they were written under the assumption that *an alteration is continuous if and only if it is part-by-part.*[42] This would explain why, in *Physics* 8.3 when Aristotle is trying to show that some alterations are in fact indivisible, he considers it sufficient to observe that some alterations in fact

---

47, 2004: 132.

[40] εὐλόγως δὴ ὧν ἐστι μεταξὺ τοῦ αἰσθητηρίου, οὐχ ἅμα πάντα πάσχει, πλὴν ἐπὶ τοῦ φωτὸς διὰ τὸ εἰρημένον, διὰ τὸ αὐτὸ δὲ καὶ ἐπὶ τοῦ ὁρᾶν· τὸ γὰρ φῶς ποιεῖ τὸ ὁρᾶν.

[41] As with *Physics* 8.3, we may wish to mitigate the appearance of a conflict between *Physics* 6.4 and *De Sensu* 6 by saying that the alterations being discussed in this latter passage are not changes, strictly speaking. But as with *Physics* 8.3, consistency is purchased at the cost of any natural reading of the passage at hand. Again, Aristotle refers to these changes as "alterations" (ἐνδέχεται γὰρ ἀθρόον ἀλλοιοῦσθαι) without any qualification. And in the subsequent few lines refers the changes in question as "heating" and "freezing" (τὸ θερμαινόμενον ἢ πηγνύμενον), which are strict changes in any other context. Aristotle does mention a case of deviant alteration (a so called "alteration" that does not conform to the usual metaphysics of change) in *De Anima* 2.4, but he is there careful to flag the distinction between alterations proper and the deviant sort. *De Sensu* 6 flags no such thing, and involves no explicit reference to that passage.

[42] See Sherry, David. "On Instantaneous Velocity" *History of Philosophy Quarterly*, Vol. 3, No. 4, 1986: 393-396

happen all-at-once. If this is right then Aristotle does not see the part-by-part conception of continuous change in *Physics* 6.4 as an innovation: he always thought continuous alterations happened part-by-part. Aristotle only changed his mind about the possibility of *discontinuous* alterations. This explains why the remarkable assumption of the part-by-part character of continuous change is both an essential premise in the argument of 6.4 234b10-20, and an unstated one.

Does the Magnitude or the Changing Thing Explain the Divisibility of Change?

At the end of *Physics* 6.4, Aristotle says that the divisibility and infinity (by which he means infinite divisibility) of change and time follows from the divisibility and infinity of the changing thing, which belong to the changing thing immediately.

> In the same way it will be shown also that the length is divisible, and generally everything in which a change takes place[43] (though some only accidentally, because the changing thing is divisible), for when one is divided, they will all be divided. Also in regards to their being finite or infinite, all will be similarly disposed. And the divisibility of all things especially—and also their being infinite—follows from the changing thing. For divisibility and infinity belong immediately to the changing thing. That divisibility does so we have shown before; that infinity does so will be made clear in what follows.[44]

---

for a brief defense of this view.

[43] As in *GC* 2.10 337a25-30, that "in which" something changes refers to the lowest genus that includes the specific starting and ending point of the change. So in a change from white to blue, color. In a change from here to there, place. See *Physics* 5.1 for an extensive discussion of the logical parts of a change, and of the specific and generic uses of these terms.

[44] ὡσαύτως δὲ δειχθήσεται καὶ τὸ μῆκος διαιρετόν, καὶ ὅλως πᾶν ἐν ᾧ ἐστιν ἡ μεταβολή (πλὴν ἔνια κατὰ συμβεβηκός, ὅτι τὸ μεταβάλλον ἐστὶν διαιρετόν)· ἑνὸς γὰρ διαιρουμένου πάντα διαιρεθήσεται. καὶ ἐπὶ τοῦ πεπερασμένα εἶναι ἢ ἄπειρα ὁμοίως ἕξει κατὰ πάντων. ἠκολούθηκεν δὲ μάλιστα τὸ διαιρεῖσθαι πάντα καὶ ἄπειρα εἶναι ἀπὸ τοῦ μεταβάλλοντος· εὐθὺς γὰρ ἐνυπάρχει τῷ μεταβάλλοντι τὸ διαιρετὸν καὶ τὸ ἄπειρον. τὸ μὲν οὖν διαιρετὸν δέδεικται πρότερον, τὸ δ' ἄπειρον ἐν τοῖς ἑπομένοις ἔσται δῆλον.

(Physics 6.4 235a35-b5)

In this passage, Aristotle summarizes the result of the series of arguments constituting 6.4, which are written to show that the divisibility of all the aspects of change (time, change itself, the changing thing, that in which something changes, such as distance) follows from (ἠκολούθηκεν…ἀπὸ) the divisibility of the changing thing. These arguments come in two phases: first Aristotle shows that the changing thing is divisible (234b10-20), and then he shows (6.4 234b21-a34) that given the divisibility of any one aspect of change, any other can be shown to be divisible as well. For example, time is how of time by appealing to the divisibility of change:

> Similarly, if the change is divisible, the time is also divisible; for if the whole [change] occupies all [of the time], then half [the change] will occupy half the time, and again less [change] will occupy less [time].[45] (*Physics* 6.4 235a22-24)

He introduces this common system of divisibility as follows…

> And since every changing thing is changing in something and for some time, and there is a change belonging to each, it is necessary that the time, the change, the changing [i.e. what is undergone by the changing thing], the changing thing, and that in which the change occurs [e.g. the place, or color] will all be subject to the same divisions.[46] (*Physics* 6.4 235a13-17)

And he sums it up in the first passage I have quoted in this section ("In the same way it will be shown also that the length…"). Why does the changing thing take pride of place? Because the divisibility belongs to it in an immediate (εὐθὺς) way. I take Aristotle to be adverting to the first

[45] ὁμοίως δὲ καί, εἰ ἡ κίνησις διαιρετή, καὶ ὁ χρόνος διαιρετός· εἰ γὰρ τὴν ὅλην ἐν τῷ παντί, τὴν ἡμίσειαν ἐν τῷ ἡμίσει, καὶ πάλιν τὴν ἐλάττω ἐν τῷ ἐλάττονι

[46] ἐπεὶ δὲ πᾶν τὸ κινούμενον ἔν τινι κινεῖται καὶ χρόνον τινά, καὶ παντὸς ἔστι κίνησις, ἀνάγκη τὰς αὐτὰς εἶναι

argument in *Physics* 6.4, where he showed that every changing thing is divisible. This argument is unlike the others in 6.4 in that it does not take the divisibility of anything else as a premise. When we try to explain the divisibility of time or change or length or anything else "in which change is," our explanations will ultimately terminate in the changing thing, to which divisibility is native.[47]

Aristotle's account, in 6.4, conflicts with Aristotle's remarks on the relationship between change, time, and magnitude in *Physics* 3 and 4. There, Aristotle says that the infinite divisibility (in *Physics* 3.7 207b21-4)[48] and the continuity (in 4.11 219a10-21, 4.12 220b24-32)[49] of time and change are ultimately explained by the infinity/continuity of the *magnitude* (μέγεθος) through which something changes.

> And since the moving thing moves from and to something, and since all magnitude is continuous, the motion follows the magnitude. For because the magnitude is continuous, the motion is also continuous, and because the motion is so, so is the time. For the time that has passed is thought to be as much as the motion. Now, before and the after belong primarily to place, because of relative position. But since before and after belong to magnitude, it is necessary also that before and after belong to motion, for an analogy holds between them. But before and after belong also to time, because each always follows the other.[50] (*Physics* 4.11 219a10-19)

Aristotle's aim in the first part of this passage is to explain why time is continuous. He says that

διαιρέσεις τοῦ τε χρόνου καὶ τῆς κινήσεως καὶ τοῦ κινεῖσθαι καὶ τοῦ κινουμένου καὶ ἐν ᾧ ἡ κίνησις.

[47] I discuss the structure and context of this argument in detail in my fifth chapter.

[48] *Physics* 3.7 207b21-4 is also quoted at Metaphysics K.10 1067a33-37

[49] Cf. also *Metaphysics* Δ.13 1020a28-32, quoted below.

[50] ἐπεὶ δὲ τὸ κινούμενον κινεῖται ἔκ τινος εἴς τι καὶ πᾶν μέγεθος συνεχές, ἀκολουθεῖ τῷ μεγέθει ἡ κίνησις· διὰ γὰρ τὸ τὸ μέγεθος εἶναι συνεχὲς καὶ ἡ κίνησίς ἐστιν συνεχής, διὰ δὲ τὴν κίνησιν ὁ χρόνος· ὅση γὰρ ἡ κίνησις, τοσοῦτος καὶ ὁ χρόνος αἰεὶ δοκεῖ γεγονέναι. τὸ δὴ πρότερον καὶ ὕστερον ἐν τόπῳ πρῶτόν ἐστιν. ἐνταῦθα μὲν δὴ τῇ θέσει· ἐπεὶ δ' ἐν τῷ μεγέθει ἔστι τὸ πρότερον καὶ ὕστερον, ἀνάγκη καὶ ἐν κινήσει εἶναι τὸ πρότερον καὶ ὕστερον, ἀνάλογον τοῖς

time will inherit its structure from change, and change from magnitude. So since magnitude is continuous, time will also be so. I include also the subsequent lines on the "before and after" because I think this helps us see why magnitude serves as an explanatory ground for the structure of change and time. This passage has received much attention in contemporary scholarship on Aristotle's theory of time.[51] I don't intend to offer a novel interpretation, but I will attempt to make explicit what I take to be Aristotle's reasoning for the priority of magnitude in explaining the continuity of change.

First of all, what does Aristotle mean by "magnitude"? Aristotle generally uses the word "magnitude" to talk about anything extended in space: lines, planes, or bodies as well as distances or paths.[52] But here, Aristotle intends "magnitude" to refer to the path covered by a motion rather than to a body. This is clear in *Metaphysics* Δ.13, where Aristotle apparently reports the view established in *Physics* 4.11.

> Some are quantities in the way in which motion and time are so; for these are called quantities and continuous because the things of which these are attributes are divisible. I mean not that which is moved, but that [through or along] which it is moved; for because that is a quantity, motion also is a quantity, and because this is a quantity time is so.[53] (*Metaphysics* Δ.13 1020a28-32)

Aristotle is explicit here that the continuity of change is not derived from the changing thing

---

ἐκεῖ. ἀλλὰ μὴν καὶ ἐν χρόνῳ ἔστιν τὸ πρότερον καὶ ὕστερον διὰ τὸ ἀκολουθεῖν ἀεὶ θατέρῳ θάτερον αὐτῶν.

[51] The two exhaustive treatments are Hussey, Edward. *Aristotle: Physics, Book III and IV*, Oxford: Oxford University Press; Clarendon Aristotle Series, 1983. , 142-149 and Coope, *Time*, 47-81.

[52] By "path" I mean the ground covered by a given token locomotion. By contrast, the distance from my home to the lake and to the grocery store might be the same, but the paths are not. The paths go to (and through) different places.

[53] τὰ δὲ ὡς κίνησις καὶ χρόνος· καὶ γὰρ ταῦτα πόσ' ἄττα λέγεται καὶ συνεχῆ τῷ ἐκεῖνα διαιρετὰ εἶναι ὧν ἐστὶ ταῦτα πάθη. λέγω δὲ οὐ τὸ κινούμενον ἀλλ' ὃ ἐκινήθη· τῷ γὰρ ποσὸν εἶναι ἐκεῖνο καὶ ἡ κίνησις ποσή, ὁ δὲ χρόνος τῷ ταύτην. The phrase "οὐ τὸ κινούμενον ἀλλ' ὃ ἐκινήθη" is perplexing. Ross provides no apparatus notes for this line, but in his commentary he suggests that this phrase should be read as "that through or along which it is moved" (Ross, *Physica*, 324). I adopt Ross' suggestion here. Kirwin, Christopher. *Aristotle Metaphysics Books Γ, Δ, and E.*

itself (τὸ κινούμενον), but from that in or through which something changes. Note also *Physics* 3.7 207b21-4, where Aristotle is discussing the sense in which magnitude, change, and time are infinite (in the sense of being infinitely divisible):

> But the infinite is not the same in magnitude and motion and time, as if there were some one nature. Rather, the posterior is said to be in accordance with the prior. For example, motion is infinite because of the magnitude over which (ἐφ' οὗ) something moves or alters or grows, while the time is infinite because of the motion.[54]

Here, again, Aristotle is clear that the "magnitude" to which he refers is the path or quantity covered by the change, rather than the changing thing itself.

Why is magnitude prior to change and time? The continuity of magnitude explains the continuity of change 1) in that that the features of a change relevant to its continuity are analogous to features of the magnitude of the change ("since then before and after hold in magnitude, they must hold also in motion…"), and 2) in that the magnitude traversed during a change is a necessary logical constituent of any complete description of that change. By (2) I mean that a complete and fully determined description of a walk would (at least) involve something such as "a walk from campus to home," and in giving such a description I necessarily make reference to the magnitude bounded by campus and my home. (1) establishes a common structure between change and magnitude, and (2) establishes that magnitude is prior, and the *explanans* of the properties of a change.

Finally, why cannot the time of a change satisfy (2)? Aristotle might answer by appealing to the following intuition. If we thought that someone had walked from campus to their home, but

---

Oxford: Oxford University Press; Clarendon Aristotle Series, 1993 translates "but [the amount by] which which it is moved" (49, 162), but Kirwin's suggestion makes Aristotle's point a triviality.

[54] τὸ δ' ἄπειρον οὐ ταὐτὸν ἐν μεγέθει καὶ κινήσει καὶ χρόνῳ, ὡς μία τις φύσις, ἀλλὰ τὸ ὕστερον λέγεται κατὰ τὸ

we then learn that they in fact walked to a coffee shop, we will have learned that a different change took place. But if we find that a change thought to have taken place from 5:00 to 5:30 in fact took place from 5:00 to 5:20, then all we have found is that the change happened more quickly than we thought. Magnitude, unlike time, seems to be part of the identity of a change. And so while time, change, and magnitude are all continuous, it is the continuity of magnitude that explains the continuity of change and time.

In *Physics* 4.11, Aristotle says that the magnitude (in the sense of a spatial path) of a change explains its continuity. In 6.4, he says that the continuity of the changing thing explains the continuity of the change. On the face of it, this does not present us with a conflict. Perhaps the continuity of change has two explanations, or perhaps they are different kinds of explanations. Aristotle is, after all, famous for believing that there is a variety of different sorts of explanation. But, we have already read two texts that militate against any reading that aims to reconcile the theories of 4.11 and 6.4. In *Metaphysics* Δ.13, quoted above, Aristotle explicitly denies that it is the continuity of the changing thing that explains the continuity of change. In *GC* 2.10 337a25-30, quoted in the introduction, Aristotle again sets the views of *Physics* 3-4 and of 6.4 against one another, *this time endorsing the latter theory against the former*. He says "is motion continuous because of the continuity of that which is moved (τῷ τὸ κινούμενον συνεχὲς), or because that in which the motion occurs (ἢ τῷ τὸ ἐν ᾧ κινεῖται)—I mean, e.g., the place or the quality—is continuous? Clearly it will be because of the moving thing." If Aristotle believed that his commitments in *Physics* 3-4 and 6.4 were compatible, we would not expect him to set up the two theories of the continuity of change mentioned in *Metaphysics* Δ.13 and *GC* 2.10 in opposition to one another, or to argue for one of them, as he does in *GC* 2.10, by arguing against

πρότερον, οἷον κίνησις μὲν ὅτι τὸ μέγεθος ἐφ' οὗ κινεῖται ἢ ἀλλοιοῦται ἢ αὐξάνεται, ὁ χρόνος δὲ διὰ τὴν κίνησιν.

the other.[55]

The Fault Line

In this section, I will argue that the two conflicts just discussed—the first, concerning all-at-once vs. part-by-part change, and the second concerning what explains the divisibility/continuity of change—lie along a single fault. I mean that Aristotle's claim that changes can occur all-at-once or instantaneously (*Physics* 1.3 186b10-18, 8.3 253b19-26, *De Sensu* 6 446b28-447a3) and his claim that the continuity of the magnitude of a change explains the continuity of the change (Physics 3.7 207b21-24, Physics 4.11 219a10-21) are expressions of the same theory. In turn, *Physics* 6.4, which says that all changes must happen part-by-part over a period of time (234b10-235a10) and that the changing thing explains the continuity of change (235a34-b5), constitutes an alternative theory. At the same time, I hope to make it clear that Aristotle was aware of this conflict, that the conflicting passages are the remnants of a deliberate shift in Aristotle's views, and that *Physics* 6.4 represents Aristotle's considered view.

We see that Aristotle regards the claims about the source of continuity and the possibility of instantaneous changes as linked in the passage from *Generation and Corruption* 2.10, which I've discussed in my introduction and which I quote again here, along with some additional context.

> And time being continuous, motion must necessarily be continuous, insofar as it is impossible for there to be time separate from motion. Therefore, time is a number of

[55] It is worth adding that Aristotle also gives no positive indication that he sees 4.11 or 6.4 as presenting consistent theories. For example, one might wish to reconcile the two theories by suggesting that the 4.11 presents a proximate while 6.4 presents and ultimate explanation for the continuity of change. But we would then expect to see "magnitude" playing some kind of explanatory role in 6.4. Instead, when Aristotle does mention the magnitude of a change (6.4 235a34-6), it is an afterthought and does no explanatory work. When Aristotle later uses an analysis of magnitude to demonstrate the infinite divisibility of the changing of the changing thing, he restricts the application of this argument to locomotion and growth, explicitly excluding "changes between contraries and contradictories" (6.6 237a28-b2).

> some continuous motion, of motion in a circle, therefore, as was established in the original account. Is motion continuous because the moving thing is continuous or because that in which it moves—I mean, for example, place or quality—is continuous? Clearly it is because of the moving thing. (For how could a quality be continuous except because the thing of which it is an accident is continuous? But also, if change is continuous because of that in which something changes, then this [i.e. being what explains the continuity of change] belongs only to place. For it has some magnitude). But among moving things,[56] only what moves in a circle is continuous such that it is always continuous with itself. Therefore this is what makes motion continuous, the body being borne along in a circle. And the motion makes time continuous[57] (337a22-33).

Just prior to this passage, Aristotle concludes his argument that the perpetual cycle of generation and destruction implies both the action of a system of eternal circular motions and the power of an unmoved and eternal mover driving this system. The quoted passage follows this and appears to be a sort of appendix, adding as it does an additional reason for thinking that the facts of nature imply the existence and causal power of a circular celestial motion.

The formost question in interpreting this passage is coming to an understanding of what is meant by "continuous" (συνεχὴς). In general, Aristotle uses this word in two senses: first to mean something is a continuum in the topological sense described in *Physics* 5.4 and 6.1, and

[56] Joachim explains that the genitive τούτου is partitive, which is sometimes in the singular, citing Nicomachean Ethics 1127a7.

[57] συνεχοῦς δ' ὄντος τοῦ χρόνου ἀνάγκη τὴν κίνησιν συνεχῆ εἶναι, εἴπερ ἀδύνατον χρόνον χωρὶς κινήσεως εἶναι· συνεχοῦς ἄρα τινὸς ἀριθμὸς ὁ χρόνος, τῆς κύκλῳ ἄρα, καθάπερ ἐν τοῖς ἐν ἀρχῇ λόγοις διωρίσθη. Συνεχὴς δ' ἡ κίνησις πότερον τῷ τὸ κινούμενον συνεχὲς εἶναι ἢ τῷ τὸ ἐν ᾧ κινεῖται, οἷον τὸν τόπον λέγω ἢ τὸ πάθος; δῆλον δὴ ὅτι τῷ τὸ κινούμενον· (πῶς γὰρ τὸ πάθος συνεχὲς ἀλλ' ἢ τῷ τὸ πρᾶγμα ᾧ συμβέβηκε συνεχὲς εἶναι; εἰ δὲ καὶ τῷ ἐν ᾧ, μόνῳ τοῦτο τῷ τόπῳ ὑπάρχει· μέγεθος γάρ τι ἔχει.) τούτου δὲ τὸ κύκλῳ μόνον συνεχές, ὥστε αὐτὸ αὑτῷ ἀεὶ συνεχές. Τοῦτο ἄρα ἐστὶν ὃ ποιεῖ συνεχῆ κίνησιν, τὸ κύκλῳ σῶμα φερόμενον· ἡ δὲ κίνησις τὸν χρόνον.

second to mean something that goes on without ceasing, forever.[58] These senses are related: what can satisfy the second must also satisfy the first. I take Aristotle to be using "continuity" in the first sense, meaning that time and change are not composed of smallest parts, and are, as Aristotle puts it at 6.2 232b24-25 "divisible into divisibles that are always divisible." When Aristotle asks what explains the continuity of motion (and so ultimately of time) the two candidates he considers are the continuity of "that in which something moves—I mean, for example, place or quantity" or the moving thing itself. Neither can be continuous in the second sense, in the sense of being eternal or everlasting. And so Aristotle is asking after what explains the *topology* of time and motion, not its everlastingness.

I sketch the argument as follows:

1) Time is continuous.

2) The continuity of time must be explained by the continuity of motion.

3) The continuity of motion must be explained either by

the continuity of that in which the moving thing moves (e.g. place) or,

the continuity of the moving thing itself.

4) The continuity of motion is explained by the continuity of the moving thing.

5) Only what moves in a circle is always continuous with itself.

6) Therefore only what moves in a circle can explain the continuity of motion.

7) Therefore only what moves in a circle can explain the continuity of time.

This is a puzzling argument (especially when we get to (5)) and I'll try to explain the conclusion in a moment. But our real interest is in (4), for there Aristotle asks the question that *Physics* 4.11 and 6.4-6 both set out to answer: what makes motion or change continuous? And he proposes

[58] This later sense of "continuous" is absent from *Physics* 5-6.

two answers, each of which finds representation in those two texts: 4.11 says that that in which something changes explains the continuity of change (and specifies: magnitude, the spatial path of a locomotion), while 6.4-6 says that the changing thing itself explains the continuity of change. Here, Aristotle sides with 6.4 and against 4.11.

Aristotle explains his reasoning in what I have marked as a parenthetical:[59]

> (For how could a quality be continuous except because the thing of which it is an accident is continuous? But also, if change is continuous because of that in which something changes, then this [i.e. being what explains the continuity of change] belongs only to place. For it has some magnitude)

If this piece of reasoning is supposed to explain the intermediate conclusion in (5) then it must do so by showing why the alternative explanation for the continuity of motion, that in which something moves, is unsatisfactory. Aristotle's invocation of alterations, changes of quality, suggests that any satisfactory answer must explain the continuity of alterations and locomotions alike. Since qualities themselves are not continuous, the continuity of alterations is apparently explained by the changing thing. In addition, that in which something changes cannot explain any change but locomotion, since that in which something locomotes is place, and place (alone among everything in which things change) has continuous magnitude. So the changing thing itself wins the day: apparently the continuity of the changing thing can explain the continuity of both locomotions and alterations and, presumably, change generally.

I take the rest of the argument to go as follows, but I am speculating on the basis of a very thin text with no parallel for the reasoning behind (5-7). Aristotle is, I think, writing with some attention to the theory in 6.4-6 and with particular attention to the idea that when something is

[59] I mark it as a parenthetical because I take the antecedent of the genitive τούτου to be τὸ κινούμενον on line 28.

changing, a part of it is in that to which it is changing and a part of it is in that from which it is changing. Now, this does not threaten the continuity of the moving body. But there is perhaps a weaker sense in which a body being heated, half of which is hot and the other half of which is cold, is not "continuous with itself": temperature wise, anyway, one part of it is different from another, and there is a boundary line, more or less, that divides these parts. This can even be said of a locomoting body: if I take a step forward, a part of me is where I was resting before, and a part of me is in the new place into which I am stepping.[60] An unchanging body is spared this, of course, but it is unchanging, and so its continuity with itself, in this respect, cannot add anything to our understanding of the continuity of time.

A sphere rotating in place, on the other hand, is not divided in this way: no part of it is differentiated from another part as being any old or new place from and to which the whole is moving. The sphere is always in the same place.[61]

I return to the question of what explains the continuity of change. *GC* 2.10 337a25-33 represents a remarkable departure from Aristotle's theory of the continuity of time and change in *Physics* 3 and 4. For in *Physics* 3 and 4, only locomotions are considered relevant to the question. Now given Aristotle's intentions here in *GC* 2.10 we might have expected him to stick with that approach: after all, it is a locomoting body that, ultimately, explains the continuity of time. But instead Aristotle demands both that the continuity of *every* sort of change be explained, and that this be given the *same* explanation in every case.

This may suggest that Aristotle wants to treat continuity as a *per se* attribute of change, such that the account of why changes are continuous must be given at the level of the genus. This is suggested by the way Aristotle frames the above discussion, where continuity is treated as an

[60] I discuss the kinematics of part-by-part locomotion in detail in my third chapter.

attribute of change in a way parallel with the continuity of time: "And time being continuous, motion must necessarily be continuous..." I refer to Aristotle's discussion, in *Posterior Analytics* i 4, of what it means for something to hold "universally" (καθόλου).

> The universal obtains when it is proved of a chance case and primarily. For example, having two right angles does not hold universally of figure. To be sure, one may show that a figure has two right angles, but not of a chance figure, nor does one use a chance figure to show it. For the quadrilateral is a figure, but it does not have angles equal to two right angles. And the isosceles triangle has angles equal to two right angles, but not primarily. Rather, the triangle is prior. Now if the chance case is proved to primarily have two right angles, or anything else, then it belongs to this primarily, and the demonstration belongs to this in itself. But of the others, it belongs in some way not in itself, nor does it belong to the isosceles universally, but with a wider extension.[62] (*Posterior Analytics* i 4 73b32-74a3)

Aristotle may be worried that giving different accounts of the continuity of different species of change would be like giving different explanations for why scalene and isosceles triangles have interior angles adding up to two right angles.[63] On the view expressed in *Physics* 6.4, it is true to say that locomotions are continuous, but a mistake to think that locomotions are continuous primitively (πρῶτον). Continuity has a wider extension, in that change itself is continuous. The

---

[61] Though cf. Aristotle's discussion of rotating spheres in *Physics* 6.9 240a29-b7.

[62] Translation is modified from Barnes 1975 8. τὸ καθόλου δὲ ὑπάρχει τότε, ὅταν ἐπὶ τοῦ τυχόντος καὶ πρώτου δεικνύηται. οἷον τὸ δύο ὀρθὰς ἔχειν οὔτε τῷ σχήματί ἐστι καθόλου (καίτοι ἔστι δεῖξαι κατὰ σχήματος ὅτι δύο ὀρθὰς ἔχει, ἀλλ' οὐ τοῦ τυχόντος σχήματος, οὐδὲ χρῆται τῷ τυχόντι σχήματι δεικνύς· τὸ γὰρ τετράγωνον σχῆμα μέν, οὐκ ἔχει δὲ δύο ὀρθαῖς ἴσας)—τὸ δ' ἰσοσκελὲς ἔχει μὲν τὸ τυχὸν δύο ὀρθαῖς ἴσας, ἀλλ' οὐ πρῶτον, ἀλλὰ τὸ τρίγωνον πρότερον. ὃ τοίνυν τὸ τυχὸν πρῶτον δείκνυται δύο ὀρθὰς ἔχον ἢ ὁτιοῦν ἄλλο, τούτῳ πρώτῳ ὑπάρχει καθόλου, καὶ ἡ ἀπόδειξις καθ' αὑτὸ τούτου καθόλου ἐστί, τῶν δ' ἄλλων τρόπον τινὰ οὐ καθ' αὑτό, οὐδὲ τοῦ ἰσοσκελοῦς οὐκ ἔστι καθόλου ἀλλ' ἐπὶ πλέον.

[63] Ibn Rushd raises this issue as a worry about the Greek solution in his commentary on *Physics* 6.4 (Lettinck, *Reception,* 504).

recognition that continuity should belong to change primitively and universally may have been what motivated Aristotle to change his mind about his own view in *Physics* 3-4 since on that theory continuity does not belong to change primitively, but only to its paradigm species, locomotion.

Finally, how does the argument at *GC* 2.10 337a25-30 help us understand the relationships between the passages we've discussed in the first two sections? The Aristotle of *Physics* 3-4 could be entirely tolerant of instantaneous, which is to say discontinuous, alterations. The continuity of change is there explained by reference to the spatial path of a locomotion, and the continuity of time is therefore explained by reference to locomotion. And so if empirical evidence or good opinion seems to suggest that some changes happen "all-at-once" and instantaneously, then this should produce no difficulties. But we know that the Aristotle of *Physics* 6.4-6 does *not* tolerate instantaneous changes, and holds that *all* changes are continuous, taking some positive amount of time. What explains the continuity of change in 6.4-6 is found in all changes necessarily, namely the continuous body of the changing thing. Finally, judging from the way he argues in *GC* 2.10 337a25-30, Aristotle came to find the account in *Physics* 3-4 insufficient because it could not explain the continuity of change generally.

Conclusions

I have argued that there is a fault line in Aristotle's Physics, one which separates two distinct views on what explains the continuity of change. On the basis of Aristotle's comments in GC 2.10, I've argued that this fault was the result of a shift in Aristotle's views, perhaps provoked by the need to justify the claim that continuity is a *per se*, primitive attribute of change. And so the two theories of the continuity of change lying on either side of the fault amount to an old

theory—the "magnitude theory"—and a new theory—the "body theory." I'll sketch each of these briefly.

The magnitude theory centers on the claim that magnitude, and specifically the spatial path of a change, explains the continuity of change. This claim is stated in Physics 3.7, 4.11, and 4.12, as well as Metaphysics Δ.13. This means that the terminal and intermediate places of a motion describe a path which is continuous *per se*, because all spatial magnitudes are continuous *per se*. Any division in the path of the change marks a corresponding division in the change itself (and of the time, given uniform velocity). A consequence of this theory is that changes involving no spatial path, such as alterations need not be continuous. It was under the influence of the magnitude theory that Aristotle wrote *Physics* 1.3, 8.3 and *De Sensu* 6, where he accepts, probably on empirical grounds, the possibility of all-at-once and instantaneous alterations.

Aristotle then at some point develops a new "subject theory."[64] On the subject theory, the continuity of a change (and thus of time) is explained by the continuity of the changing thing itself. Every changing thing is divisible, and since every change happens part-by-part, every change must be divisible as well. On the subject theory, all-at-once changes are ruled out as impossible, if changes must be continuous. And in *GC* 2.10, we find Aristotle explaining his rejection of the magnitude theory in favor of the subject theory, on the grounds that the magnitude theory allows for discontinuous changes. Aristotle never does tell us what to make of *apparently* all-at-once changes like freezing. He does not think that freezing necessarily happens , and he may just instruct us to discount apparently all-at-once changes as in fact very rapid part-by-part changes.[65]

[64] There are also references to *Physics* 6.4-6 in *Posterior Analytics* ii 12 95b1-12 and *Metaphysics* Θ.8 1049b29-1050a3.

[65] Cf. Aristotle's insistence in *Physics* 8.8, on entirely metaphysical grounds, that a ball thrown straight upwards

In this chapter, I've argued that *Physics* 6.4-6 conflicts with a variety of other texts in Aristotle's corpus, and that it does so because it was written as a revision of his own views. I've outlined in very general terms the argument behind this new theory: changing bodies are continuous in a kind of original way, while the continuity of everything else in nature derives from that of bodies. In the remainder of this dissertation, I present a detailed analysis of this argument.

must come to an arbitrarily small rest before falling, or that a pendulum must come to an arbitrarily brief rest at the top of its arc.

Chapter 2: *Physics* 6.4 234b10-20, The Partwise Argument

In the beginning of Physics 6.4 Aristotle argues that every changing thing is divisible on the grounds that changes occur part-by-part. That is, if something changes in color, it must do so in such a way that the new color spreads out over the surface of the thing. And because changes occur in this way, changing things must have parts. I'll call this the "Partwise" argument.

As I discussed in my introduction, the Partwise argument, 234b10-20, occupies a central role in Physics 6.4-6. The overarching aim of these chapters is to show that the structure of changing bodies is responsible for the structure of time, distance, and change. Changing things earn pride of place, by way of a unique feature of the argument in which Aristotle shows that they are necessarily divisible: this argument does not take the divisibility of anything else as a premise. Hence, changing things are—unlike anything else in nature—divisible in an "immediate" way.

The Partwise argument has struck commentators, both ancient and modern, as an implausible bit of reasoning. As a result, the passage has been treated somewhat dismissively, despite the importance Aristotle seems to attach to it. In particular, I think the modern situation is dire: there can be no understanding of Physics 6.4-6 (nor much of the rest of Physics 6) if we do not have a grip on this passage. So it is the aim of this chapter to explain Aristotle's argument within these ten lines and to understand the implications of this argument for the kinematic theory he develops in what follows.

Here is the argument in full:

> Further, every changing thing must be divisible. For since every change is from something to something, and when something is in that to which it is was changing, it is no longer changing, and when it—both itself and all its parts—is in that from which it

was changing, it is not changing (for whatever is, itself and all its parts, in the same condition is not changing); it is necessary, therefore, that one part of the changing thing is in this and the other is in the other. For it cannot be in both or in neither. By 'that to which it changes' I mean the first thing in the process of change, e.g. from white, grey, not black. For it is not necessary that the changing thing be in either of the extremes. It is clear, then, that every changing thing will be divisible[1] (*Phys*. 6.4 234b10-20).

I reconstruct the argument as follows, where "that to which" is to be understood as the first thing to which something changes.

1) When a changing thing is changing, it cannot be in that to which it is changing (*Phys*. 6.4 234b10-20).[2]

2) Nor can it be in that from which it is changing.

3) Nor can it be wholly in both that from which and that to which it is changing.

4) Nor can it be wholly in neither that from which nor that to which it is changing.

5) Therefore, it must be partly in that from which and partly in that to which it is changing.

6) Therefore, it must be divisible.[3]

The argument proceeds to its conclusion (6) through the intermediate result (5), which is

[1] Τὸ δὲ μεταβάλλον ἅπαν ἀνάγκη διαιρετὸν εἶναι. ἐπεὶ γὰρ ἔκ τινος εἴς τι πᾶσα μεταβολή, καὶ ὅταν μὲν ᾖ ἐν τούτῳ εἰς ὃ μετέβαλλεν, οὐκέτι μεταβάλλει, ὅταν δὲ ἐξ οὗ μετέβαλλεν, καὶ αὐτὸ καὶ τὰ μέρη πάντα, οὕπω μεταβάλλει (τὸ γὰρ ὡσαύτως ἔχον καὶ αὐτὸ καὶ τὰ μέρη οὐ μεταβάλλει), ἀνάγκη οὖν τὸ μέν τι ἐν τούτῳ εἶναι, τὸ δ' ἐν θατέρῳ τοῦ μεταβάλλοντος· οὔτε γὰρ ἐν ἀμφοτέροις οὔτ' ἐν μηδετέρῳ δυνατόν. λέγω δ' εἰς ὃ μεταβάλλει τὸ πρῶτον κατὰ τὴν μεταβολήν, οἷον ἐκ τοῦ λευκοῦ τὸ φαιόν, οὐ τὸ μέλαν· οὐ γὰρ ἀνάγκη τὸ μεταβάλλον ἐν ὁποτερῳοῦν εἶναι τῶν ἄκρων. φανερὸν οὖν ὅτι πᾶν τὸ μεταβάλλον ἔσται διαιρετόν.

[2] Τὸ δὲ μεταβάλλον ἅπαν ἀνάγκη διαιρετὸν εἶναι. ἐπεὶ γὰρ ἔκ τινος εἴς τι πᾶσα μεταβολή, καὶ ὅταν μὲν ᾖ ἐν τούτῳ εἰς ὃ μετέβαλλεν, οὐκέτι μεταβάλλει, ὅταν δὲ ἐξ οὗ μετέβαλλεν, καὶ αὐτὸ καὶ τὰ μέρη πάντα, οὕπω μεταβάλλει (τὸ γὰρ ὡσαύτως ἔχον καὶ αὐτὸ καὶ τὰ μέρη οὐ μεταβάλλει), ἀνάγκη οὖν τὸ μέν τι ἐν τούτῳ εἶναι, τὸ δ' ἐν θατέρῳ τοῦ μεταβάλλοντος· οὔτε γὰρ ἐν ἀμφοτέροις οὔτ' ἐν μηδετέρῳ δυνατόν. λέγω δ' εἰς ὃ μεταβάλλει τὸ πρῶτον κατὰ τὴν μεταβολήν, οἷον ἐκ τοῦ λευκοῦ τὸ φαιόν, οὐ τὸ μέλαν· οὐ γὰρ ἀνάγκη τὸ μεταβάλλον ἐν ὁποτερῳοῦν εἶναι τῶν ἄκρων. φανερὸν οὖν ὅτι πᾶν τὸ μεταβάλλον ἔσται διαιρετόν.

[3] Almost every argument in *Physics* 6.4-6 comes in the style of a disjunctive syllogism.

supposed to entail (6) *a fortiori*. (6) is stated in very general terms; Aristotle does not say that "all locomoting things are divisible" or "all things that change color are divisible" but that "every changing thing is divisible" (πᾶν τὸ μεταβάλλον ἔσται διαιρετόν). No further premises are provided between (5) and (6), and so *prima facie* this suggests that the argument of (1-5) should likewise be understood in entirely general terms. Aristotle simply assumes that every sort of change, and every instance, happens part-by-part.[4]

The Partwise argument has met with a number of objections by commentators on *Physics* 6, both ancient and modern. The foremost difficulty, discussed in my last chapter, is the conflict between Aristotle's idea here that changes happen part-by-part, and his comments in *Physics* 1.3, 8.3 and *De Sensu* 6, that some changes happen not part-by-part but all-at-once.[5] I've argued that there is no way to reconcile these texts. A passage from *GC* 2.10 337a25-33 gives us reason to think that Aristotle changed his mind, and that *Physics* 6.4 represents a new view.

But there are also difficulties internal to 6.4. These are best articulated by David Bostock in his 2006 essay "Continuity in *Physics* 6." His objection is as follows. Premise (4) is implausible on the face of it: driving from Chicago to Philadelphia, I'll spend a lot of time in neither city. Aristotle seems to anticipate this objection, when he says that by "that to which" he means "the first thing with regard to the change" (τὸ πρῶτον κατὰ τὴν μεταβολήν), not necessarily the extreme term. It's clear from the example he provides that "the first thing" isn't the starting point of the change, but rather the first result; he says that in a change from white to black (apparently through at least one shade of grey), the "first thing" is "grey." But this qualification only seems to make things worse. Bostock says:

[4] Cf. Simplicius, *Physics* 6, 967.1-969.24 for an extensive discussion of the generality of this argument.
[5] This appears to have worried commentators as far back as Aristotle's own contemporary, Theophrasus, who raised this concern in his *On Motion*.

> But here of course we may object that there need not be any such 'first' state, and there cannot be if, as with motion, the states intermediate between A and B form a continuum. Indeed, Aristotle himself is going to argue for that very point in the next two chapters. (176)

Bostock's thought is that if change is continuous then the change to any supposed "first thing" would be divisible into a pair of sub-changes, the first of which would be a change to a state prior to the alleged first one. And this sub-change would be divisible in the same way, with the result that no "first thing" could be found, any more than one could find a first moment within the change and after the last moment of rest. It only sharpens this objection that Aristotle is clearly committed to the continuity of all change throughout *Physics* 6.4-6, and he himself makes the point that there can be no first stage of a change at 6.5 236a7-27.

Finally, interpreters as far back as Aristotle's own contemporaries tend to be as put off by what Wagner calls its "frightening generality"[6] as anything else. For surely Aristotle does not think that *all* changes happen part-by-part. Does a carpet bleaching in the sun change part-by-part? Do trees grow, part-by-part? Does a stone fall, part-by-part? But this is just to say that readers of *Physics* 6 have found Aristotle's argument for (5) to be both unpersuasive in itself and unnecessary for understanding the more compelling material about the continuity of change that we find later in the book.

I begin with a discussion of what is probably a Platonic antecedent of this argument from the *Parmenides*. By examining this antecedent and noting how Aristotle modifies it for his own purposes, we can get a better sense of his interest in the argument as a basis for his new theory of the continuity of change. I then engage with the latter two objections just discussed. I first argue

[6] "Wie die These besteht, und bewiesen wird, ist sie von erschreckender Allgemeinheit…" Wagner *Physikvorlesung*

that Bostock is wrong to assume that "the states intermediate between A and B form a continuum." On the contrary, I will show that Aristotle believes that the terminal and intermediate states to which something changes always constitute a discrete, finite series, such that there is always a first thing to which something changes. Aristotle's conception of continuity prohibits him from seeing the states to and through which something changes as capable of constituting a continuum.

The Platonic Antecedent of the Partwise Argument

In the second part of the Parmenides, the titular character fulfills a promise to show the young Socrates how to engage in a kind of training necessary to properly think through a theory of forms. They shall practice with an analysis of Parmenides' famous "One," the singular being that constitutes all of reality. Nearly everything about the structure and content of these deductions is obscure, and for the purposes of this chapter I'll try to avoid generalities about the dialogue's overall project. That said, Parmenides begins his demonstration by considering a hypothesis: the One is one. What follows thereafter is an examination of the consequences of this hypothesis, the most immediate of which seems to be the claim that the One cannot have parts. Parmenides deduces from this that the One, being partless, cannot be in a place, it cannot move or change in any way, nor can it be at rest. The penultimate argument of this line of thought ends with the conclusion that the One cannot come to be in a place from being outside of it. This argument is plausibly the antecedent of Aristotle's Partwise argument at the beginning of 6.4.[7]

"But by changing places does it come to be here at one time, there at another, and move

---

p. 623

[7] Cf. Owen, G. E. L. "Tithenai ta phainomena." *Logic, Science and Dialectic*, ed. Martha Nussbaum. Ithaca: Cornell University Press 1986: 95 and Bostock, *Space*, 178.

in this way?"—"If in fact it moves at all."—"Wasn't it shown that it cannot be anywhere in anything?"—[8]"Yes."—"Then is it not even more impossible for it to come to be [in something]?"—"I don't see why."—"If something comes to be in something, isn't it necessary that it not yet be in that thing – since it is still coming to be in it – and that it no longer be entirely outside it, if in fact it is already coming to be in it?"—"Necessarily."—"So if anything is to undergo this, only that which has parts could do so, because some of it would already be in that thing, while some, at the same time, would be outside. But a thing that doesn't have parts will not by any means be able to be, at the same time, neither wholly inside nor wholly outside something."—"True."—"But isn't it much more impossible still for a thing that has no parts and is not a whole to come to be in something somewhere, if it does so neither part by part nor as a whole?"—"Apparently."—"Therefore it doesn't change places by going somewhere and coming to be in something, nor does it move by spinning in the same location or by being altered."—"It seems not."—"The one, therefore, is unmoved by every sort of motion."—"Unmoved"[9] (*Parmenides* 138d2-139a3).

Imagine a chess pawn moving from the square e4 to e5. Before it moves, it is wholly outside e5. Once it has moved, it is wholly contained within e5. So what is going on with the pawn when it is moving into e5? It will be divided by the boundary between e4 and e5, into whatever part of

[8] At 138a-b, Parmenides argues that since the one has no parts, it cannot be in a place.

[9] Translation from Gill, Mary L., & Ryan, Paul. *Parmenides.* Indianapolis: Hackett Classics, 1996: *ad loc.* Ἀλλὰ δὴ χώραν ἀμεῖβον ἄλλοτ' ἄλλοθι γίγνεται καὶ οὕτω κινεῖται; — Εἴπερ γε δή. — Οὐκοῦν εἶναι μέν που ἔν τινι αὐτῷ ἀδύνατον ἐφάνη; — Ναί. — Ἆρ' οὖν γίγνεσθαι ἔτι ἀδυνατώτερον; — Οὐκ ἐννοῶ ὅπῃ. — Εἰ ἔν τῳ τι γίγνεται, οὐκ ἀνάγκη μήτε πω ἐν ἐκείνῳ εἶναι ἔτι ἐγγιγνόμενον, μήτ' ἔτι ἔξω ἐκείνου παντάπασιν, εἴπερ ἤδη ἐγγίγνεται; — Ἀνάγκη. — Εἰ ἄρα τι ἄλλο πείσεται τοῦτο, ἐκεῖνο ἂν μόνον πάσχοι οὗ μέρη εἴη· τὸ μὲν γὰρ ἄν τι αὐτοῦ ἤδη ἐν ἐκείνῳ, τὸ δὲ ἔξω εἴη ἅμα· τὸ δὲ μὴ ἔχον μέρη οὐχ οἷόν τέ που ἔσται τρόπῳ οὐδενὶ ὅλον ἅμα μήτε ἐντὸς εἶναί τινος μήτε ἔξω. — Ἀληθῆ. — Οὗ δὲ μήτε μέρη εἰσὶ μήτε ὅλον τυγχάνει ὄν, οὐ πολὺ ἔτι ἀδυνατώτερον ἐγγίγνεσθαί που, μήτε κατὰ μέρη μήτε κατὰ ὅλον ἐγγιγνόμενον; — Φαίνεται. — Οὔτ' ἄρα ποι ἰὸν καὶ ἕν τῳ γιγνόμενον χώραν ἀλλάττει, οὔτ' ἐν τῷ αὐτῷ περιφερόμενον οὔτε ἀλλοιούμενον. — Οὐκ ἔοικε. — Κατὰ πᾶσαν ἄρα κίνησιν τὸ ἓν

the pawn is already within the new square and a part that's still outside. Only something with parts could be so divided, and so the chess piece must have parts. Since, however, Parmenides' One has no parts—in the first deduction anyway—it can never come to be in a place.

It is useful to consider a contrasting conception of change. We could also regard the move from e4 to e5 as a "move" within the context of the rules of chess. In terms of the rules of chess, there is no significance to a piece's being half way between two squares. So while there are moves in the game of chess, nothing is ever moving. The game of chess involves no physical motions, except incidentally, and indeed we needn't play with physical pieces at all: nothing, so far as the game goes, is lost if we play by simply listing moves. This is evidently not how Parmenides' understands the proposed motion of the One, and so in order to distinguish this conception of change from the one Parmenides actually has, we can say that Parmenides' argument relies on a suppressed premise. Namely, everything that moves must, at some time, be moving.

Excepting the final inference concerning the One, Plato's argument in the Parmenides mirrors Aristotle's Partwise argument in 6.4. The two passages share an important and distinctive feature. In both, the crucial question is what we should say about the changing thing when it is changing. In order to see the significance of this feature of both passages we can construct an argument to similar effect in the style of Melissus:[10]

> -every motion into a place—think of a pawn moving into a new square—has a beginning, a middle, and an end;
>
> -when something is in the middle of a motion, it cannot be where it was at the beginning (outside) nor where it will be at the end (inside);

ἀκίνητον. — Ἀκίνητον.

-therefore, when the moving thing is in the middle of its motion, it is partly outside and partly inside its destination.

My Melissian argument assumes the divisibility of a motion into parts (beginning, middle, end), and concludes that the moving thing itself must have parts. But it does not ever mention anythings moving. By contrast, neither Aristotle nor Parmenides rely on the assumption that motions come in stages or have parts. The divisibility of the changing thing follows, in Parmenides' version, from the fact that it must at some time be moving[11], not from the assumption that changes have parts. This feature of the Partwise argument is also the reason for Aristotle's interest in it. Aristotle will go on in Physics 6.4 to argue that every other aspect of change (e.g. time, distance, etc.) is divisible, but each of these arguments presumes the divisibility of something else. Aristotle argues that time must be divisible because change is, and that change must be divisible because the changing thing is. Once the divisibility of some aspect of change is established, the divisibility of every other aspect follows without much difficulty. The difficulty is in establishing the sui generis divisibility of one of these aspects, and that is precisely the contribution of the Partwise argument to what immediately follows it in 6.4.

Bostock's Objection

David Bostock has raised a serious objection to the Partwise argument: it assumes that there is always a first result in any process of change. Bostock thinks that Aristotle is already committed, however, to the continuity of change, which is thought to require that there is a dense

[10] Cf. Simplicius' discussion of Melissus' arguments in Simplicius, *Physics 1.3-4*, 109.19-110.6.
[11] One might think that the statement that introduces the Partwise argument, that "every change is from something and to something" already implies that changes are divisible. But note that we can naturally talk about chess moves as being from one square and to another, and these are not divisible—at least not in the quantitative sense that magnitudes or times are.

ordering of intermediate results in every change: between any two shades in a process of darkening, there is a third shade. This should make any "first result" of a change impossible, since between an alleged first result and the starting point, there will be an intermediate result. I argue that Aristotle does indeed assume that there is a first result, but that it does not conflict with the thesis that changes are continuous as he understands it. Changes are continuous, Aristotle is at pains here to show, because of the bodies that undergo them, not because of any continuous series of results. As I will show, Aristotle's assumption of a first result is not only consistant with the continuity of change, it is by his lights necessary for it.

Here again is my reconstruction of the Partwise argument at 234b10-20.

1) When a changing thing is changing, it cannot be in that to which it is changing.

2) Nor can it be in that from which it is changing.

3) Nor can it be wholly in both that from which and that to which it is changing.

4) Nor can it be wholly in neither that from which nor that to which it is changing.

5) Therefore, it must be partly in that from which and partly in that to which.

6) Therefore, it must be divisible.

The problem at hand is Aristotle's justification for (4), which he defends by saying that "that to which" something changes should be read as the "first thing with regard to the change" (τὸ πρῶτον κατὰ τὴν μεταβολήν). Given the generality of Aristotle's argument, he appears to be committed to the following principle.

I) If something is changing from some A to some terminal B, then there is some A' (where A' might be identical to B) such that there is no intermediate between A and A', and A' is the "first thing with regard to the change."

Bostock believes that Aristotle could not possibly endorse this, as it would be tantamount to an

admission that changes proceed in discrete, indivisible steps. And Aristotle is at pains to deny precisely this atomistic approach to change throughout Physics 6. On these grounds, he says, the argument is "worthless."

It is easy to see why one might think that the continuity of change is inconsistent with the idea that there is a first result in every change. In Physics 6.6, Aristotle says:

> II) Since, then, it has changed in a period of time, and every time is divisible, in half the time it will have completed another change, and again in half of this, another, and so on always.[12] (*Phys*ics 6.6 237a25-28)

Let us try to sharpen the appearance of a conflict here: suppose something has changed from A to B in the time t0-t1. In any part that time, say t0-t.5, it will have undergone another change, from A to A'. In a part of that time, t0-t.25, it has undergone yet another change, from A to A'', and so on. The time of every change is infinitely divisible, and so there is no first division to be made in the time of a change: prior to any division, another can be made. From this it would seem to follow that there is likewise no first thing (A', A'', A''',…) to which anything changes.

But there is a suppressed premise in this line of reasoning. Bostock assumes that

> III) a proper part of a change cannot share both terminal states (i.e "that from which" and "that to which") with that larger change of which it is the part.

We see this assumption in operation when a new division in the time of a change invariably produces a new thing to which the changing thing changes ("at t.25, it has undergone another change, from A to A'""). I intend to resolve Bostock's objection by showing that (I) and (II) are not inconsistent on their own. Rather, (I), (II) and (III) constitute an inconsistent triad. Bostock is right to think that Aristotle is committed to (I) the continuity of change, and that (II) the Partwise

[12] ἐπεὶ οὖν ἐν χρόνῳ μεταβέβληκεν, χρόνος δ' ἅπας διαιρετός, ἐν τῷ ἡμίσει ἄλλο ἔσται μεταβεβληκός, καὶ πάλιν ἐν

argument assumes that all changes have a first result, but wrong to assume that Aristotle accepts (III).

A Continuum of States

The idea (III) that every proper part of a change has at least one terminal state different than the whole is powerfully intuitive, and so it is worth examining how we might arrive at it. This is also a good place to expand on something I covered only briefly in my last chapter: why does Aristotle reject the possibility that qualitative changes could constitute a continuum through which something could change? I begin by sketching out the view that Bostock (and some others) have mistakenly attributed to Aristotle.

Here is Hasper explaining Aristotle's claim that every change is from and to something:

> The idea that every change is from something to something is in its presentation a quasi-spatial one: there is a place or state A, there is a place or state B, and the object changes from A to B. But of course there is temporal dimension to it, since there is an order: first the object is in A, then in B. So in its barest outline the idea involves two states[13] or places correlated to two times – I shall call these two states and times in their correlation the termini of the change.[14]

This is all correct: in a change from A to B over the time t0 to t1, the changing thing is necessarily A at t0 and B at t1. To this extent there is a "correlation" between the terminal moments associated with a change and the terminal states from and to which the change occurs.

But what should we say about the *parts* of a change? Now, Aristotle will agree that every

---

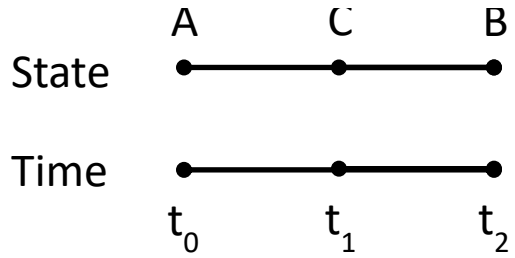
τῷ ἐκείνου ἡμίσει ἄλλο, καὶ αἰεὶ οὕτως·

[13] By "state," Hasper means only "anything that could count as the result of a change."

[14] Hasper, *Continuity*, 156.

proper part of a change necessarily has at least one temporal terminus different from the whole (a proper part of a walk from t0 to t1 can take place from t1-tn, tn-tm, or tn-t1, but not from t0-t1). We might well infer that, if the terminal states and the terminal times of a change are correlated, then (III) the proper parts of change must also have at least one different terminal *state* from the whole. If we divide a change (in thought that is, without actually interrupting it) we get something like this:

Figure 1: state-time isomorphism



In the case of a walk, the "A" and "B" represent the starting and final positions from and to which someone walks. The spatial path between A and B is continuum isomorphic to the time of the walk, such that if one walks continuously, each new moment will correspond with a new position, C, between A and B.

I take it that Bostock's objection appears on the scene when we accept this picture, and in addition apply it to change generally: the states through which something changes (as it, for example, cools or darkens or grows or moves) constitute a continuum in just the same way as a spatial path or a period of time is a continuum. Any division in the time of the change, say into a first half and a second half, also divides this state continuum. On this picture, there is no first thing to which anything changes for the same reason that there is no first moment after the change has begun: in general, between any two points on a continuum, there will always be a third.

But Aristotle does not accept this conception of change, nor could he, given his understanding of the continuum. We may first observe that nowhere in Aristotle's corpus does he suggest that the states through which something changes constitute a continuum. There are precious few comments on this matter, and I believe I have discussed nearly all of them in the last chapter. At 6.4 235a17-18 and 6.5 236b1-7 Aristotle says that the places through which something travels constitute a continuum, but otherwise the states involved in a change do so only "accidentally" because the changing thing is itself continuous. I have omitted only Aristotle's discussion of changes between contradictories, which I will discuss later in this chapter. Of course, there is no intermediate between two contradictory states, much less a continuum.

Aristotle never suggests that there could be a continuum of states other than places. Indeed, he denies it. But why? In order to answer this, it is necessary to review Aristotle's understanding of continuity generally. He generally glosses continuity as infinite divisibility, though it is also clear that he does not consider infinite divisibility to be sufficient for continuity. In GC 1.2 Aristotle considers whether a beam of wood could be divided through and through everywhere. He has several objections to this notion, which he takes to be incoherent, but one of which is that no set of divisions or points could constitute a finite magnitude. He reasons that continua must have a positive size equal to the sum of the sizes of their parts, the sum of the sizes of a set of indivisible parts would be zero (the reasoning behind this conclusion will be explained in a moment).

Continuity is central to the whole of Physics 6, and Aristotle presents an abstract discussion of continuity at the opening of 6.1, before any discussion of change or time specifically. There, he argues that continua cannot be composed from or decomposed into indivisibles, and on the

basis of this, that continua must be infinitely divisible. But both of these defining features are explained in terms of what is apparently a more fundamental concept of continuity, a two-place relation by which some A is continuous with some B.

Continuity as a two-place relation is defined in Physics 5.3:

> A thing that is in succession and touches is contiguous. The continuous is a subdivision of the contiguous: things are called continuous when the touching limits of each become one and the same and are, as the word implies, contained in each other: continuity is impossible if these extremities are two. This definition makes it plain that continuity belongs to things that naturally in virtue of their mutual contact form a unity. And in whatever way that which holds them together is one, so too will the whole be one, e.g. by a rivet or glue or contact or organic union. (5.3 227a10-227a16)

So for example the magnitude AB and BC are continuous because, first, there is a boundary of AB that touches a boundary of BC, and second, the touching boundaries of AB and BC are identical. In 6.1, Aristotle refers back to this definition before using it to argue that no continuous thing can be composed of points, on the grounds that points cannot be continuous with one another.

> Now if the terms ‘continuous’, ‘in contact’, and ‘in succession’ are understood as defined above—things being continuous if their extremities are one, in contact if their extremities are together, and in succession if there is nothing of their own kind intermediate between them—nothing that is continuous can be composed of indivisibles: e.g. a line cannot be composed of points, the line being continuous and the point indivisible. For the extremities of two points can neither be one (since of an indivisible there can be no extremity as distinct from some other part) nor together (since that which has no parts can

have no extremity, the extremity and the thing of which it is the extremity being distinct). (6.1 231a18-231a28)

Points cannot be continuous with one another because on the condition that that they touch and that their touching boundaries are one, the points are simply identical. Points can have no part distinct from another, and so if the boundaries of two points are identical, then the points are identical *simpliciter*. Aristotle infers from this that a series or set of points cannot be continuous, since none can be continuous with another. He also infers that a continuum must be infinitely divisible: if the division of a continuum ever bottomed out in indivisibles, then the whole would be a continuum only on the condition that the indivisibles are in continuous with one another.

This means that continua cannot be constituted by anything other than continua. A period of time, for example, cannot be constituted by any series, even an infinite and densely ordered series, of indivisible moments.[15] Aristotle makes this point when replying to Zeno's paradox of the arrow, generalizing it :

> Zeno's reasoning, however, is fallacious, when he says that if everything when it occupies an equal space is moving or at rest, and if that which is in locomotion is always in a now, the flying arrow is therefore motionless. This is false; for time is not composed of indivisible nows any more than any other magnitude is composed of indivisibles (6.9 239b5-9) (H&G)

So what then do we make of our state continuum, which is supposed to consist of shades, hues, temperatures, and the like? The fundamental fact about a continuum is that it is distinguishable into parts continuous with one another. And so the first question Aristotle would

[15] Cf. *Physics* 6.8-9. It was not until the work of Dedekind and Cantor in the 19th century that we found a way to understand the continuum as constructible from indivisibles, though I doubt this would cut much ice with Aristotle, as it does not answer to the above reasoning.

ask if we were to press him on the possibility of a continuum of colors, sizes, etc., is "can these things, such as colors, be continuous with one another?" The *prima facie* absurdity of one color sharing a boundary with another[16] explains why Aristotle never seems to take the idea of a continuum of color seriously.[17] As we saw in the previous chapter, Aristotle gives every indication of believing (at both stages of development identified in my previous chapter) that alterations occur either part-by-part, or discontinuously.

This does not itself show that (I) there is always a first result in every change. The states through which something darkens or cools may well be densely ordered, even if they do not constitute a continuum. However, we can conclude that if Aristotle has made a mistake in saying that (I) every change involves a first result, it is not because this conflicts with his dictum that (II) every change is continuous. The series of states from and to which something changes cannot constitute a continuum in any case, and so if changes are continuous, it is not in virtue of the states to and through which a given thing changes. But this is enough to disable Bostock's objection, as it stands: Bostock's objection is that (I) and (II) *conflict*. Aristotle may be entirely at sea in claiming that changes are continuous, given his views about what can and cannot constitute a continuum, but this would just be a problem for Aristotle's acceptance of (II), not a conflict between it at (I). Next, I will discuss the part-by-part conception of change Aristotle seems to adopt in 6.4. My aim will be to show how part-by-part change makes it possible for

[16] Of course, colored *things* may share boundaries, as for example when we construct a color wheel. The absurdity I am pointing to is one on which colors *themselves* somehow take up space, have edges, and touch one another. The way Aristotle puts this is to say that colors (and qualities generally) are not continuous *per se*. Cf. *De Sensu* 6 445b26.

[17] Place and locomotion might seem to be exempt from these difficulties, but if we may distinguish between "positions" (points in space) and "places" (volumetric areas in space) then it seems to me that the same argument will show that there can be no continuum of positions through which something moves. And as we have seen, the probable inspiration for the Partwise argument in *Parmenides* does indeed see locomotion in terms of places, rather than positions. I shall follow this thread, and the implication that locomotion should be thought of as a motion from one volumetric area into another, in the next chapter.

Aristotle to accept that (I) changes have first results, and that (II) changes are always continuous, while eschewing the assumption that (III) the proper parts of a change always have different terminal states from the whole.

Part-by-part Change

The Partwise argument itself (234b10-20) offers very little guidance on how to understand part-by-part change, but the subsequent passage (234b21-235a10) is richer. There, Aristotle sets out to show that that a change is divisible into the changes of the parts of the moving thing.

> And change is divisible in two ways. One way is by way of the time, and the other is according to the changes of the parts of the moving thing. For example, if AC moves as a whole, both AB and BC will move. Let DE be the change of the part AB and EF be the change of the part BC. Now, it is necessary that the whole [change] DF be the change of AC (234b21-26).[18]

To illustrate with a familiar case first, suppose we immerse a stick of wood (AC) in a bucket of blue paint. Ignoring the motion of the stick from one place to another, let us call the whole change by which the stick becomes blue "DF". The change DF can be divided into serial parts, for example into a first half DE followed by the second, EF. Notice then that DE is the change by which the bottom half of the stick (AB) became blue, while EF is the change by which the top half of the stick (BC) became blue. At least in such a case, we can identify a correspondence between parts of the stick and parts of the change.

This is not a change through a series of hues or shades, but nevertheless it is clear that

[18] κίνησις δ' ἐστὶν διαιρετὴ διχῶς, ἕνα μὲν τρόπον τῷ χρόνῳ, ἄλλον δὲ κατὰ τὰς τῶν μερῶν τοῦ κινουμένου κινήσεις, οἷον εἰ τὸ ΑΓ κινεῖται ὅλον, καὶ τὸ ΑΒ κινήσεται καὶ τὸ ΒΓ. ἔστω δὴ τοῦ μὲν ΑΒ ἡ ΔΕ, τοῦ δὲ ΒΓ ἡ ΕΖ κίνησις τῶν μερῶν. ἀνάγκη δὴ τὴν ὅλην, ἐφ' ἧς ΔΖ, τοῦ ΑΓ εἶναι κίνησιν.

Aristotle is entitled to think that this change is continuous. The stick itself is an infinitely divisible body, and so we can take any part of the time of the whole change and find the corresponding part of the stick that changed in that period. Despite the fact that there is only one "thing to which" the stick changes, being blue, the change has infinitely many intermediate stages.

At this point, we can revive Bostock's worry. Here is one way to understand the change: the stick goes from being 0% blue to 100% blue, where the percentage tracks the amount of the surface of the stick covered in blue paint. Since the stick changes continuously, we can divide the change from 0% to 100% into a first half, in which it changes from 0% to 50% blue, and a second half, in which it changes from 50% to 100% blue. Understood thus, the change is both (II) continuous and (III) every proper part of the whole change has a unique pair of terminal "states" (where these have the form "being n% blue"). There is, moreover, no first result: there is no change to n% blue that is not preceded by a change to m% blue, where m<n. This is Bostock's understanding of part-by-part change,[19] and if Aristotle is also committed to this analysis, then he makes the mistake Bostock attributes to him.

Aristotle does not appear to proceed in this way: in 6.4 234b10-20, he says says that when something is changing from white to grey, it is partly white and partly grey. Since grey is the "first thing" in the change, being "partly grey" doesn't appear to count as something to which the changing thing changes. Aristotle would understand the stick's change to blue thus: there is only one (and therefore there is a first) thing to which the stick changes, namely "blue," though while it is changing it is partly white and partly blue. On Aristotle's understanding, the change is (I) continuous (since the body of the stick is continuous) and there is (II) a first result. Hence, we

[19] Bostock, *Space*, 174.

have identified the view on which 6.4 234b10-20 would not be the blatant error that Bostock finds. But there remains the question of the viability of Aristotle's approach. In particular, it is worth examining the implications of the fact that, on this view, (III) is false, and so any proper part of the stick's change from white to blue is also a change (of a part of the stick) from white to blue. In at least some cases, it appears, the proper parts of a change can share their terminal states with the whole.

Nothing can become "partly F"

We have seen that a theory of change on which changes are both continuous and have a first result requires a restriction on what can count as "that to which" something changes: being partly F, or being n% F (or however we want to put it) cannot count as something from or to which something changes. If Aristotle's argument is a good one, then he must have good reasons to accept this restriction, as well as the principle that there is always a first result of a change, independent of the Partwise argument.

Bostock's objection expresses a modern willingness to treat just about any sort of transition from one situation to another as a change. By comparison Aristotle is extremely restrictive: changes must be changes of quality, quantity, place, or they must be the coming to be or destruction of some substance. The things to and from which things change must be the *infima species* within each of these categories. And so an immediate reason for restricting the things from and to which something can change so as to exclude things like "being partly F" or "being 30% F" is that these are not categorical predicates: "blue" and "30% blue" are not two distinct species of color. The latter term does not describe a quantity, quality, or place. Rather, it bundles together a quality, and a specification of the part of a whole thing having that quality.

I will explain the claims of the above paragraph by turning to Aristotle's discussion of the logical parts of a change in *Physics* 5.1. *Physics* 5.1 is Aristotle's first step in his taxonomy and analysis of changes. He begins by describing the logical parts of a change. These are 1) the *agent* of the change, which is the efficient cause of the change, 2) the *patient* or *subject* of the change, which undergoes the change, 3) the *time* of the change, and finally 4) *that from and to which* something changes. In each case, one can understand these terms…

> …accidentally, or according to a part and with reference to something other than itself, or primarily and with no reference to anything else[20] (*Physics* 5.1 224b16-18)

Aristotle lists three ways in which we can understand, for example, the patient of a change: accidentally, according to a part, and primarily. Suppose for example you were to burn my blue chair. In this case, the fact that a blue thing was burned would be a change described according to an accident, since it's not insofar as it is blue that it was burned. Rather, it is the chair, or perhaps the wood of the chair, that is burned unqualifiedly (ἁπλῶς). Aristotle's example of something that undergoes a change non-accidentally but also not primarily is a man who is healed because his eye or chest is healed: the man is genuinely healed (μεταβάλλειν ἁπλῶς), but he is healed in virtue of a part of him (κατὰ μέρος) having been healed. By contrast, Aristotle can describe the eye or chest thus:

> But there is something which is neither moved accidentally, not in virtue of something else belonging to it, but in virtue of itself primarily moving[21] (*Phys* 5.1 224a26-28).

The eye or chest itself is changed, not accidentally nor in virtue of a part, but primarily and in itself.

[20] ἔστιν δὲ καὶ ἐν ἐκείνοις καὶ τὸ κατὰ συμβεβηκὸς καὶ τὸ κατὰ μέρος καὶ [τὸ] κατ' ἄλλο καὶ τὸ πρώτως καὶ μὴ κατ' ἄλλο,

[21] ἔστι δέ τι ὃ οὔτε κατὰ συμβεβηκὸς κινεῖται οὔτε τῷ ἄλλο τι τῶν αὐτοῦ, ἀλλὰ τῷ αὐτὸ κινεῖσθαι πρῶτον.

Aristotle is moved to make these distinctions in order to accommodate colloquial claims about changes and changing things with the results of Aristotle's inquiry into what change strictly entails. We can answer "what did you burn?" correctly with "the blue thing" if it pleases us, while acknowledging that, strictly speaking, only what has a potential to be burned may be burned, and so in the primary sense what burned was the wood. In addition to a distinction between accidental and non-accidental change, Aristotle makes a further distinction within non-accidental change. First something might change "in itself" and "primarily" or it might change "according to a part (κατὰ μέρος).[22] In doing so, he follows Plato's precedent in the Republic and may be motivated by the same kinds of concerns we find in Republic 4 436c-d: how is it that someone can both move and yet not move? They move according to a part (when they wave their arm), while some other part of them remains still. One finds a contradiction only in the claim that something at the same time moves primarily and yet does not move.

Aristotle's distinction between something's changing primarily and changing according to a part entails a restriction on what sorts of things can be the terminal states of a change: no primary changing thing, i.e. nothing that changes in itself, can change to being partly F. If anything did change to being partly F, then this could not be the primary subject of the change, since the primary subject must change as a whole. Rather, the part of the thing that is now wholly F would have to be counted as the primary subject.

Aristotle's Partwise argument should be read then as pertaining to primary subjects of change. Aristotle gives us some indication that this is his intention in Physics 6.10 240b8-241a6, which presents another version of the Partwise argument. There, Aristotle argues that no

[22] See Rosen, Jacob. "Physics V-VI versus VIII: Unity of Change and Disunity in the Physics" in Aristotle's Physics: A Critical Guide Ed. Mariska Leunissen. Cambridge: Cambridge University Press, 2015: 66-72 for a roughly parallel account of these distinctions, though one that does not emphasize the notion of being an unqualified

indivisible thing could change, and he clarifies beforehand that an indivisible thing can change accidentally, if it belongs to or inheres in a changing divisible body. But indivisible things cannot change in themselves (καθ' αὑτὸ). The argument that follows this clarification therefore pertains only to what does change in itself. This explains why Aristotle takes for granted, both in 6.4 and 6.10, that being partly F is not something to which a changing thing can change.

The Paradox of Continuous Change Between Contradictories

It is worth a digression into the case of contradictory change, so as to see how this restriction solves an otherwise sticky paradox. At the end of *Physics* 6.9, Aristotle sets out to resolve a paradox[23] about how a change between contradictories can be continuous given that nothing lies between the original and final situations of the change.

> Nor in reference to contradictory change shall we find anything impossible—e.g. if a thing is changing from not-white to white, and is in neither condition, then it will be neither white nor not-white; for the fact that it is not wholly in either condition will not preclude us from calling it white or not white. We call a thing white or not-white not because it is wholly either one or the other, but because most of its parts or the most essential parts of it are so: not being in a certain condition is different from not being wholly in that condition. So, too, in the case of being and not-being and all other conditions which stand in a contradictory relation: while the changing thing must of necessity be in one of the two opposites, it is never wholly in either (*Physics* 6.9 240a19-

subject of change.

[23] I call this a "paradox" because it appears in *Physics* 6.9, a chapter given over to the discussion of the paradoxes of motion and change. Its placement here suggests that it has a history as a debating point among Aristotle's interlocutors.

29).[24]

To paraphrase: if something changes from one contradictory to another, then it must at some time *be changing*, and while it is changing it cannot be in that from which nor that to which it is changing (cf. the first two premises of the Partwise argument). So if something changes from not-white to white, then it must at some time *be changing*, and when it is changing, it can neither be white nor not white. But as a matter of logic, everything must be white or not-white, and so it looks like continuous change between contradictories are impossible.

Bostock raises doubts about Aristotle's account of contradictory change in *Physics* 6, essentially in terms of this paradox. Bostock is unimpressed with Aristotle's explicit response to this worry at 6.9 240a19-29, quoted above. He sums up this objection as follows:

> Now on the face of it this does not resolve our problem, for it reaffirms that at any instant the thing either is white or is not white, and so leaves no time for it to be changing from the one to the other. But at the same time the passage strongly suggests—without quite affirming it—that the change in question is 'really' between contraries and not between contradictories, namely between the initial state of being wholly not white, and the final state of being wholly white.[25]

Bostock sees Aristotle as vacillating here between two horns of a dilemma. On the one hand, Aristotle suggests that the change is between being *wholly* not-white and being *wholly* white. But, Bostock thinks, these are not really contradictories, because not everything needs to be one or the other. If this is Aristotle's strategy, then he has conceded that genuine contradictory

[24] οὐδὲ δὴ κατὰ τὴν ἐν τῇ ἀντιφάσει μεταβολὴν οὐθὲν ἡμῖν ἔσται ἀδύνατον, οἷον εἰ ἐκ τοῦ μὴ λευκοῦ εἰς τὸ λευκὸν μεταβάλλει καὶ ἐν μηδετέρῳ ἐστίν, ὡς ἄρα οὔτε λευκὸν ἔσται οὔτε οὐ λευκόν· οὐ γὰρ εἰ μὴ ὅλον ἐν ὁποτερῳοῦν ἐστιν, οὐ λεχθήσεται λευκὸν ἢ οὐ λευκόν· λευκὸν γὰρ λέγομεν ἢ οὐ λευκὸν οὐ τῷ ὅλον εἶναι τοιοῦτον, ἀλλὰ τῷ τὰ πλεῖστα ἢ τὰ κυριώτατα μέρη· οὐ ταὐτὸ δ' ἐστὶν μὴ εἶναί τε ἐν τούτῳ καὶ μὴ εἶναι ἐν τούτῳ ὅλον. ὁμοίως δὲ καὶ ἐπὶ τοῦ ὄντος καὶ ἐπὶ τοῦ μὴ ὄντος καὶ τῶν ἄλλων τῶν κατ' ἀντίφασιν· ἔσται μὲν γὰρ ἐξ ἀνάγκης ἐν θατέρῳ τῶν ἀντικειμένων, ἐν οὐδετέρῳ δ' ὅλον αἰεί.

change is impossible after all. On the other hand, Aristotle also says that something can be called "not-white" and "white" in a variety of situations, for example when it is just mostly white, or if its important bits are white. Bostock takes Aristotle to be imagining an instantaneous transition from "not-white" to "white," say at the point at which the thing is over 50% white. But if this is Aristotle's intention, then the transition between not-white and white is discontinuous. There will be no continuous change between the initial state and the final one. It does no good to say, as Hasper (2003 181-2) does, that there is a continuous change through various degrees[26] of whiteness (all of which count as being "not-wholly-white") at the end of which something comes to be wholly white. For we cannot identify the change ether with the transition from not-wholly-white to wholly-white, since this is discontinuous, nor with the process through degrees of whiteness, since this involves intermediates and so is not a change between contradictories.

The paradox is stubborn, and I think the modern reader will generally acquiesce to its conclusion: changes between contradictories are discontinuous, or they're just derivative ways of describing what are really continuous changes between contraries—that is, states having intermediates between them. But this is a case where Aristotle's approach allows for a theory of some descriptive power. By making use of his concept of a primary changing thing, Aristotle can admit genuinely continuous changes between genuine contradictories.

Considered as the primary subject of a change, what does it mean for something to be not-white or white? Since it must—if it is indeed the primary subject of a change—change as a whole, then to be not-white is to be *wholly* not-white, and to be white is to be *wholly* white. This means that nothing can be the primary subject of a change to white if any part of it is white prior to the change. Likewise, nothing can be the primary subject of a change from not-white if any

[25] Bostock *Space*, 2006, p.174

part of it remains not-white by the end of the change. If something goes from being half-white to being wholly white, or not at all white to half-white, then the primary subject of the change was not the whole thing, but the half of it that changed completely. In short, for the primary subject of a change, "being wholly F" and "being F *simpliciter*" amount to the same thing.

Suppose we paint a beam white, and that the beam is the primary subject of change, so that it went from being wholly not-white to being wholly white. Is this change really continuous? Yes, since there is a continuous process by which the change came to be white part-by-part as it was painted. But then is this really a change between contradictory termini? Yes. Considered as a primary subject of change, and thus as a *whole*, the crate is in no intermediate situation between being (wholly) not-white and being (wholly) white.

Once this is understood, Aristotle's explicit response to the paradox is clear enough: the primary changing thing, considered as such and therefore as a whole, is neither white nor not-white when it is changing. But the fact that the primary subject of the change is neither white nor not white while it is changing is no more paradoxical than the fact that a daisy is neither white nor not-white *as a whole*. Aristotle then assures us that in any case, we can always call the crate white or not-white by whatever standard we care to stipulate. For we needn't think of the crate as the primary subject of a change when we apply these standards. In order to emphasize the deflationary nature of this solution, he puts the point in terms of what *we say* (λεχθήσεται and λέγομεν), which, I suggest, is the "we" of everyday speakers[27] of Greek. Likewise, the thought then that something can become partly F is not, therefore, to be forbidden. It's a perfectly

[26] Murphy raises similar objections, "Alteration," 215-216.
[27] This "anthropological we" is found everywhere in Aristotle's works, and in the *Physics*, though it's not always easy to distinguish between this and the "we" of Aristotelian physicists. For a local example of the anthropological we, see *Physics* 6.6 236b19-22: "Now every changing thing changes in time, but we say 'the time in which it changed' both 'primarily' and 'according to something different.' For example, 'in a year' because something is changing in a day."

reasonable way of speaking. But we should not get confused and treat this way of speaking as if it belongs to the fundamental analysis of change.

The Structure of Part-by-Part Change

Up to this point, I've sketched out a conception of change on which there is no inconsistency between a change's being continuous and its having a first result. To sum it up: suppose something (the primary subject of the change) changes from A to B, and let us assume that there are no intermediates: B is the first and the last thing to which the subject changes. The change occurs part-by-part, and so while the thing is changing, or if the change is interrupted at any point, the whole changing thing will be partly A and partly B. If we interrupted the change, then the part of it that is now B will have been the primary subject of the change instead of the whole thing, since the part that is B is the only thing that is entirely in the new state. The primary subject of a change is just whatever has completely changed at a given moment, and it need not be a separate body in its own right.

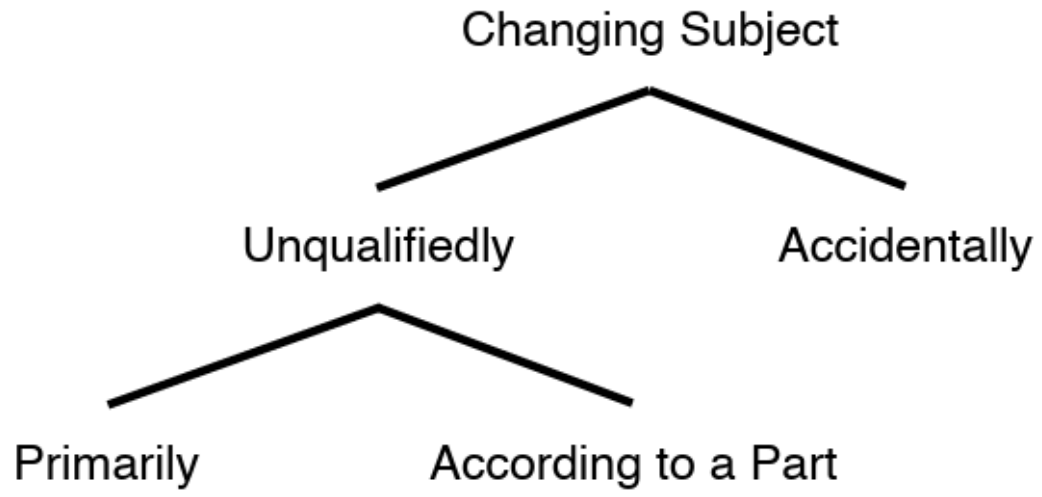
If there is an intermediate between A and B, A', then let us assume that the changing thing changes from A to A' part-by-part, and then from A' to B part-by-part.[28] Since "being partly F" cannot be the result of a change for any primary changing thing, a proper part of the change from A to some immediate B will also be a change from A to B. The part of such a change is the change of a different primary subject, namely a proper part of the whole thing. On this conception of change, every change is continuous (because the changing body is so), and every change has a first result, this being whatever state first spreads out or propagates through the body of the changing thing.

[28] A more complex picture is certainly possible, but Aristotle gives us no hints as to how to explore this question, so

It is also worth clarifying some of the distinctions relating to the changing thing as a changing thing. Suppose you set about painting a plank of wood. As it happens, "something flammable" is the subject of the change, but this is only *according to an accident (*κατὰ συμβεβηκὸς). Really, you are painting a plank, which happens to be flammable. When I say "really, you are painting a plank" what I mean in Aristotle's terminology is that that the plank is the unqualified (ἁπλῶς) subject of the change. Once you finish painting the plank, the plank is now also something that changed *primarily* and i*n its own right*. But, now, suppose you knock over your can of paint before you finish painting the plank, and so you stop some ways through to clean up. Still, the half-painted plank is the unqualified subject of the change, but it is not the primary subject. The primary subject of the change is just whatever part of the plank has been painted. The whole plank is the subject of the change *according to a part* (κατὰ μέρος).

We can diagram these distinctions as follows:

Figure 2: modalities of change



If we want to find the term within this set of distinctions that best maps on to our ordinary ways

for the sake of the present analysis I will assume the simpler one.

of picking out the subject of a change, it is undoubtedly the unqualified (ἁπλῶς) subject. By contrast, the notion of a primary subject of change verses what changes according to a part is somewhat more artful: the sort of thing one would sort out when composing a theory, or answering a particularly exacting questioner.

A final question: supposing that changes do sometimes pass through intermediate states (such as A' above), isn't it possible that in a given change, there are infinitely many such states? I don't think Aristotle's conception of part-by-part change rules this out. Rather, Aristotle would rule out this possibility on the grounds that, since these states cannot constitute a continuum, they could be infinite only in the pernicious way: not infinite in terms of divisibility, but infinite in number. With this, we can posit a theorem: every change involves a finite number of things to which it changes.

μchanges and Mchanges

It will be useful, going forward, for me to introduce a theoretical contrivance. Aristotle says in 234b10-20 that whenever something is changing, a part of it is in that from which it is changing and a part of it is in that to which it is changing. This makes sense so long as "that to which it is changing" is the *next* thing in the change, and Aristotle restricts his point to these cases. He does not intend to suggest that, if I am driving from Chicago to Philadelphia, there is any part of my car that is ever partly in Chicago and partly in Philadelphia. In order to bring the kinds of changes for which Aristotle's part-by-part conception holds into higher contrast, I will distinguish between "μchanges" (or "micro-changes") and "Mchanges" (or "macro-changes"). A μchange is a change between some original condition and a *next* or *first* condition. To take up Aristotle's own example, if something changes from white to light grey, to grey, to dark grey, to

black, then the changes from white to light grey, or light grey to grey are μchanges; there are no intermediate shades between the original and the final shade. However the change from white to grey and the change from white to black are Mchanges: they are changes from an original to a final condition through at least one intermediate. Aristotle's thesis that the changing thing must be partly in that from which and partly in that to which it changes is true *only* of μchanges.

I call this a theoretical contrivance because the distinction between μchanges and Mchanges appears nowhere in Aristotle's text, and corresponds to no pair of Greek terms. However, I do see these terms as a logical extension of Aristotle's explicit distinction between the "first thing" (τὸ πρῶτον) to which something changes and "the extremes" (τῶν ἄκρων), at 234b17-19. Changes to the "first thing" are μchanges, changes to "the extreme," where this is not identical to the first thing, are Mchanges. Mchanges always consist of at least two μchanges, such that μchanges are temporally distinct parts, or stages, of the whole Mchange.

As we will see, Aristotle's ambitions in *Physics* 6.4-6 are limited to explaining the continuity of time, change, spatial distances, etc. and do not include an articulate theory of how changes happen part-by-part. Some substantial interpretive construction (I do not say *re*construction) is therefore necessary for a full understanding of the conception of change found here. The distinction between μchanges and Mchanges is the first major step in that construction. Fortunately, Aristotle generally leaves us few choices in deciding how to fill out his understanding of change: there aren't many ways to conceive of a "first place" to which some locomoting body moves, given the necessity that a continuous locomotion have such a first place. On the other hand, we will sometimes be left with questions we cannot answer decisively and as a matter of scholarship.

With that preamble, we can make some observations about the structure of, and relation

between, μchanges and Mchanges. Mchanges, and the μchanges of which they are composed, will be divisible into infinitely many parts. Take for example the change from A to a "first thing" B, and finally to an "extreme" C. The whole change from A to C is what I am calling a Mchange, while the change from A to B, and the subsequent change from B to C, are μchanges. As we've seen, that a change is divisible does not entail that the parts of that change have different termini than the whole. In particular, the parts of an μchange *always* have the same termini as the whole μchange. These parts are distinct in that they are changes of different *primary subjects*, the parts of the changing thing. Since the changing thing is infinitely divisible into parts, so is the μchange. We have no reason to doubt that Mchanges are also infinitely divisible, at least in the case of locomotions and changes of size. Aristotle is clear in *Physics* 6.6 237a28-32 that motions involving magnitude (locomotions and changes of size) are divisible according to the magnitude of the motion: a kilometer-long run may be divided into as many parts as one likes. One set of divisions also divides the run into μchanges. On the other hand, I think we are much less inclined to see changes that don't involve magnitude as composing Mchanges. Generations and destructions are always μchanges by definition, since they exclude any intermediates. And in an alteration from A to B to C, there seems little reason to privilege the Mchange from A to C, as opposed to calling this two μchanges from A to B and then B to C.

This analysis does result in an odd feature: there will be parts of the Mchange that are not μchanges of the whole changing thing, nor parts of μchanges of the whole changing thing. For example if the changing thing is partly in A and partly in B at t2 and partly in B and partly in C at t4, then the change occupying the time t2-4 cannot be understood as the change of the whole changing thing if it is to be understood in terms of the places A, B, and C, or if it is a change of the whole changing thing, it is not a change to or from A, B, and C in any sense. I don't know

what Aristotle would say in this case. Since the details of a kinematic theory aren't his primary concern, he doesn't explore the issue. In my estimate the best fit would be for Aristotle to remind us that not every part of the change of a given changing thing Z is itself a change where Z is the primary subject of change. Indeed, in a μchange, Z isn't the primary subject of change in any part of a μchange of Z where it is the primary subject. Nor, if there are genuinely continuous Mchanges, is every part of a change from some A to some B necessarily also a change from A to B. Parts of an Mchange like the change of Z during t2-4 are simply parts that are neither a change from and to the same terminal states as the whole Mchange (like μchange parts of an Mchange), nor are they changes of the same primary changing thing as the Mchange (like the μchange parts of a μchange). As complicated as this sounds, the point is just that nothing prevents Aristotle from acknowledging that a) Mchanges are not measured by the division in the changing thing the way μchanges are, b) not all parts of Mchanges are μchanges of the same primary changing thing. With these two points in mind, Aristotle can safely say that Mchanges are divisible because μchanges are divisible, and μchanges are divisible because changing things are.

What unifies Mchanges? I think this question is not answered by any appeal to the parts of the change in either the case of Mchanges (where these parts are variegated) or μchanges, where the parts correspond to the changes of the parts of the thing. We should take our cue from Physics 5 and 8 where Aristotle discusses the unity of changes. There, we find a set of criteria: it must take place in a continuous time (which every μ- and Mchange satisfies), it must be of one subject (which both satisfy given that changing *kata mere* is changing non-accidentally), and it must be a change from and to something entirely specific: of changes of color, blue or black, for example. Additionally, Aristotle suggests in 8.10 that a change might even apparently meet all of

these conditions yet fail to be one change. He has in mind the ballistic motion of an arrow after it's left the bow. The changing thing is one, the arrow, the time of its change is continuous, and the change throughout is a unidirectional locomotion. Yet the change is not one because there is no one efficient cause in contact with the arrow throughout its flight: after its left the bow, the arrow's motion is sustained by the air around it. So the motion of the arrow is a series of consecutive but separate changes. In sum, the unity of a change doesn't have anything to do with the distinction between μchanges and Mchanges.

Chapter 3: Part-by-part Change

I have argued that the "Partwise argument," namely 6.4 234b10-20, depends upon a certain kinematic principle: that all changes happen part-by-part. I also suggested, in my first chapter, that this principle was always a part of Aristotle's physical theory: while Aristotle change his mind about the possibility of discontinuous changes, and about what explains the continuity of change, he always seems to have believed that any *continuous* change happens part-by-part. Yet it is clear from a survey of scholarship on Aristotle's natural philosophy that this principle is neither widely acknowledged, nor well understood. Aristotle himself is guilty here: he never takes the time to explain the consequences of the part-by-part conception of change and I expect that this is because it is neither original to him nor something he takes to be particularly interesting *until* it becomes the basis for his explanation of continuity in general. There is a certain need, then, for a detailed discussion of part-by-part change, and that is what will occupy this chapter. My main aim will be to show that a part-by-part kinematic story can be brought into line with Aristotle's theory of change generally. That is, I mainly want to show that Aristotelian changes are *consistant* with part-by-part kinematics. In order to accomplish this, I will need to substantively elaborate on Aristotle's own description of part-by-part kinematics.

I will approach this topic by taking each species of change in turn,[1] but two will capture most of my attention, because they teach us some particularly important lessons. The first is locomotion, or the motion of a body from place to place. Examining the case of locomotion is a good way to explore the sense in which a changing thing has parts, since it will turn out that the parts implicated in something's changing are of a very specific (and change relative) kind. The second is the case of generation. Generation presents a particular puzzle because the changing

thing only comes into existence at the *end* of the change. So when we hear that something comes to be part-by-part, we can reasonably ask "parts of *what*?" Finally, I briefly discuss growth: Aristotle's demand that growth always preserve the proportions of the growing body poses some particular challenges for the part-by-part theory of change, but I show that these can be overcome by application of the lessons learned from a study of locomotion and generation.

I will summarize here what a part-by-part kinematic theory entails. This will give us some sense of the standards we need to meet in order to make sense of a certain sort of change. I take these to be:

> -The states from and to which something changes constitute a finite series, and so there is always a "first" state to which something changes.
>
> -The states from and to which something changes are restricted to: qualities, quantities, places, being, and non-being.
>
> -Every changing thing is infinitely divisible into spatially differentiated parts.
>
> -When something is changing, it is partly in its original state and partly in the first or next state.

Locomotion

Locomotion, motion from one place to another, might seem to offer Aristotle a relatively easy case of part-by-part change. Or at any rate, it is easy to imagine a box moving from one box-shaped-and-sized-place AB to an adjacent box-shaped-and-sized place BC in such a way that, when it is moving, part of the box is in AB and part is in BC. Bostock, who is pessimistic about the Partwise argument generally, thinks that locomotion is nevertheless a plausible case in

[1] Excepting alterations, which I take to be covered adequately by the discussion in my last chapter.

which something can be said to be partly in that from which, and partly in that to which, it is moving while it is moving.

If, quite apart from the context of Aristotle scholarship, one asked me to describe the kinematics of a locomotion, I would be inclined to treat to the moving body as if it were a point, following a one dimensional path through space. I would find a (literal) point of measurement, such as the center of gravity or a point on the leading edge of a body, and then I would trace a continuum of points between an initial position and a final one. On this analysis, it is impossible that there could be a "first" point to which something changes, because there is no first or next point after the point of origin, along a continuous path. Whatever I do say about the idea that the body is "moving," I could not say that "it is partly in that from which, and partly in that to which, it is moving when it is moving." A body, construed as a point, cannot be "partly" in anything, because points have no parts. Nor, for the same reason, can anything be partly in a point-like location.

Aristotle himself often writes about locomotion in just this way, and this approach underlies his analysis change, magnitude, and time in Physics 4.10-14—the "old theory" for which 6.4-6 is intended as a revision.

> The 'now' in one sense is the same, in another it is not the same. In so far as it is in succession, it is different (which is just what its being now was supposed to mean), but its substratum is the same; for motion, as was said, goes with magnitude, and time, as we maintain, with motion. Similarly, then, there corresponds to the point the body which is carried along, and by which we are aware of the motion and of the before and after involved in it. This is an identical substratum (whether a point or a stone or something else of the kind), but it is different in definition—as the sophists assume that Coriscus'

> being in the Lyceum is a different thing from Coriscus' being in the market-place. And the body which is carried along is different, in so far as it is at one time here and at another there. But the 'now' corresponds to the body that is carried along, as time corresponds to the motion.[2]

This is a dense and controversial passage, and so I wish to focus on the connection Aristotle draws between the now—a point-like division in time, between past and future—the moving body, and a point on a spatial path. Imagine a locomotion has just now come to an end; a stone has rolled from its initial position A to a new position B, where A and B are points that terminate the spatial path of the stone. Corresponding to these points are the two nows that terminate the time of the locomotion: the last moment in which the stone was in A and the first moment at which it is in B. Then we have the locomotion itself: if the locomotion, the time, and the spatial path are all corresponding continua, what in the locomotion corresponds with B, and to the terminal moment of the change? Aristotle's answer is: the moving body, and specifically the body-in-B. The moving body, as well as that from and to which it changes, are seen as indivisible limits of the continua they delimit. Of course, the rolling stone is not actually a point: like any body it has dimensionality. Only, this dimensionality is irrelevent to the kinematics of its motion, and in particular to the relationship between that motion, that from and to which the motion occurs, and the time in which it occurs. The parts of the stone are never implicated in the locomotion.

I've argued, in my first chapter, that Aristotle revises this kinematic theory in favor of the

[2] τὸ δὲ νῦν ἔστι μὲν ὡς τὸ αὐτό, ἔστι δ' ὡς οὐ τὸ αὐτό· ᾗ μὲν γὰρ ἐν ἄλλῳ καὶ ἄλλῳ, ἕτερον (τοῦτο δ' ἦν αὐτῷ τὸ νῦν <εἶναι>), ὃ δέ ποτε ὄν ἐστι τὸ νῦν, τὸ αὐτό. ἀκολουθεῖ γάρ, ὡς ἐλέχθη, τῷ μὲν μεγέθει ἡ κίνησις, ταύτῃ δ' ὁ χρόνος, ὥς φαμεν· καὶ ὁμοίως δὴ τῇ στιγμῇ τὸ φερόμενον, ᾧ τὴν κίνησιν γνωρίζομεν καὶ τὸ πρότερον ἐν αὐτῇ καὶ τὸ ὕστερον. τοῦτο δὲ ὃ μέν ποτε ὂν τὸ αὐτό (ἢ στιγμὴ γὰρ ἢ λίθος ἤ τι ἄλλο τοιοῦτόν ἐστι), τῷ λόγῳ δὲ ἄλλο, ὥσπερ οἱ σοφισταὶ λαμβάνουσιν ἕτερον τὸ Κορίσκον ἐν Λυκείῳ εἶναι καὶ τὸ Κορίσκον ἐν ἀγορᾷ. καὶ τοῦτο δὴ τῷ ἄλλοθι καὶ ἄλλοθι εἶναι ἕτερον· τῷ δὲ φερομένῳ ἀκολουθεῖ τὸ νῦν, ὥσπερ ὁ χρόνος τῇ κινήσει

part-by-part theory articulated in *Physics* 6. In particular *Physics* 6.10 speaks directly to question of the changes of indivisibles, with a special focus on locomotion. The central argument of that chapter is a rehearsal of the Partwise argument found at 6.4 235b10-20.

> Suppose something changes from AB to BC, either from magnitude to magnitude, or from form to form, or in terms of some pair of opposites. And let the time in which it primarily changes be D. Then, in the time in which it is changing, it must either be in AB or in BC or partly in one and partly in the other. For this holds of every changing thing. Now, it will not be partly in each of the two, for then it would be divisible. But neither can it be in BC, for then it will have changed, but by hypothesis it is changing. It remains then that it is in AB, in the time in which it is changing. Therefore it will be resting, for something is at rest when it is in the same thing for a period of time. So it is not possible for something partless to be in any way moving or changing[3] (6.10 240b20-31).

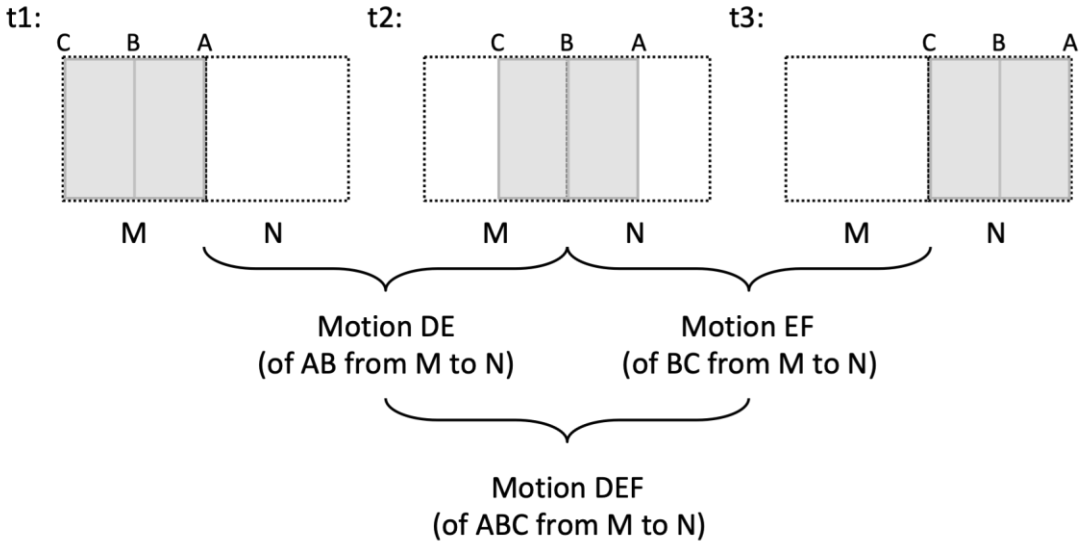
Contrast this line of thought with that found in 4.11: here there is no attempt to connect the states from and to which the thing changes with the termini of a period of time. The original and final state of the changing thing are, like the changing thing itself, understood as continua divisible into parts. It is not hard to imagine the diagram Aristotle would produce for his students: he might draw a line and make three marks in it, A, B, and C, defining two regions, AB and BC. Then we can imagine him moving some object, or drawing something to indicate a moving object, from its position in AB to rest entirely in BC. He might then observe that so long as it is moving, the division B marks a division somewhere in the moving thing. This might well echo

[3] μεταβαλλέτω γὰρ ἐκ τοῦ ΑΒ εἰς τὸ ΒΓ, εἴτ' ἐκ μεγέθους εἰς μέγεθος εἴτ' ἐξ εἴδους εἰς εἶδος εἴτε κατ' ἀντίφασιν· ὁ δὲ χρόνος ἔστω ἐν ᾧ πρώτῳ μεταβάλλει ἐφ' οὗ Δ. οὐκοῦν ἀνάγκη αὐτὸ καθ' ὃν μεταβάλλει χρόνον ἢ ἐν τῷ ΑΒ εἶναι ἢ ἐν τῷ ΒΓ, ἢ τὸ μέν τι αὐτοῦ ἐν τούτῳ τὸ δ' ἐν θατέρῳ· πᾶν γὰρ τὸ μεταβάλλον οὕτως εἶχεν. ἐν ἑκατέρῳ μὲν οὖν οὐκ ἔσται τι αὐτοῦ· μεριστὸν γὰρ ἂν εἴη. ἀλλὰ μὴν οὐδ' ἐν τῷ ΒΓ· μεταβεβληκὸς γὰρ ἔσται, ὑπόκειται δὲ μεταβάλλειν. λείπεται δὴ αὐτὸ ἐν τῷ ΑΒ εἶναι, καθ' ὃν μεταβάλλει χρόνον. ἠρεμήσει ἄρα· τὸ γὰρ ἐν τῷ αὐτῷ εἶναι χρόνον τινὰ ἠρεμεῖν ἦν. ὥστ' οὐκ ἐνδέχεται τὸ ἀμερὲς κινεῖσθαι οὐδ' ὅλως μεταβάλλειν·

the demonstration found in the Parmenides wherein a body moved into a space must be at some point divided by the boundary of that space.

Let us take this, then, as a model for the part-by-part analysis of locomotion. Our objective is to make sense of locomotion in the terms laid out in the introduction of this chapter. I should point out now that I will use the more articulate terminology of 6.4 rather than 6.10. So here, ABC is the moving body, and DEF is the change. I invent M and N as the places from and to which the body ABC moves:

Figure 3: part-by-part locomotion



The body ABC undergoes a continuous locomotion that begins from an initial place (M) and ends in an adjacent place (N) over the time t1-3, where "t2" represents a division (in thought only) half way through the time of the whole change. On this analysis of change, we may say that

(1) the "first thing" to which ABC changes is N,

where (as a general principle) this is the place that might wholly contain the moving that is

contiguous with its original place. Further,

(2) between t1 and t3 ABC is moving, and ABC is partly in that *from* which it moved (BC is in M) and partly in that *to* which it moved (AB is in N).

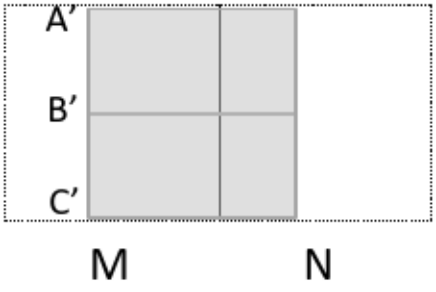
Finally,

(3) The motion of the whole ABC, namely DEF, is divisible into two (serial) parts (DE and EF), which are identical to the motions of the leading and trailing halves of ABC.

In the first half of the motion, the leading half of the body ABC moves from M to N, and in the second half of the change, the trailing half of ABC, BC, undergoes moves from M to N. (1) and (2) explain how this conception of locomotion might satisfy the Partwise argument in 6.4, or correlatively avoid the refutation just cited, from 6.10 240b10-241a6. (3) explains how we might satisfy the analysis given in 234b21-235a10, wherein a change is divisible according to the changes of the parts of the changing thing.

Note that the division "B" in the body ABC is, to an extent, arbitrary: we could divide the body along its length in the direction of motion, and however many times we like, and this will produce a corresponding set of divisions in the change. But not any division in ABC will correspond to a division in its motion. Suppose we divide the moving body thus:

Figure 4: division of a body in two dimensions



The division B' does not correspond with any division in the change, and the parts A'B' and

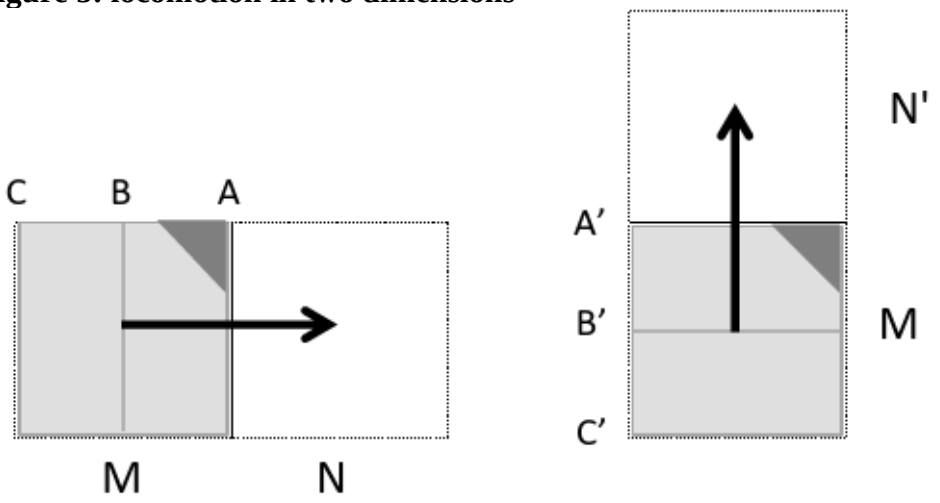
B’C’ go from being in M to being in N simultaneously. And so only a very specific set of divisions in a changing body will, in general, correspond with divisions in the change itself.

This suggests an important principle, the present simplicity of which belies its significance for an adequate understanding of Aristotle’s part-by-part kinematic theory:

-The parts implicated in the part-by-part analysis of change are relative to that change.

As an illustration of this, consider two different locomotions our block might undergo:

Figure 5: locomotion in two dimensions



The division B will correspond with a division in the motion of the block from M to N, but it will correspond with nothing in the motion from M to N’. There, a divison in the motion corresponds with B’. And so in general in locomotions we cay say something like this: the parts implicated in a locomotion are distinguished by divisions orthogonal to the direction of motion.

Note that these are not parts in any robust hylomorphic sense: they are not organs. Nor, in the case of our block, is there a special front part made for being the first to penetrate a new place. That said, a block has no natural motion, qua block. But a fox or a bird or a person does, in that vein these animals have a front and a back, and so a part naturally such as to be the first part that

penetrates a new place. Of course these organs are themselves infinitely divisible into parts. But think of the nose of a fox: it is like the driving point of a spear for the fox's most powerful sense; not only is the nose meant to go first, the very tip of the nose is meant to go before any other part. And so in bodies having a natural locomotion, particularly bodies having self-locomotion, such as animals, we should expect to see its parts ordered in such a way as to be fit for moving into a new place so as to meet that animal's desires. One can, of course, toss a fox up into the air, or spin it around. The parts of the fox implicated in this change are not the same as the parts implicated in its natural motion. But then, this is not a motion natural to foxes.

In any case, tthis principle—that the parts of a body implicated in a change are relative to that change—will help to sort out a doubt as to the coherence of this kinematic story for locomotion in particular. We might object that both parts of ABC move whenever the whole does. The motion EF is supposed to be the motion of the part BC, but before EF even begins, BC has already moved—from one part of M to the other. This motion across M cannot be any part of DEF, because the parts of DEF are serial, and this motion would be both distinct from DE and simultaneous with it.

Aristotle should answer thus: let it be granted that between t1 and t2, BC is moving, and its motion is neither DE (which is the motion of AB) nor EF (which comes later). However, this motion is not a part of the motion of ABC. The starting point for this analysis of change is a whole change, undergone by a whole changing thing, ABC. And so the parts into which this change are divided are the parts of *its* change, from M to N. To the extent that we do consider the motion of BC prior to EF, we are regarding BC as a moving thing in its own right, with a motion in its own right. Aristotle might well permit this, with the cautionary note that BC is a continuous part of ABC, and therefore it is not a thing in its own right, and it does not, in fact, have any

motion of its own.

Finally, what is the relationship between the part-by-part kinematic theory, and the theory evidenced in *Physics* 4.10-14, in which the moving thing is treated as a point traversing a magnitude? To be sure, Aristotle never repudiates or abandons this latter way of speaking, even in the midst of *Physics* 6.4-6:

> Again, the truth of what has been said is more evident in the case of magnitude, because the magnitude over which the changing thing changes is continuous. For suppose that something has changed from C to D. Then if CD is indivisible, partless things will be contiguous with partless things. But since this is impossible, what is between them must be a magnitude and infinitely divisible. Therefore, it was changing to these [i.e. these divisions] before. And therefore everything that has changed was changing before[4] (237a 28-35).

On the other hand, Aristotle argues extensively in 6.10, as we have discussed, that this conception of locomotion should be seen as a theoretical contrivance. To the extent that we understand something's moving as the motion of a point across a magnitude, we under stand it in terms of an "accident", that is, in terms of the coincidence of the body and some point that can be located on or within it:

> That having been demonstrated, we next assert that that which is without parts cannot be in motion except accidentally, i.e. in so far as the body or the magnitude to which it belongs is in motion, just as that which is in a boat may be in motion in consequence of the locomotion of the boat, or a part may be in motion in virtue of the motion of the

[4] ἔτι δ' ἐπὶ τοῦ μεγέθους φανερώτερον τὸ λεχθὲν διὰ τὸ συνεχὲς εἶναι τὸ μέγεθος ἐν ᾧ μεταβάλλει τὸ μεταβάλλον. ἔστω γάρ τι μεταβεβληκὸς ἐκ τοῦ Γ εἰς τὸ Δ. οὐκοῦν εἰ μὲν ἀδιαίρετόν ἐστι τὸ ΓΔ, ἀμερὲς ἀμεροῦς ἔσται ἐχόμενον· ἐπεὶ δὲ τοῦτο ἀδύνατον, ἀνάγκη μέγεθος εἶναι τὸ μεταξὺ καὶ εἰς ἄπειρα διαιρετόν· ὥστ' εἰς ἐκεῖνα μεταβάλλει

whole[5] (240b8-20).

But the point does not move, not in its own right anyway. The physically fundamental description of a locomotion must remain the part-by-part description. However, it can avoided notice that the part-by-part analysis of locomotion is hugely inconvenient as a way to describe locomotions longer than the length of the moving body, and so it is useful to continue to talk about moving bodies as if they were points traversing magnitudes.

Generation and Destruction

As we've seen in the case of locomotion, the parts whose motions together constitute the motion of the whole are relative to a given change. This observation gives us the means to approach changes like generation. It is obvious that no organism is generated front-to-back or top-to-bottom as if it had emerged out of a 3D printer. So what are the parts in terms of which something comes to be part-by-part?

I speculated in my first chapter that Aristotle *always* thought of continuous, non-locomotive changes as part-by-part changes; hence his assumption that "all-together" (αθρόος) changes are instantaneous. This means that in general, we should expect a part-by-part understanding of continuous changes other than locomotion anywhere in Aristotle's *corpus*, and I believe that this includes the generations and destruction of substances.

My aim here is to show that the part-by-part analysis of generation and destruction is intelligible, and that Aristotle himself sees things along these lines. A passage at the end of *Generation of Animals* 2.6 makes the point concisely.

πρότερον. ἀνάγκη ἄρα πᾶν τὸ μεταβεβληκὸς μεταβάλλειν πρότερον.

[5] Ἀποδεδειγμένων δὲ τούτων λέγομεν ὅτι τὸ ἀμερὲς οὐκ ἐνδέχεται κινεῖσθαι πλὴν κατὰ συμβεβηκός, οἷον κινουμένου τοῦ σώματος ἢ τοῦ μεγέθους τῷ ἐνυπάρχειν, καθάπερ ἂν εἰ τὸ ἐν τῷ πλοίῳ κινοῖτο ὑπὸ τῆς τοῦ πλοίου

> And what comes into being first is the principle; this is the heart in the sanguinea and its analogue in the rest, as has been often said already. This is plain not only to the senses (that it is first to come into being), but also in view of its end; for life fails in the heart last of all, and it happens in all cases that what comes in to being last fails first, and the first last, nature running a double course, so to say, and turning back to the point from whence she started. For the process of becoming is from the non-existent to the existent, and that of perishing is back again from the existent to the non-existent[6] (741b15-24).

The generation of an animal begins with the heart, and proceeds from here to the rest of the body in a series, and likewise when an animal dies, its parts die off one before the other, until death comes also for the heart. Hence, both the generation and the destruction of an animal (or plant, or any organism whatsoever) is a change in which division in the parts of the changing thing will correspond with a division in the change itself.

In *GA* 2.3-6 Aristotle takes himself to have both empirical[7] and theoretical reasons for thinking that animals come to be part-by-part:

> And for this reason that part which contains the first principle [i.e. the heart] comes into being first, next to this the upper half of the body. This is why the parts about the head, and particularly the eyes, appear largest in the embryo at an early stage, while the parts below the umbilicus, as the legs, are small; for the lower parts are for the sake of the upper, and are neither parts of the end nor able to form it[8] (742b14-17).

φορᾶς ἢ τὸ μέρος τῇ τοῦ ὅλου κινήσει.

[6] Γίγνεται δὲ πρῶτον ἡ ἀρχή. αὕτη δ' ἐστὶν ἡ καρδία τοῖς ἐναίμοις, τοῖς δ' ἄλλοις τὸ ἀνάλογον, ὥσπερ εἴρηται πολλάκις. καὶ τοῦτο φανερὸν οὐ μόνον κατὰ τὴν αἴσθησιν ὅτι γίγνεται πρῶτον ἀλλὰ καὶ περὶ τὴν τελευτήν· ἀπολείπει γὰρ τὸ ζῆν ἐντεῦθεν τελευταῖον, —συμβαίνει δ' ἐπὶ πάντων τὸ τελευταῖον γενόμενον πρῶτον ἀπολείπειν τὸ δὲ πρῶτον τελευταῖον, ὥσπερ τῆς φύσεως διαυλοδρομούσης καὶ ἀνελιττομένης ἐπὶ τὴν ἀρχὴν ὅθεν ἦλθεν. ἔστι γὰρ ἡ μὲν γένεσις ἐκ τοῦ μὴ ὄντος εἰς τὸ ὄν, ἡ δὲ φθορὰ ἐκ τοῦ ὄντος πάλιν εἰς τὸ μὴ ὄν.

[7] Cf. 733b24-734a16 and 735a10-735a25

[8] διὸ τὰ περὶ τὴν κεφαλὴν καὶ τὰ ὄμματα μέγιστα κατ' ἀρχὰς φαίνεται τοῖς ἐμβρύοις, τὰ δὲ κάτω τοῦ ὀμφαλοῦ, οἷον

Roughly speaking, the heart comes to be first (because something must distribute nutriment to spur on the process of generation) followed by the organs of the head and upper torso, followed thereafter by the lower parts and limbs.

It is worth being precise about what Aristotle's metaphysics of change in 6.4-6 demands, and how Aristotle's understanding of generation conforms with that demand. In accordance with the parameters of part-by-part change mentioned in my introduction, a part-by-part generation or destruction must be characterized as follows:

> -a generation is a change from non-being to being, or being to non-being (cf. *Physics* 5.1 225a1-19).
>
> -every generation or destruction is a continuous, and therefore infinitely divisible change.
>
> -when something is coming to be or being destroyed, a part of it is, or exists, and a part of it is not, or does not exist.

This requires that if some animal is coming to be, then while the animal as a whole is not yet alive, some part of the animal *is* alive. And in fact we can say that "the dog has come to be" when only the dog's heart has come to be, so long as we quickly add the qualification "*kata mere,* according to a part." Likewise if a dog is dying, then while the whole dog is not yet dead, some part of it is dead. And in fact we can say that "the dog has died" when only a limb has died, so long as we are quick to add the same qualification.

But here I have touched on a controversial thesis. For Aristotle famously says in a number of places[9] that the identity of an organ or part depends on its functional role in the whole. An eye

---

τὰ κῶλα, μικρά. τοῦ γὰρ ἄνω τὰ κάτω ἕνεκεν καὶ οὔτε μόρια τοῦ τέλους οὔτε γεννητικὰ αὐτοῦ.

[9] This principle is stated clearly and explained in Meteorology 4.12, 390a10–12, De Anima 2.1 412b21–23, Parts of Animals 1.1 640b34–641a34, Generation of Animals 2.1 734B24–7. But see also Generation and Corruption 1.5 321b29–32, Metaphysics Z.10 1035b10–26; Politics 1.2 1253a19–25.

that cannot see, to use Aristotle's example from *De Anima*,[10] is an eye homonymously, or in name only. But if a heart or an eye is only a heart or an eye when it is a part of a living body, how can a heart come to be before the whole living body of which it is a part comes to be?

For reasons I will discuss in my fifth chapter, Aristotle is particularly focused at the end of *Physics* 6.6 on the case of generation. He says there:

> So it is clear also that what has become was becoming before, and what is becoming must previously have become, to the extent that it is divisible and continuous. Though it is not always[11] what becomes. Sometimes it is something else, for example some part of this, just as in the case of the foundation stone of a house[12] (*Physics* 6.6 237b9-13).

I take it that Aristotle means that in a process of generation, it's not the case that some part of the house has become a house, as if one's first building stone became a little house, and when one added another then they merged into a slightly larger (but still tiny) house. Rather, some part of a house, like a foundation stone, has taken on the structure and situation it will, eventually, have in the complete house. In the case of a foundation stone, this means little more than having the right shape and being in the right position. In the case of the heart, this means being such as to supply food to the organic parts of a body that does not yet exist.

This leads us to a second principle, useful for navigating the part-by-part theory of change and for dissolving our difficulty in relation to the homonymy principle:

> **-In a change to F, a part of the changing thing need not become F, but may become such as it must be when the whole is F.**

---

[10] *De Anima* 2.1 412b19-22

[11] I believe Aristotle says "not always" here because there are both non-organic generations (i.e. the generations of elemental substances) and organic generations (i.e. the generations of organized bodies, with differentiated parts). In the coming to be of a body of air, the part that comes to be comes to be *air*, whereas in the coming to be of an organic body or a house the part that comes to be does not come to be that organism or that house.

[12] φανερὸν οὖν ὅτι καὶ τὸ γεγονὸς ἀνάγκη γίγνεσθαι πρότερον καὶ τὸ γιγνόμενον γεγονέναι, ὅσα διαιρετὰ καὶ

So in the coming to be of a dog, an early stage is the development of the dog's heart. This part does not "come to be a dog," but rather it comes to be such as it must be when the generative process is a complete, and a puppy has arrived on the scene: a functioning heart.

How does this help us square the part-by-part character of generation with the homonymy principle? The answer is that Aristotle's homonymy principle does not state that parts absent their wholes are only homonymously identified. Rather, it states that a part unable to perform their characteristic functions are only homonymously identified. This is clear both from the way Aristotle explains the principle…

> And yet a dead body has exactly the same configuration as a living one; but for all that is not a man. So also no hand of bronze or wood or constituted in any but the appropriate way can possibly be a hand in more than name. For like a physician in a painting, or like a flute in a sculpture, it will be unable to perform its function[13] (*Parts of Animals* 1.1 640b34-641a3).

…and from the fact that the severing of the organ or death of the organism is not a necessary condition on triggering the homonymy principle. Even when it is still a part of a living organism, an eye is merely homonymously an eye when it is blind: if "seeing is removed, the eye is no longer an eye, except in name"[14] (De Anima 2.1 412b20-22). But the heart of a dog, developed as the dog is coming to be, *can* perform its characteristic function, both in the sense that it has the relevant capacity, and in the sense that it exercises this capacity during the generative process

---

συνεχῆ, οὐ μέντοι αἰεὶ ὃ γίγνεται, ἀλλ' ἄλλο ἐνίοτε, οἷον τῶν ἐκείνου τι, ὥσπερ τῆς οἰκίας τὸν θεμέλιον.

[13] Καίτοι καὶ ὁ τεθνεὼς ἔχει τὴν αὐτὴν τοῦ σχήματος μορφήν, ἀλλ' ὅμως οὐκ ἔστιν ἄνθρωπος. Ἔτι δ' ἀδύνατον εἶναι χεῖρα ὁπωσοῦν διακειμένην, οἷον χαλκῆν ἢ ξυλίνην, πλὴν ὁμωνύμως, ὥσπερ τὸν γεγραμμένον ἰατρόν. Οὐ γὰρ δυνήσεται ποιεῖν τὸ ἑαυτῆς ἔργον, ὥσπερ οὐδ' αὐλοὶ λίθινοι τὸ ἑαυτῶν ἔργον, οὐδ' ὁ γεγραμμένος ἰατρός. Tr. Joachim in Barnes 1991.

[14] ἧς ἀπολειπούσης οὐκέτ' ὀφθαλμός, πλὴν ὁμωνύμως, καθάπερ ὁ λίθινος καὶ ὁ γεγραμμένος.

by distributing nutriment to the developing embryo.[15] Similarly, though less impressively, a foundation stone, once properly cut and placed, can perform its characteristic function, both in the sense that it has the capacity (now un-utilized) to support a complete structure, and in the sense that it is used by the builder as a basis for the remaining construction.

Perhaps I have shown that Aristotle's conception of the generation of natural (and artificial) substances is consistant with the part-by-part kinematic theory developed in *Physics* 6.4. This task is complete when I've shown that in any generation, we can correlate the parts of the change with the parts of the changing thing, and in what sense "what is coming to be has come to be." But we should probe a bit further; much of what delights about Aristotle's thinking lies in his treatment of each subject and question on its own terms and finding unity in analogy, rather than by the application of abstract and very general principles[16]. So it is unsatisfying to look for mere consistency between the part-by-part theory of change and the natural particulars of generation. How can we more substantively connect this kinematic theory to the process of generation?

I will speculate a little, because we have exhausted Aristotle's guidance in *Physics* 6. I begin with a passage from *De Sensu* 6, nearby to one discussed in my first chapter.

> But still, for all that, if the body which is heated or frozen is extensive, each part of it successively is affected by the part contiguous, while the part first changed in quality is so changed by the cause itself which originates the change, and thus the change throughout the whole need not take place simultaneously and all at once[17] (*De Sensu* 6

[15] See Carraro 2017 for a discussion of Aristotle's embryology in relation to the homonymy principle. Carraro argues convincingly that an embryo is alive, but has soul only potentially. In these terms, the coming to be of a dog is a process by which an embryo goes from having dog soul only potentially to having it actually, and this process proceeds by the gradual development and articulation of the dog's organic body (and therefore its vital capacities), starting with the heart.

[16] A brilliant statement of this methodology is found in *Generation and Corruption* 1.2 316a6-316a14.

[17] οὐ μὴν ἀλλ' ἂν ᾖ πολὺ τὸ θερμαινόμενον ἢ πηγνύμενον, τὸ ἐχόμενον ὑπὸ τοῦ ἐχομένου πάσχει, τὸ δὲ πρῶτον ὑπ' αὐτοῦ τοῦ ἀλλοιοῦντος μεταβάλλει καὶ ἀνάγκη ἅμα ἀλλοιοῦσθαι καὶ ἀθρόον.

447a3-6).

Recall that on the developmental story I told in my first chapter, the part-by-part conception of continuous change is not new to 6.4-6. Aristotle finds a special use for it there, in justifying his new explanation for the structure of natural continua, but as an understanding of continuous change, it was always his position. Before the revision of his theory enacted in 6.4-6, Aristotle admitted of all-at-once changes, but these are not *continuous* changes. In this passage, Aristotle has just brought up the possibility of all-at-once alterations, and now he qualifies this by saying that changes like heating or cooling needn't actually occur all-at-once: when the changing body is very large, they will happen part-by-part.

What I want to extract from this passage is the idea that "each part of it successively is affected by the part contiguous." Why should the already heated parts have to do any work in heating the remainder? The answer has to do with the requirement that agents, or their instruments, be in contact with patients in order to effect a change. Suppose we have two blocks of copper, one hot (A) and one cold (B). I push the hot one so that its face meets the face of the cold block. The plane of contact is what makes it possible for the agent to affect the patient, but as soon as any part of the heating has been accomplished, the agent is no longer in direct contact with the cooler parts of B. What *is* in contact with the cooler parts of B, however, is the newly heated part of B. This newly heated part becomes the instrument, the moved mover, through which the primary agent A continues to change the patient B.

I mentioned before that the foundation stone of a house or the heart of a dog may precede the house and the dog in time because they may nevertheless carry out their characteristic functions in the development of the complete things of which they will be mere parts. Now we see that this point has more substance than merely allowing us to evade a puzzle: the part-by-part generation

of a substance is, at least in these clear cases, an important part of the story of how an agent realizes this generation in a patient. The already finished parts become agents themselves, in the sense that the primary agent uses them as instruments for the furtherance of the change.

Growth

How does growth occur part-by-part? We may put this in terms of a puzzle: if ABC is growing from 1 to 1.1, then the dictum that "part if it must be in that from which and part in that to which it is changing" may be taken to suggest that while ABC is growing, AB is at size 1 and BC is at size 1.1, meaning that the whole is (absurdly) at size 2.1.

But our second principle, in a change to F, a part of the changing thing need not become F, but may become such as it must be when the whole is F, can fruitfully be applied here. The part AB need not grow to the size the whole will eventually have, but only to the size *it* will have when the whole is finished growing. And so when AB has changed, we should expect it to grow from size .5 to .55, the latter being its size once the whole has become 1.1.

If any difficulty remains, it lies in the idea that the parts of a growing thing do not grow at the same time. Aristotle believes that any account of growth must respect the fact that whatever grows grows in every part of itself, and retains its original proportions; otherwise growth would be tangled up with another kind of change, a change of shape.[18]

I stress that I am speculating here, since Aristotle never himself discusses growth in *Physics* 6. But it is possible to navigate the proportionality requirement as follows. Assuming that a body ABC is the primary changing subject, we may take for granted that it changes as a whole. While its proportions are not maintained *while it is changing*, the same proportions will rule before and

[18] See *Generation and Corruption* 1.5 321a27-30

after the change. If the change is somehow interrupted, then the original proportions of ABC will be disturbed, but in this case we should not say that ABC grew, strictly speaking. Only the part that had grown before the interruption (suppose this is AB) is the primary subject of a growth, and so we need only apply the proportionality requirement to this part.

This suggestion has a certain empirical plausibility—which cannot help to justify the theory, but may serve to dispel some doubt: growing organisms, such as young people in the throes of puberty, do tend to be a bit out of proportion as they are growing…though normally things are put in good order by the time they are adults.

Chapter 4: What Is A Primary Time?

Having discussed the partwise argument and the part-by-part conception of change, it is time to begin in on the overarching argument of 6.4-6. The first step is to make sense of the series of arguments that make up most of the remainder of this text, after the partwise argument in 6.4. The aim of this chapter is therefore to make a study of these arguments.

In Physics 6.5, 6.6, and 6.8, Aristotle presents a series of arguments having to do with whether or not there is a "primary" time corresponding to some event. For example, is there a primary time of something's having completed a change? (Yes). Is there a primary part of a changing thing that has changed? (No). It is worth saying in advance what these arguments are meant to accomplish. The aim of 6.4-6 as a whole is to show that the changing thing explains the topological features of time, change, and all natural continua, namely divisibility, and infinity.[1] The arguments dealing with primacy in Physics 6.5 and 6.6 were written to show that the changing thing is indeed "infinite," They do so by way of an intermediate conclusion, established in 6.6: there is no primary time in which something is changing. But what is a "primary time" and what would it mean to deny that something has one? So, in order to prepare for a discussion of the overarching argument of 6.4-6, it will be necessary to develop an understanding of what Aristotle means by "a primary time," how the arguments involving this notion work, and especially how they relate to 6.4, and its thesis that the various aspects of change are mutually divisible.

Until fairly recently, commentators have thought that, by "primary," in these chapters, Aristotle just means the first thing in a temporal sequence.[2] So when, for example, Aristotle says

[1] "Infinity" here should be read as "infinite divisibility." I discuss this in the subsequent chapter.
[2] E.g. Bostock *Space*, 170-2, 183; Sorabji, Richard "Atoms and Time Atoms." In *Infinity and Continuity in Ancient*

that there is no primary time when something begins to change, this has been taken to mean that there is no first time when something begins to change. In the last thirty years, beginning with Nico Strobach's 1992 book The Moment of Change, scholars have turned toward alternative understandings of "primary."[3] Centrally, this is because of Aristotle's own explanation of the meaning of "primary" in this context suggests that the sort of primacy at issue in these passages is not that of being first in a temporal sequence, but rather first in an explanatory order.

> Now the time primarily in which that which has changed has changed must be indivisible, where by 'primary' I mean a thing's being such-and-such not because something other than it is such-and-such. (6.5 235b32-34)[4]

But it is not at all clear what it means for a time to be primary in this sense, and as a result, there is little consensus about the the argument and import of these chapters, as I will discuss.

I suggest that primary times are called "primary" roughly on analogy with "primary substances"; everything in time is in time either because it has a primary time, or in relation to the primary time of something else. So any answer to a question about the duration or "when" of something must ultimately appeal to a primary time. In getting to this reading, I will show that a distinction crucial to understanding the primary time arguments has been ignored by prior commentary: the distinction between heterogenous events and homogeneous events. For the purposes of this discussion, "events" are anything (excluding times) about which "when…?" questions are intelligibly asked. This obviously includes motions, but also rests and persisting or non-persisting states of affairs, as in "when was Socrates sitting?" and "when did Socrates

---

and Medieval Thought. Ed. Norman Kretzmann. Ithaca: Cornell University Press, 1982: 37-86; White *Continuous*, 49-57.

[3] See Strobach *Moment*, 63-75; Hasper, *Continuity*, 195-7, Wagner *Physics*, 626-7, who all implicitly or explicitly reject the reading of "primary" as "first in a temporal order." Morison, Benjamin. "Primary Time in Aristotle's Physics 6." *Oxford Studies in Ancient Philosophy* 45, 2013: 149-93: 159-160, contains a clear and most recent argument that that "primary" cannot mean "first in a temporal order" in *Physics* 6.5-8.

arrive?". There is no noun in Aristotle's vocabulary that precisely corresponds to the English word "event." However, at Physics 4.12 221a7-9 and 221b14-a9, Aristotle distinguishes a set of things that are "in time." For something to be in time means that its being is measured by time (τὸ μετρεῖσθαι αὐτῶν τὸ εἶναι ὑπὸ τοῦ χρόνου). Aristotle consistently uses similar language to describe motion and change in Physics 6: at 6.6 235b20, 6.7 237b23, 6.8 239a23, and 6.10 241a15. So let "event" capture the set of things that Aristotle marks out as being "in time."

A heterogeneous event is one the parts of which are distinct in definition from the whole. For example, the first half of a walk from A to C is not a walk from A to C, but a distinct walk from A to B. An homogeneous event is one where the parts and the whole of the event are the same: I am resting in the first half of the time in which I am resting. The primary time arguments are focused on homogeneous events specifically in this sense: the argument is only sound when applied to homogeneous events.

I will also discuss two relatively recent scholarly works aimed at understanding what makes a time "primary" in Physics 6. In his 2013 article "Primary Time in Aristotle's Physics 6," Benjamin Morison argues that a time is primary if and only if it is the most precise time of something: if my walk begins at exactly 5:00 and ends at exactly 5:30, then 5:00-5:30 is the most precise, and therefore the primary time of my walk. When Aristotle denies that something has a primary time, he is denying we can say precisely when this event occurs. Morison believes that Aristotle wrote these arguments in order to respond to potential paradoxes concerning the transition from motion to rest, or rest to motion. By contrast, Niko Strobach, in The Moment of Change, argues that primary times are indivisible or atomic times, as might be conceived by the target of the peripatetic text known as On Indivisible Lines. Strobach takes Aristotle to be

[4] λέγω δὲ πρῶτον ὃ μὴ τῷ ἕτερόν τι αὐτοῦ εἶναι τοιοῦτόν ἐστιν.

denying that any kind of event has an extended primary—i.e. indivisible—time, a part of Aristotle's broader attack on atomistic conceptions of time, space, bodies, and motion.

In the final part of this chapter, I will relate the primary time arguments in 6.5-6 back to the arguments that concern divisibility in 6.4. I argue that when Aristotle shows that some event has no primary time, this has consequences for the question of whether that event is "divisible according to," e.g. time. The close connection between these sets of arguments—those in 6.4 having to do with mutual divisibility and those in 6.5-6 having to do with primary time—makes clearer the unity of 6.4-6 as a whole.

Primary time, the problem and two proposals

In this section, I will lay out the difficulties in understanding what, for Aristotle, makes a time "primary." Morison and Strobach come to very different conclusions about the import of Aristotle's discussion of primary times, but the basis for the disagreement between them rests on a single question. At the end of each primary time argument, Aristotle says that the event in question must occur in every parts of its primary time. From here, he immediately infers that the event has no divisible primary time. Why?

Their disagreement is not easy to resolve because Aristotle's discussions of primary time are systematically ambiguous on that very question. So in this section, I first present an overview of Aristotle's discussions of primary time, almost all of which consist in a set of proofs to the effect that some event has no primary time. I explain how the ambiguity in Aristotle's argument arises, and show how Morison and Strobach each respond to it. I also briefly discuss some of the implications of their respective interpretive choices. As we'll see, apparently small interpretive decisions have an outsized impact on our understanding of what a primary time is, and therefore

of what the primary time arguments in Physics 6 are supposed to show.

Aristotle's Direct Remarks About Primary Time

Aristotle makes two direct statements about primary times, in 6.5 and in 6.6:

> Now the time primarily in which that which has changed has changed must be indivisible, where by 'primary' I mean a thing's being such-and-such not because something other than it is such-and-such[5] (6.5 235b32-34).

> Now, everything that changes changes in time, but 'to change in time' means 'in [the] primary [time], or 'according to something different', as for example when we say that a thing changes in a year because it changes in a day. A changing thing necessarily changes in any part of the primary time of its change. This is clear from our definition of primary, for 'primary' is meant to express just that[6] (6.6 236b19-15).

This much is clear from the above pair of statements: an event[7] may have more than one time, but these times are not all of equal standing. Suppose I walk from campus to home, leaving at exactly 5:00 and arriving home at exactly 5:30. We can say that my walk home from campus took place in the time '5:00-5:30' or 'between 5:00 and 6:00' or 'this evening' or '2018'. All of these are times of my walk home—they all answer the question "when?"—but not all of them are

[5] ἐν ᾧ δὲ πρώτῳ μεταβέβληκεν τὸ μεταβεβληκός, ἀνάγκη ἄτομον εἶναι. λέγω δὲ πρῶτον ὃ μὴ τῷ ἕτερόν τι αὐτοῦ εἶναι τοιοῦτόν ἐστιν.

[6] Ἐπεὶ δὲ τὸ μεταβάλλον ἅπαν ἐν χρόνῳ μεταβάλλει, λέγεται δ' ἐν χρόνῳ μεταβάλλειν καὶ ὡς ἐν πρώτῳ καὶ ὡς καθ' ἕτερον, οἷον ἐν τῷ ἐνιαυτῷ ὅτι ἐν τῇ ἡμέρᾳ μεταβάλλει, ἐν ᾧ πρώτῳ χρόνῳ μεταβάλλει τὸ μεταβάλλον, ἐν ὁτῳοῦν ἀνάγκη τούτου μεταβάλλειν. δῆλον μὲν οὖν καὶ ἐκ τοῦ ὁρισμοῦ (τὸ γὰρ πρῶτον οὕτως ἐλέγομεν).

[7] For the purposes of this discussion, "events" are anything (excluding times) about which "when…?" questions are intelligibly asked. This obviously includes motions, but also rests and persisting or non-persisting states of affairs, as in "when was Socrates sitting?" and "when did Socrates arrive?". By contrast, Socrates himself is not an event. We cannot ask "when was Socrates" except as a way of asking when he lived, and it is his living, not himself, that is an event.

primary. For example 2018 is not the primary time of my walk, because I only walk in a part of it. This means that 2018 is a time of my walk only "according to something else" ("καθ' ἕτερον"/"ᾧ ἕτερόν τι αὐτοῦ εἶναι τοιοῦτόν ἐστιν"). What is this "something else"? It must be the primary time of my walk, which 2018 contains and, by containing, counts as a time of my walk at all. It is natural and, I think, correct, to assume that the primary time of my walk is 5:00-5:30.

The Primary Time Arguments

Each of Aristotle's primary time arguments consists of two stages. The first asks: does the event have an indivisible primary time? The second asks: does the event have a divisible primary time? The first stage is always occupied with the question of whether the event can occur in an indivisible time at all, rather than with the requirements for having a primary time. So, since we are trying to understand what makes a time primary, our present concern is the second stage. The second stage begins by supposing that the primary time of an event is divisible, and then proceeding by reductio to show (in all five cases) that the event in question cannot have a divisible primary time. This argument works as follows.

-If some event has a divisible primary time, then this time can be divided into parts. The event in question (E) must occur in neither of the two parts of the primary time (t), in only one, or in both.

-(i) If E occurs in neither part, then E does not occur in t.

-(ii) If E occurs in only one part, then t is not the primary time of E.

-Therefore E occurs in both parts of t.

-But if E occurs in both parts of t, then t is not the primary time of E.

-Therefore, E has no divisible primary time.

This argument appears five times, always with some notable variations. I have marked the steps of the arguments according to the possibility that step is meant to rule out: (i) for "neither part," (ii) for "only one part).

T1: 6.5 235b32-236a6 (concerning having changed, in the sense of having completed a change)

> For let AC be divisible, and let it be divided at B.
>
> ii) If on the one hand it has changed in AB or again in BC, AC cannot be the primary thing in which it has changed.
>
> i) If, on the other hand, it was **changing** in each of the two singly (for it must either have changed or be changing in each of them singly), it must have been **changing** in the all of the whole too; but our assumption was that it **had changed** in that.
>
> ii) The same argument applies if we suppose that it **changes** in one part and **has changed** in the other; for then we shall have something prior to what is primary.
>
> As a result, that in which a thing has changed will not be divisible.[8]

Here, and in the next passage, Aristotle examines a case where something that has changed in a divisible primary time is changing in some or both parts of that time. The significance of this is clear in light of the principle stated in 6.1 231b28-232a1:

> Now if something moving from here to there cannot at the same time be moving and have moved to that to which it was moving when it was moving (e.g. if a man is walking to

[8] ἔστω γὰρ διαιρετὸν τὸ ΑΓ, καὶ διῃρήσθω κατὰ τὸ Β. εἰ μὲν οὖν ἐν τῷ ΑΒ μεταβέβληκεν ἢ πάλιν ἐν τῷ ΒΓ, οὐκ ἂν ἐν πρώτῳ τῷ ΑΓ μεταβεβληκὸς εἴη. εἰ δ' ἐν ἑκατέρῳ μετέβαλλεν (ἀνάγκη γὰρ ἢ μεταβεβληκέναι ἢ μεταβάλλειν ἐν ἑκατέρῳ), κἂν ἐν τῷ ὅλῳ μεταβάλλοι· ἀλλ' ἦν μεταβεβληκός. ὁ αὐτὸς δὲ λόγος καὶ εἰ ἐν τῷ μὲν μεταβάλλει, ἐν δὲ τῷ μεταβέβληκεν· ἔσται γάρ τι τοῦ πρώτου πρότερον· ὥστ' οὐκ ἂν εἴη διαιρετὸν ἐν ᾧ μεταβέβληκεν.

Thebes, he cannot be walking to Thebes and at the same time have walked to Thebes);[9] The cases where something is *changing* or *moving* in some part of a time are therefore cases where it cannot *have changed* or *have moved* in that time. So when, in the next passage, Aristotle says "if…it is changing in both parts, it is likewise changing in the whole", the case being considered is equivalent to (ii) one in which it has not changed in either part, and so has not changed in the whole.

T2: 6.5 236a20-27 (concerning having changed, in the sense of having *begun* to change)

> Since then AD is not without parts, it must be divisible, and the changing thing must have changed in every part of it for
>
> i) if it has changed in neither of the two parts into which AD is divided, it has not changed in the whole either;
>
> i) if, on the other hand, it is **changing** in both parts, it is likewise **changing** in the whole; and
>
> ii) if, again, it has changed in one of the two parts, the whole is not the primary time in which it has changed:
>
> it must therefore have changed in every part. It is evident, then, that there is no primary time in which it has changed; for the divisions are infinite.[10]

T3: 6.6 236b25-32 (concerning moving/changing)

[9] εἰ δὴ ἀνάγκη τὸ κινούμενον ποθέν ποι μὴ ἅμα κινεῖσθαι καὶ κεκινῆσθαι οὗ ἐκινεῖτο ὅτε ἐκινεῖτο (οἷον εἰ Θήβαζέ τι βαδίζει, ἀδύνατον ἅμα βαδίζειν Θήβαζε καὶ βεβαδικέναι Θήβαζε)

[10] ἐπεὶ δ' οὐκ ἔστιν ἀμερές, ἀνάγκη διαιρετὸν εἶναι καὶ ἐν ὁτῳοῦν τῶν τούτου μεταβεβληκέναι· διαιρεθέντος γὰρ τοῦ ΑΔ, εἰ μὲν ἐν μηδετέρῳ μεταβέβληκεν, οὐδ' ἐν τῷ ὅλῳ· εἰ δ' ἐν ἀμφοῖν μεταβάλλει καὶ ἐν τῷ παντί, εἴτ' ἐν θατέρῳ μεταβέβληκεν, οὐκ ἐν τῷ ὅλῳ πρώτῳ. ὥστε ἀνάγκη ἐν ὁτῳοῦν μεταβεβληκέναι. φανερὸν τοίνυν ὅτι οὐκ ἔστιν ἐν ᾧ πρώτῳ μεταβέβληκεν· ἄπειροι γὰρ αἱ διαιρέσεις.

Let XR be the primary time in which the moving thing moves, and let it be divided at K. For every time is divisible. Now in the time XK it either moves or does not move, and likewise for the time KR.

i)Then if it moves in neither of the two, it will be at rest in the whole. For it is impossible that it moves in a time in no part of which it moves.

ii) If on the other hand it moves in only one of the two, XR cannot be the primary time in which it moves. For the motion will be according to something else.

It must, therefore, be moving in any part of XR.[11]

The argument in 6.6 is remarkable in that the anticipated conclusion "there is no primary time in which something is moving" does not arrive until 237b3, after a lengthy discussion of the relationship between moving/changing and having moved/having changed.

T4: 6.8 238b31-36 (concerning coming to a stand)

And that which is coming to a stand must be coming to a stand in any part of the primary time in which it is coming to a stand.

i) For if it is coming to a stand in neither of two parts into which the time may be divided, it cannot be coming to a stand in the whole time, with the result that that which is coming to a stand will not be coming to a stand.

ii) If on the other hand it is coming to a stand in only one of the two parts, the whole cannot be the primary time in which it is coming to a stand; for it is coming to a stand in

[11] ἔστω γὰρ ἐν ᾧ πρώτῳ κινεῖται τὸ κινούμενον ἐφ' ᾧ ΧΡ, καὶ διηρήσθω κατὰ τὸ Κ· πᾶς γὰρ χρόνος διαιρετός. ἐν δὴ τῷ ΧΚ χρόνῳ ἤτοι κινεῖται ἢ οὐ κινεῖται, καὶ πάλιν ἐν τῷ ΚΡ ὡσαύτως. εἰ μὲν οὖν ἐν μηδετέρῳ κινεῖται, ἠρεμοίη ἂν ἐν τῷ παντί (κινεῖσθαι γὰρ ἐν μηθενὶ τῶν τούτου κινούμενον ἀδύνατον)· εἰ δ' ἐν θατέρῳ μόνῳ κινεῖται, οὐκ ἂν ἐν

this derivatively, as we said before in the case of things in motion.[12]

T5: 6.8 239a17-22 (concerning rest)

> Since, then, it is divisible, it must be a period of time, and the thing must be at rest in every one of its parts, as may be shown by the same method as that used above. So there can be no primary time; and the reason is that rest and motion are always in time, and there is no primary time—nor magnitude nor in fact anything continuous; for everything continuous is divisible into an infinite number of parts.[13]

Unlike the first four passages, this one does not spell out the argument. Instead Aristotle just refers back to 238b31-36.

The task at hand is deriving a set of necessary and jointly sufficient conditions on some event's having a primary time. The difficulty is that these passages are ambiguous on a crucial point. The penultimate step of each of the above arguments is the intermediate conclusion that the event in question must occur in both parts of its (alleged) divisible primary time. From here, Aristotle immediately concludes that the event cannot have a divisible primary time. There are two ways we might understand this inference. Strobach takes the inference at face value: anything that occurs in every part of its (alleged) primary time has no divisible primary time. Morison understands Aristotle to be saying that whatever has a divisible primary time must occur in every part of that time, but that the events being discussed in the primary time arguments

---

πρώτῳ κινοῖτο τῷ ΧΡ· καθ' ἕτερον γὰρ ἡ κίνησις. ἀνάγκη ἄρα ἐν ὁτῳοῦν τοῦ ΧΡ κινεῖσθαι.

[12] ἐν ᾧ δὲ χρόνῳ πρώτῳ τὸ ἱστάμενον ἵσταται, ἐν ὁτῳοῦν ἀνάγκη τούτου ἵστασθαι. διαιρεθέντος γὰρ τοῦ χρόνου εἰ μὲν ἐν μηδετέρῳ τῶν μερῶν ἵσταται, οὐδ' ἐν τῷ ὅλῳ, ὥστ' οὐκ ἂν ἵσταιτο τὸ ἱστάμενον· εἰ δ' ἐν θατέρῳ, οὐκ ἂν ἐν πρώτῳ τῷ ὅλῳ ἵσταιτο· καθ' ἕτερον γὰρ ἐν τούτῳ ἵσταται, καθάπερ ἐλέχθη καὶ ἐπὶ τοῦ κινουμένου πρότερον.

[13] εἰ δὲ μεριστόν, χρόνος ἂν εἴη, καὶ ἐν ὁτῳοῦν αὐτοῦ τῶν μερῶν ἠρεμήσει. τὸν αὐτὸν γὰρ τρόπον δειχθήσεται ὃν καὶ ἐπὶ τῶν πρότερον· ὥστ' οὐθὲν ἔσται πρῶτον. τούτου δ' αἴτιον ὅτι ἠρεμεῖ μὲν καὶ κινεῖται πᾶν ἐν χρόνῳ, χρόνος

cannot meet that condition. Both theories face distinct difficulties, but both are helpful in understanding what an adequate theory of Aristotle's concept of primary times would have to accomplish.

Morison's Reading: Primary times are the most-precise ones.

On Morison's view, the three necessary and jointly sufficient conditions on being a primary time are as follows:

> "The primary time of an event E (an occurrence or a change or whatever) is the time AB—either a stretch of time (A≠B), or an instant (A=B)—such that
>
> a) E occurs in AB, and
>
> b) no part of E occurs at any time outside AB, and such that
>
> c) there is no stretch of time CD which is a part of AB in which E is not taking place."[14]
>
> (Morison 2013 p. 164)

For Morison, any time that satisfies these three conditions is the most precise possible time of an event and is therefore the primary time of that event. So if I am walking home from exactly 5:00PM to exactly 5:30, then the primary time of my walk is 5:00-5:30, just because this is the most precise possible specification of the time of my walk. 5:00-5:30 includes no time in which I am not walking (c), and there is no part of my walk that falls outside this time (b). By contrast, "4:00-4:30" is not the primary time of my walk because it fails to satisfy (a) (and so it is not a time of my walk at all). "5:00-5:15" is not the primary time because it fails to satisfy (b), while "5:00-6:00" fails to satisfy (c). Morison derives these criteria on the assumption that Aristotle

---

δ' οὐκ ἔστι πρῶτος οὐδὲ μέγεθος οὐδ' ὅλως συνεχὲς οὐδέν· ἅπαν γὰρ εἰς ἄπειρα μεριστόν.

[14] From here on, I will use "*t"* to refer to times in this list of conditions, so as to avoid confusion with Aristotle's own use of letters to indicate places, states, and times.

intends an analogy with primary places, discussed in Physics 4.

So how could some event fail to have a primary time, or a divisible primary time? Certain kinds of events, like getting started or finishing a change, are of such a nature that no divisible time of these events can possibly satisfy all the conditions on being a primary time. Morison supplies Aristotle with the following argument:

> Since AD is a stretch of time, x covered a certain amount of ground during it (if it did not, then it did not get going in it). But now, we can divide AD into two; x covered some ground in the first half, and some more ground in the second half. But then that first half of AD already contains x's starting to move. The second half of AD does not even look any more like a time during which part of x's transition [from rest to motion] occurred. Given that x covered some ground in that time, that period of time encompasses an occurrence which counts as x's starting to move. But of course, we can make the same observation about the first half of AD: we can divide it, and find always that in the first half of that division x has covered some ground, and so that stretch of time will encompass the transition. Hence, because we can always divide time at any point we want—as Aristotle puts it: 'the divisions are endless'—we can always find a substretch of AD which will count as the primary time in which x has started moving. (ibid. p.177)

A certain set of events, including the beginning and ending of a change, will be asymmetrical in the following sense: any divisible time of an event can always be divided into one half which also counts as a time of that event, and another that does not. As a result, we can never find a most-precise, divisible time for such an event. And if this sort of event also cannot be said to occur in an *indivisible* time, as is the case with having begun to change or coming to a stand, then this event can't have a primary time at all. Recall the inferential gap I identified at the end

of the last section, between the proposition that "event E must occur in any part of its primary time" and the conclusion that "E has no divisible primary time." Morison's supplied argument is meant to bridge this gap, by explaining that an event *must* occur in every proper part of its primary time, but that some events (those discussed in the primary time arguments) cannot satisfy this condition.

On Morison's reading, the primary time arguments were written to settle worries about the transition between motion and rest. (Some of) the primary time arguments show us that while indeed we cannot account for when something begins to change on its own terms, nevertheless we can without paradox discuss the time when something began to change by appealing to its immediate context, like the end of a bounding period of rest.[15]

Morison's reading faces two difficulties. First, Morison's supplied argument is substantial, and it does not appear in the text.[16] Second, Morison's argument cannot be supplied in two of the five primary time arguments. At 239a11, Aristotle says "Nor indeed is there any time in which something resting primarily rests" (οὐδὲ δὴ τὸ ἠρεμοῦν ὅτε πρῶτον ἠρέμησεν ἔστιν) and proceeds in the manner common to the primary time arguments. In order for Morison's reading to work, "rests" (ἠρέμησεν) must be a asymmetrical event in the same way the beginning or end of a change is asymmetrical.[17] Yet if I am resting over a period of time, then I am resting in both

[15] Morison, "Primary," 191

[16] Something very much like Morison's supplied argument does appear at 6.5 236a27-35, but Aristotle is there arguing that there is no primary *part* of something that changes. I think this weighs against Morison's reading: Aristotle thought the argument Morison supplies is significant enough to make explicit—for he does so at when discussing primary parts at 236a27-35—but he doesn't state it in any of the primary time arguments. This suggests that the supplied argument does not capture Aristotle's intention.

[17] Morison reads ἠρέμησεν as an ingressive aorist, such that the argument that follows concerns the time when something begins to rest. For a precedent of this use of the aorist, Morison notes that some manuscripts print an aorist at 6.5 235b15: μετέβαλεν, where Aristotle is talking about the beginning of a change (ibid. p. 174 fn. 40, p. 181). However, I think Ross correctly opts for the imperfect μετέβαλλεν. When Aristotle summarizes the result of this argument later in 6.5, at 236a35-36, he uses the imperfect, and here there is no manuscript conflict. Aristotle's use of the aorist 'ἠρέμησεν' in 6.8 is remarkable, but we may read it in a complexive—rather than ingressive—sense indicating the whole period in which something is at rest. This is in any case suggested by the fact that Aristotle

halves of that time.[18]

The second case is that of "changing" (μεταβάλλει) or "moving" (κινεῖται) in Physics 6.6, which is problematic for the same reason: there is no difficulty in saying that something is moving in every part of a time in which it is moving, yet there is no primary time in which something is moving. Morison does not discuss 6.6 as an argument that there is no primary time in which something is moving, but this seems to be Aristotle's intention. Aristotle begins 6.6 by establishing, as he does in the other primary time arguments, that something must be moving in any part of the primary time in which it is moving. From there, he shows that whenever something is moving or changing, it has already moved or changed, and whenever something has moved or changed, it was previously moving or changing. Aristotle concludes that:

> whatever has changed was changing, and whatever is changing has changed, and a changing is preceded by a having changed and a having changed by a changing, and one can never take something primary (237b3-7).[19]

Aristotle is referring back to just this result when he says at Physics 6.8 237b37:

> And just as there is no primary time in which that which is in motion is in motion, so too there is no primary time in which that which is coming to a stand is coming to a stand.[20]

But if Physics 6.6 as a whole is aimed at showing that "moving" and "changing" have no primary time, then Morison's argument concerning asymmetry cannot be supplied: these events are not asymmetrical in the way Morison's argument requires. Moreover, since there appears to be no difficulty in providing a most precise time in which something is moving or changing, this

---

takes it as obvious that the time in which something rests most be a time in which it could possibly be moving. Precedent for a complexive use of the aorist in this context can be found at *Physics* 6.1 231b27.

[18] Equally problematic is Aristotle's remark at 6.8 238b36-239a2: "just as there is no primary [time] in which the moving thing is moving (κινεῖται)…".

[19] ὥστε ἀνάγκη τὸ μεταβεβληκὸς μεταβάλλειν καὶ τὸ μεταβάλλον μεταβεβληκέναι, καὶ ἔσται τοῦ μὲν μεταβάλλειν τὸ μεταβεβληκέναι πρότερον, τοῦ δὲ μεταβεβληκέναι τὸ μεταβάλλειν, καὶ οὐδέποτε ληφθήσεται τὸ πρῶτον.

cannot be what Aristotle means by "primary time."

Strobach's Reading: Primary times are the indivisible ones.

Strobach's criteria on having a primary time are the same as Morison's, with one addition. For Strobach, a time t is a primary time of E if and only if:

a) E occurs in t, and

b) no part of E occurs at any time outside t, and

c) there is no stretch of time t', which is a part of t, in which E is not taking place.

d) there is no stretch of time t', which is a part of t, in which E is taking place.[21]

Whereas Morison supplies Aristotle with the asymmetry argument, Strobach instead adds the condition (d) that no primary time of E can have a proper part in which E occurs. Since (c) and (d) are inconsistent for any time having proper parts, no event has a divisible primary time. This, Strobach says, is precisely the point: a primary time would be a time-atom, and Aristotle aims to show that no time-atoms are possible. Strobach does, however, grant that these criteria allow for indivisible primary times, and so events that occur in an instant may have primary times.

The virtue of Strobach's reading is that it provides a natural answer as to why Aristotle goes from "E must occur in every part of its (alleged) primary time" to "E has no divisible primary time" without much explanation. If (d) is a necessary (and, presumably, intuitive) condition on having a primary time, then this inference is straightforward: if something is resting in both halves of the primary time when it is resting, then this alleged primary time cannot in fact be

---

[20] ὥσπερ δὲ τὸ κινούμενον οὐκ ἔστιν ἐν ᾧ πρώτῳ κινεῖται, οὕτως οὐδ' ἐν ᾧ ἵσταται τὸ ἱστάμενον·

[21] I don't quote Strobach directly because his notation is different from Morisons', which I've roughly adopted. Here is the passage from which I draw this list of conditions on being a primary time: "A time z is, according to Physics VI, a prime element of the extension of a statement P iff (i) z satisfies F [cf. Morison's (a)], (ii) There is no (proper) part of z which does not satisfy F [cf. Morison's (c)], (iii) There is no (proper) part of z which does satisfy F, [cf. (d)] (iv) There is no period c for which holds: *-P(c) [i.e. all proper parts of c satisfy F] and z falls within c

primary.

However, Strobach's reading faces a straightforward objection: if the primary time of an event must be indivisible as a matter of definition, then why would Aristotle ever bother to consider the possibility (much less five separate times, each time discussing a different sort of event) that the primary time of a given event is divisible? Presumably, it would suffice to make this point once and at the appropriate level of generality. Further, Strobach must accuse Aristotle of an obvious fallacy in the version of the primary time argument found in 6.6. On Strobach's view, the point of the primary time arguments is to show that every period of time is divisible. But the divisibility of every period of time is taken as an assumption in T3, above.

What makes a time primary?

Our dilemma is this: Strobach's reading is best supported by the details of the primary time arguments found in T1-5, but it leads to an implausible picture of the context and aim of these arguments. For if Strobach is right that the primary time arguments were written to show that there are no time-atoms, then Aristotle handled these arguments in a circuitous, unnecessarily specific, and sometimes fallacious way. To put this difficulty in more precise terms, Strobach appears to be on good ground in saying that

(d), there is no stretch of time t', which is a part of t, in which E is taking place,

is a necessary condition on some event's having a primary time. Yet if

(c), there is no stretch of time t', which is a part of t, in which E is not taking place,

is also such a necessary condition, then no event can have a primary time, and this leads to implausible conclusions about Aristotle's argument.

[Morison's (b)]" Strobach *Moment*, 75.

The solution is this: (d) is, but (c) is not a necessary condition on having a primary time. Aristotle's primary time arguments are designed to show that events of a specific kind, namely "homogeneous" events, cannot have divisible primary times. As I will show, this solution coheres into a conception of primary times as being those times defined by the event of which they are times.

There are, however, compelling reasons for thinking that (c) is necessary condition on having a primary time. First, it seems to play a role in the canonical primary time argument, second it seems intuitively true that events must occur in proper parts of the times in which they occur, and third it seems to be explicit in Aristotle's characterization of what makes times primary in *Physics* 6.6. So it is no accident that this is a point of agreement between Morison and Strobach, even given their very different conceptions of primary times.

Let us examine the relevant part of the canonical primary time argument:

> If some event (E) has a divisible primary time, then this time can be divided into parts. E must occur in neither of the two parts of the primary time (*t*), in only one, or in both.
>
> i) If E occurs in neither part, then E does not occur in *t.*
>
> ii) If E occurs in only one part, then *t* is not the primary time of E.
>
> Therefore E occurs in both parts of *t*.
>
> But if E occurs in both parts of *t*, then *t* is not the primary time of E.
>
> Therefore, E has no divisible primary time.

Aristotle doesn't directly state (c) in the course of the argument, but one might derive it from (i) or (ii). That is, the hypotheticals in (i) and (ii) both describe cases where E fails to occur in some proper part of t. Note, however, that (ii) also describes a case where an event would fail to satisfy Strobach's (d), since t would then also include a time in which E does occur. So in order to test

the theory that (c) is a genuine condition on having a primary time, we must focus on the case described in (i). Does Aristotle think that (i) is true of all events?

Consider a walk from A to C. By "a walk" here I do not mean the path from A to C or the repeatable act of traveling from A to C, but a token, historical event wherein someone walked from A to C. This event took up a period of time, say 5:00 to 5:30, and it can be divided into parts, such as a first and a second half. But the first half of the walk from A to C is not a walk from A to C. Rather, it is a distinct event, a walk from A to a midpoint B. We can call events like this "heterogenous" events, and they are characterized by a certain relationship to their parts: every proper part of an heterogenous event is a distinct event. As a consequence, it is possible that an heterogenous event could occur in a time t, but fail to occur in any part of t. In my example, my walk from A to C occurs in the time 5:00-5:30, but it does not occur in any part of that time. By contrast, "walking" or even "walking from A to C" is homogeneous, in that if I am walking from 5:00-5:30, then I am also walking in every proper part of that time.

Aristotle is himself attentive to the distinction between heterogenous and homogeneous events in Physics 6. In Physics 6.1, Aristotle distinguishes between two distinct, but always contemporaneous events—a motion, and something's moving.

> Therefore, since where there is motion there must be something that is in motion, and where there is something in motion there must be motion, therefore the being-moved will also be composed of indivisibles (231b18-27).[22]

Aristotle marks this distinction throughout Physics 6 verbally by contrasting the noun "motion" (ἡ κίνησις) with a form of the verb "to move" in the middle voice[23] (here the infinitive κινεῖσθαί,

[22] εἰ δὴ παρούσης κινήσεως ἀνάγκη κινεῖσθαί τι, καὶ εἰ κινεῖταί τι, παρεῖναι κίνησιν, καὶ τὸ κινεῖσθαι ἔσται ἐξ ἀδιαιρέτων.

[23] Hence "to move" in the sense of undergoing some motion, rather than causing something else to move (which

but elsewhere he uses finite verb forms such as κινεῖταί, "it moves," as well). Aristotle will make the same distinction with "change" (μεταβάλλειν) as well, again distinguishing between a change and something's changing.[24] Every change is a change of something, such as a horse, person, or stone. Changing is what this subject is doing insofar as this subject is the subject of a change. On the basis of the principle that a motion and something's moving are always contemporaneous events, Aristotle argues in 6.3 that nothing can be moving in an instant (since a motion cannot occur in an instant), and in 6.4 (235a25-34) that the moving of a moving thing is subject to the same sorts of divisions as the corresponding motion.

However, these two events differ with regard to the question of structure. Motions are heterogenous, while the moving of a moving thing is homogeneous. The hypothetical that I have marked (i) in the canonical primary time argument, i.e.

(i) if E occurs in neither part, then E does not occur in *t*,

is true of all homogeneous events, but not true of any heterogenous events. Since we find this step in all four explicit primary time arguments (and the fifth, T5, suggests no variation), we can infer[25] that the events discussed in every one of these arguments are homogeneous: having changed (both in the sense of having completed and having begun a change), changing, coming to a stand, and being at rest. Hence, the primary time arguments are meant to show that this set of events, being homogeneous, can have no divisible primary time (and in all but one case, no

---

would require the active κινεῖν). Unfortunately, English is ambiguous on this score in a way that Greek is not.

[24] A possible exception, where the verb is used to indicate a motion rather than the act of moving, is 240b22-3, where he talks about the primary time in which something is changing (μεταβάλλει). In light of the result of 6.6, which is that changing and moving do not have a primary time, we must say: Aristotle means the primary time of its change, not its changing, and since his discussion of heterogenous vs. homogeneous events is here behind him, he is no longer careful with his language.

[25] Another possibility that I will not consider is that (i) is true of all events having primary times. I ignore this possibility because it would result that Strobach's theory of primary times as atomic times is correct, and thus that Aristotle intends to deny the possibility of divisible primary times, but also that the primary time arguments are invalid, since one of its premises is only true of a subset of events. This seems like too obvious a mistake for

primary time at all).

Instead of expressing a requirement on having a primary time then, (i) just expresses a requirement on an homogeneous event taking up a divisible time at all. If this reading is correct, we should expect to find the parts of the primary time arguments marked (i) and (ii) to be phrased differently. The consequent of (i) should be something such as "but then it doesn't occur in the time at all", while the consequent of (ii), which expresses a genuine requirement on having a *primary* time, should say "but then the time in question cannot be the primary time of the event." And this is just what we find:

> i) If, on the other hand, it was changing in each of the two singly (for it must either have changed or be changing in each of them singly), **it must have been changing in the all of the whole too**; but our assumption was that it had changed in that.
>
> i) if it has changed in neither of the two parts into which AD is divided, **it has not changed in the whole either**;
>
> i) if, on the other hand, it is changing in both parts, **it is likewise changing in the whole**;
>
> i) Then if it moves in neither of the two, **it will be at rest in the whole. For it is impossible that it moves in a time in no part of which it moves.**
>
> i) For if it is coming to a stand in neither of two parts into which the time may be divided, **it cannot be coming to a stand in the whole time**, with the result that that which is coming to a stand will not be coming to a stand.
>
> ii) If on the one hand it has changed in AB or again in BC, AC cannot be the **primary thing** in which it has changed.

Aristotle to have made, considering his attention to divisibility and heterogenousness of changes.

ii) The same argument applies if we suppose that it changes in one part and has changed in the other; for then we shall have something **prior to what is primary.**

ii) if, again, it has changed in one of the two parts, the whole is not the **primary time** in which it has changed:

ii) If on the other hand it moves in only one of the two, XR cannot be the **primary time** in which it moves.

ii) If on the other hand it is coming to a stand in only one of the two parts, the whole cannot be the **primary time** in which it is coming to a stand; for it is coming to a stand in this derivatively, as we said before in the case of things in motion.

We can conclude first that (c) is not necessary for making sense of the primary time arguments as they appear in the text, and second that Aristotle does not think that it is true of all events that in order for them to occur in a divisible time t, they must also occur in every part of t. So much, then, for the first two reasons for accepting (c) as a condition on having a primary time.

The third reason for thinking that (c) is a requirement on something's having a primary time is that Aristotle seems to say as much when he is explicitly discussing what makes a time primary at the beginning of Physics 6.6:

> That being so, that which changes must be changing in any part of the primary time in which it changes. This is clear from the definition, in which the word is said to express just this (*Physics* 6.6 236b22-24).[26]

But what does Aristotle mean when he says that something "is clear from the definition"? Aristotle apparently does not use this locution to describe the contents of a definition.[27] Rather,

[26] ἐν ᾧ πρώτῳ χρόνῳ μεταβάλλει τὸ μεταβάλλον, ἐν ὁτῳοῦν ἀνάγκη τούτου μεταβάλλειν. δῆλον μὲν οὖν καὶ ἐκ τοῦ ὁρισμοῦ (τὸ γὰρ πρῶτον οὕτως ἐλέγομεν)

[27] As far as I have found, the claim that something is clear or evident from a definition occurs ten times in the

he generally means to call attention to the consequences of a definition in a particular context. So when "P is clear from the definition of A", Aristotle means that "P is entailed by the definition of A (along with, perhaps, other assumptions)" and not "P is a part of the definition of A." To take an example from the Prior Analytics, Aristotle says at 33a23-25:[28]

> For if *A* is possible for every *B*, and *B* for some *C*, then *A* is possible for some *C*. This is clear from the definition of being possible.[29]

Aristotle has just given his definition of "possible" at 32a17:

> I use the terms 'to be possible' and 'the possible' of that which is not necessary but, being assumed, results in nothing impossible.[30]

The validity of the syllogism described in the first quote can't be understood as a part of the definition of the possible. Rather, the definition of the possible, given in the second quote, entails that the syllogism of the first is valid. So I understand Aristotle's comment on what "is clear from the definition of primary" in 6.6 as follows. A primary time is the time defined by the event of which it is the time. It follows from this that if an homogeneous event like "moving" were to have a divisible primary time, it would have to occur in every part of that time. If it did not occur in every part, then the whole time would have to be defined in terms of some other event, since it extends beyond the event of which it is allegedly the primary time. As in the case of the definition of the possible, what "follows from the definition" is not (at least not necessarily) a part of the definition of a primary time, but a corollary of it. So this passage from 6.6 does not in

---

Aristotelian corpus: Here in the *Physics*, *Prior Analytics* 32b40, 33a25; *Sophistici Elenchi* 168b21; *De Caelo* 282b2; *Metaphysics* 1012a11, 1056a13; *Rhetoric* 1369a35, 1380b22, 1386a5. Some of these are ambiguous, but Aristotle never clearly uses this phrase to state part or all of a definition.

[28] I choose this example because it is one of the very few cases in which Aristotle is clear on what definition he's referring to, and at some point gives that definition.

[29] εἰ γὰρ τὸ Α παντὶ τῷ Β ἐνδέχεται, τὸ δὲ Β τινὶ τῷ Γ, τὸ Α τινὶ τῷ Γ ἐνδέχεται. τοῦτο δὲ φανερὸν ἐκ τοῦ ὁρισμοῦ τοῦ ἐνδέχεσθαι.

[30] λέγω δ' ἐνδέχεσθαι καὶ τὸ ἐνδεχόμενον, οὗ μὴ ὄντος ἀναγκαίου, τεθέντος δ' ὑπάρχειν, οὐδὲν ἔσται διὰ τοῦτ'

fact suggest that (c) should be taken to be a part of the definition of a primary time.

If we leave (c) out of the criteria on having a primary time, then we can follow Strobach's insight and retain (d) without suffering any of the difficulties of Strobach's reading. Further, once we've seen that (d) rules out the possibility of an homogeneous event having a divisible primary time, we can leave out (b) as something superfluous: if a part of my walk from A to C occurs outside time t, then the walk from A to C cannot occur in t. So any event that satisfies (a) and (d) will never fail to satisfy (b). In effect, I pare Strobach's criteria down from these, were E is some event and t is its alleged primary time:

a) E occurs in t, and

b) no part of E occurs at any time outside t, and such that

c) there is no stretch of time t' which is a proper part of t in which E does not occur.

d) there is no stretch of time t', which is a proper part of t, in which E occurs.

To these:

a) E occurs in t, and

d) there is no stretch of time t', which is a proper part of t, in which E is taking place.

Now it remains to show that (a) and (d) are sufficient for an understanding of primary times.

First, (a) and (d) can together explain Aristotle's "year and day" example from 6.6. Suppose something happens on a particular day. The year in which that day falls also counts as the time of that event, but not as its primary time. If we take Aristotle to be saying that the year is not primary because it contains a period in which the event is not happening, then it would seem to suggest the need for (c) in our theory of primary time. But it is not necessary to read the example this way, because (d) also explains the example. (d) states that E must not occur in any proper

---

ἀδύνατον·

part of the primary time of E. Suppose I say that the time of my walk from campus to home is "2018". My report is truthful, but did I give the primary time of my walk? No, assuming it didn't actually take a full year to get home, because there is a proper part of 2018, namely 5:00-5:30 on a particular day, which contains the walk from campus to home. As a time of my walk, "2018" satisfies (a), but it can be regarded as non-primary just because it fails to satisfy (d).

Second, all the primary time arguments proceed by showing that if some event must occur in any part of the alleged primary time of that event, then the event cannot have a primary time. That is to say, no homogeneous event can have a primary time. And (a) and (d) are sufficient to explain why any homogeneous event has no primary time, since no homogeneous event could satisfy (d).

Finally, (a) and (d) are sufficient to show that any event having a primary time has a unique primary time. Take again my walk from campus to home (an heterogenous event), from 5:00-5:30 on a particular day. If my walk begins at exactly 5:00 and ends at exactly 5:30, then 5:00-5:30 is the primary time of my walk. No longer time (say 5:00-5:45) can be the primary time of my walk because it would fail to satisfy (d). Whereas any smaller time would fail to satisfy (a), since it would not contain the whole of my walk. As a result, 5:00-5:30 is the only time that could count as the primary time of my walk.[31]

I have so far approached the question of primary time as a problem of decoding Aristotle's argument 6.5-6 and 6.8. It is additionally necessary both to provide some intuitive sense of what a primary time is, and then to explain the significance of these arguments within the broader project of 6.4-6.

So first, why is it that if I am sitting from 5:30-6:00, and therefore in every part of the time

[31] Therefore, my reading converges with that of Morison in saying that when an event has a divisible primary time,

from 5:30-6:00, 5:30-6:00 cannot be the primary time of my sitting? The answer is simply that sitting does not allow me to define a unique time as the time of my sitting. For I can correctly point to 5:30-5:45 as the time of my sitting as well. One can insist that I point to the time between when I first sat down and the moment before I got up again, but this is to define the time in terms of events (sitting down and standing up) other than merely "sitting." By contrast, if one asked me to give the time of my walk from campus to home, there is only one answer that is defined by the event in question: 5:00-5:30 on some particular day. In general, we can say that a primary time is that unique time that is defined by the event of which it is the time. And homogeneous events cannot define any unique time in which they occur.

As we would expect, primary times play an explanatory role. Only events having primary times can be used as units of temporal counting. For Aristotle, a time is a number, and therefore a relation between one event, used as a unit of counting, and another, which is thereby counted. So when I give the time of some event by saying something such as "the walk took 30 minutes" I number one event by means of some quantity of other events, which serve as units. In this case, I number a walk by counting out a plurality of motions of a second hand around the face of a clock: thirty rotations for one walk. Since each rotation has a unique primary time, number of rotations accomplished always has a definite answer. We can use any repeated motion as a unit of counting, and we build clocks so as to present (or report) just these sorts of motions.

But suppose you wished to number the time of my walk by using an homogeneous event as your unit, say your sitting in an armchair. Since you are sitting in an armchair in every part of the time of your sitting, you may as correctly say "your walk took one sitting" as "your walk took thirty sittings." Sitting lacks the structure necessary to determine any particular answer to the

---

that time is the most precise time of the event.

question "how many?" Events that do not have primary times cannot be used to count times. In this sense primary times are the temporal analog of primary substances: they are the fundamental elements of time to which any temporal claim must ultimately appeal.[32] Indeed, Aristotle might say that time is heterogenous, in the sense I have employed above, precisely because the events that have primary times are heterogenous.

I've argued that a crucial part of these arguments is the distinction between heterogenous and homogeneous events. The primary time arguments isolate and describe a feature of homogeneous events, and Aristotle takes a particular interest in homogeneous events that must take a positive amount of time. These, he concludes can have no primary time: no time of such an event cannot be defined by that event.

In the final part of this chapter, I wish to relate the primary time arguments I've been discussing to the series of arguments found in 6.4, having to do with the idea that one aspect of change (change, time, magnitude, etc.) can be divided according to another. I will show that: if A is divisible according to B, then a given element of A has a primary corresponding element of B. So for example, if change is divisible according to time, as Aristotle argues in 6.4 235a10-24, then a given change has a primary time. Correlatively, if some event, like changing, has no primary time, then it is not divisible according to time. Aside from explaining the consequences of the primary time arguments for Aristotle's theory of time, my aim in drawing out this relationship is to make transparent Aristotle's procedure in 6.4-6. The primary time arguments do not appear out of nowhere. Rather, they are a modification of the arguments dealing with mutual divisibility in 6.4.

[32] Though as Aristotle observes in *Physics* 4.12 223b12-24, only regular locomotions, such as the motions of the

Division According To

Excepting the partwise argument at 234b10-20, much of the rest of *Physics* 6.4 consists of a series of arguments that show that some aspect of change is divisible according to another. He runs through explicit arguments in a few cases, leaving us to extrapolate over the rest: "it follows that the time, the motion, the being-in-motion, the thing that is in motion, and the sphere of the motion must all be susceptible of the same divisions" (235a15-17). The first such argument, and certainly the most complete, is found at 6.4 234b21-235a10. There, Aristotle tries to show that a change is divisible according to the changes of the parts of the changing thing. Aristotle also refers back to this long argument at 235a31-33, suggesting that the same schema can be applied to other cases:

> Change is divisible in two ways. One way is by way of the time, and the other is according to the changes of the parts of the changing thing. If AC changes as a whole, both AB and BC will also change. Let DE be the change of the part AB and EF be the change of the part BC.[33]

To say that a change is divisible according to "the changes of the parts of the changing thing" is a slightly infelicitous way for Aristotle to describe this relationship. The whole change DF is not divisible according to DE, at least not in any sense parallel to the way in which DF is divisible according to its time.

Aristotle means rather that the whole motion DF is divisible according to the changing thing, AC. If we begin with some division of a changing body, we will thereby mark a corresponding division in its change. I presume that the reason Aristotle expresses himself in this way is the

---

celestial bodies, are actually useful for measuring time.

[33] κίνησις δ' ἐστὶν διαιρετὴ διχῶς, ἕνα μὲν τρόπον τῷ χρόνῳ, ἄλλον δὲ κατὰ τὰς τῶν μερῶν τοῦ κινουμένου κινήσεις, οἷον εἰ τὸ ΑΓ κινεῖται ὅλον, καὶ τὸ ΑΒ κινήσεται καὶ τὸ ΒΓ. ἔστω δὴ τοῦ μὲν ΑΒ ἡ ΔΕ, τοῦ δὲ ΒΓ ἡ ΕΖ

relativity of the divisions in the changing thing to its change.[34] But we can find the set of divisions that will so serve by noticing which parts of the changing thing have motions that are successive, as do AB and BC in Aristotle's example.

The long argument has three parts which together winnow down the ways in which we might try to understand the structure of changes, given the assumption that they occur part-by-part. Suppose I have a block of copper, AC and it goes from being cold to being hot. The block is the primary subject of the change, and so it must change as a whole, and the change progresses part-by-part over its divisible body. We divide the block into two halves, AB and BC, and stipulate that the change by which AB becomes hot is called DE and the change by which BC becomes hot is called EF. Aristotle then argues:

> Now, it is necessary that the whole [change] DF be the change of AC. For it [AC] changes according to this [DF] since each of the parts [AB and BC] changes according to each [DE and EF]. But nothing can change according to the change of something else, consequently the whole change is the change of the whole magnitude.[35]

Aristotle's aim in this argument is to show that a given division in the changing thing produces a unique division in the change: in this case the division B in the thing produces the division E in the change. He accomplishes this by way of an intermediate conclusion: the change (DF) of a whole body (AC) can be found by joining the successive changes of that body's continuous

---

κίνησις τῶν μερῶν.

[34] Aristotle actually faces a similar problem in *Physics* 4.10-14, where he says that the before and after in change follow the before and after in distance. Of course, a spatial distance has parts, but not parts that are prior and posterior in the way that the parts of a change are. There is no "first" mile between Chicago and Philadelphia, or at any rate, there is no way to decide between the two candidates without presuming a particular motion from the one to the other.

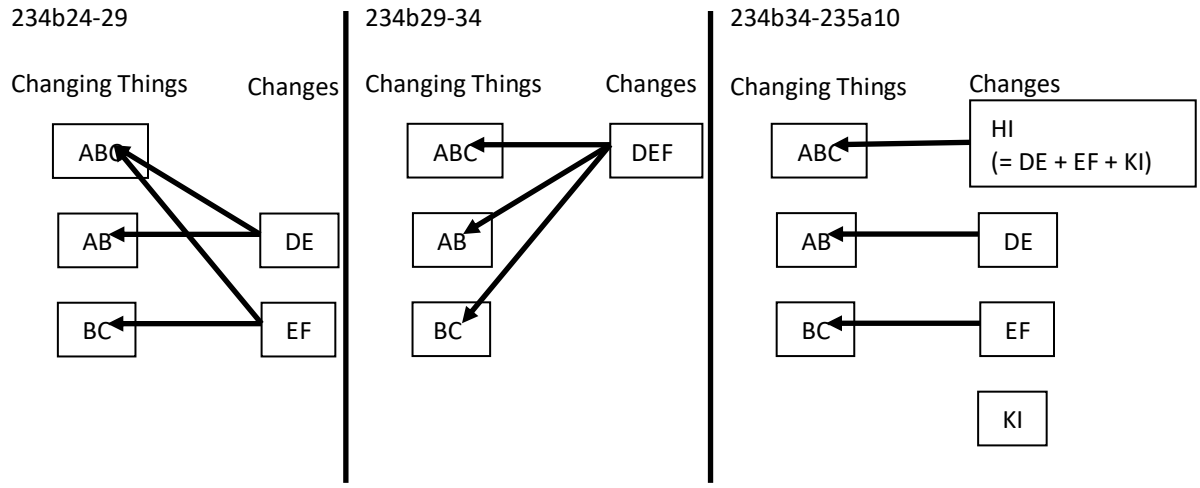
[35] εἰ τὸ ΑΓ κινεῖται ὅλον, καὶ τὸ ΑΒ κινήσεται καὶ τὸ ΒΓ. ἔστω δὴ τοῦ μὲν ΑΒ ἡ ΔΕ, τοῦ δὲ ΒΓ ἡ ΕΖ κίνησις τῶν μερῶν. ἀνάγκη δὴ τὴν ὅλην, ἐφ' ἧς ΔΖ, τοῦ ΑΓ εἶναι κίνησιν. κινήσεται γὰρ κατὰ ταύτην, ἐπείπερ ἑκάτερον τῶν μερῶν κινεῖται καθ' ἑκατέραν· οὐθὲν δὲ κινεῖται κατὰ τὴν ἄλλου κίνησιν· ὥστε ἡ ὅλη κίνησις τοῦ ὅλου ἐστὶν μεγέθους κίνησις.

parts.

This can feel abstract, and so it is useful to consider the argument, (and the two that follow it) as if they were rejecting a series of alternative conceptions of the relationship between the changes of the parts of a thing, and the parts of a changing thing. Imagine our block, changing from cold to hot part by part. What would it mean to deny that DE and EF constitute some whole change corresponding to the whole AC? In the spirit of this denial, one might instead think that the whole block AC does not suffer any single change. Rather, it undergoes the change DE, and then a second change EF, where these are understood to follow one another in time but to be otherwise unrelated. Aristotle takes it as a hypothesis in this argument that DE is *also* the change of the part AB. Now, Aristotle has grounds for an objection: DE would then belong to two primary subjects, AC and its part AB. But in principle no change may be the change of more than one changing thing.

This principles is applied again to refute the possibility that AC and its parts AB and BC all suffer the same change DEF, and that there is some change, HI that is other than the composite of DE and EF. In short, Aristotle's argument serves to exclude these three possibilities:

Figure 6: 234b20-235a10 in diagram



It may be helpful to remark that Aristotle has effectively defined the relation of a function from changes to changing things. If we read the opening of the long argument, "if AC moves as a whole, both AB and BC will also move" as requiring that each part of the changing body corresponds to a change, then Aristotle is describing a *surjective* function.[36] So in general when Aristotle says that "A is divisible according to B" we can presume that this means, at least, that for every element of B, there is at least one corresponding element of A. An appropriately change-relative division in the body of the changing thing *produces* a division in the change because there can be no fewer changes than there are changing things: if there is a surjective function from elements of A to elements of B, and there are three elements of B (a body and its two halves, say) then there must be no fewer than three elements of A (a motion and its two halves).

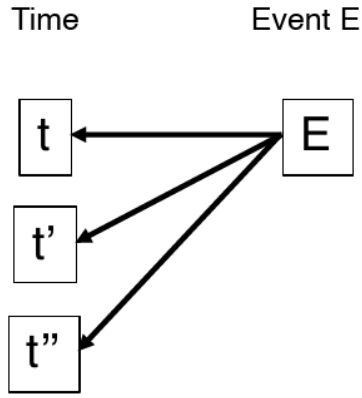
I want to return now to the thesis I proposed earlier: that the question of whether or not something has a primary time will have consequences for whether or not it is divisible according to time. I described that thesis in terms of a conditional: if some aspect of change A is divisible according to another, B, then every element of A has a primary element of B. So for example, if change is divisible according to time, then changes have primary times. If something, like changing, does not have a primary time, then it is not divisible according to time either. Given the above analysis of Aristotle's arguments in 6.4 concerning divisibility, we can now see why this is the case.

In the first part of this chapter, I argued that an event E has a primary time *t* only if it satisfies these two conditions: a) E occurs in *t*, and d) there is no stretch of time *t',* which is a proper part

[36] There is a surjective function from a set X and to a set Y when: a) every element of X corresponds to some element of Y, b) no element of X corresponds to more than one element of Y, and c) each element of Y there corresponds at least one element of X.

of *t*, in which E occurs. We can now get a grip on this second condition in terms of Aristotle's analysis of the mutual divisibility of aspects of change in 6.4. An homogenous event like changing or resting fails to satisfy this second condition, because if any time is the time of my resting, then some proper part of that time is the time of my resting as well. Hence, the relationship between an homogeneous event and its time is as follows:

Figure 7: homogeneous events



Because E an an homogenous event, there are proper parts of its time *t*, here *t'* and *t''*, which are also times of E. We can now recognize this as one of the relations Aristotle aims to rule out in order to show that one thing is divisible according to another, at 234b29-34. And so because changing stands in this relationship to its time, the changing of a changing thing cannot be divided according to its time. As above, if we were to mark a division in the time of something's changing, we would not thereby be assured of marking a division in the corresponding changing: the changing of a changing thing will correspond equally with any part of a given time (so long as that time does not include parts in which the thing has ceased to be changing).

I conclude that the primary time arguments in 6.5-6 are plausibly a development of the divisibility arguments found in 6.4. Much of the work of this dissertation, and especially the next chapter, is to argue that 6.4-6 represents a single, coherent line of thought, contrary to the

readings of most contemporary scholars. An important step in understanding the coherence of this text is to see that it not only drives towards a single conclusion—the explanatory priority of the changing thing among all the continua of nature—but that the reasoning therein is developed from a kernal. Aristotle approaches his thesis with the confidence that he can show that changing things stand in this position of explanatory priority entirely by examining the relationships of mutual divisibility (and the failure of these relations) among the various aspects of change.

Chapter 5: Divisibility and Infinity

The primary aim of this chapter is to explain the overarching argument of *Physics* 6.4-6. I will show here that 6.4-6 is constructed out of a series of subordinate arguments (along with some very sparing commentary), each of which contributes to the larger argument described at a signposting passage at 6.4 235a35-b5. In the previous chapter, I examined these subordinate arguments on their own terms, while in this chapter, I focus on that overarching argument. In doing so, I will also discuss the context of that argument within the rest of *Physics* 6 and try to give some sense of what, if anything, unifies the book. For we cannot infer from the fact that a set of texts have been collected by tradition into a book that they constitute a continuous argument, or that they have a common topic. So much the less in *Physics* 6 itself, given its many interpretive difficulties. However, I will argue that while *Physics* 6 is not a continuous text,[1] and not united by any one topic or aim, it is nevertheless a coherent and intelligible work. And while *Physics* 6 is unlike the topically coherent *Physics* 1, which can be called "a book on principles," nevertheless it would be reasonable to think that *Physics* 6 should be presented, as we have it, as a single course of study. The book is united by a common set of concepts and argumentative strategies, which it would have been useful to teach and use in one go. To give what is perhaps the primary example: the discussion of the constitution of a continuum 6.1 231a21-b18, and the claim therein that the points on a continuum are dense, is both conceptually difficult and crucial to everything that follows it. It would be reasonable, I think, to say that *Physics* 6 is the book constituted by those lines of reasoning that depend on this initial discussion.

The most important of these lines of reasoning is 6.4-6. I say "most important" because these

[1] By "a continuous text" I mean a text every part of which can be understood as having been written with every other part in view. For example this dissertation aspires to be a continuous text, and it is the responsibility of a

chapters represent the most radical and substantive philosophical result of *Physics* 6: a theory of the ground of all natural continua: body, time, change, and distance. The result of Aristotle's investigation is that the divisibility and infinity of *changing bodies* explains the divisibility and infinity of everything else.

I begin with a signposting passage at the end of 6.4, and its complimentary passage at the end of 6.6.

> In the same way it will be shown also that the length is divisible, and generally everything in which a change is (though some only accidentally, because the changing thing is divisible), for the division of one will divide all. Also as regards their being finite or infinite, all will be similarly disposed. And the divisibility of all things especially—and also the infinity—has followed from the changing thing. For divisibility and infinity belong immediately (εὐθὺς γὰρ ἐνυπάρχει) to the changing thing. That divisibility does so we have shown before; that infinity does so will be made clear in what follows.[2] (6.4 235a35-b5)

Aristotle indicates four theses here, which I have marked as "signposted" (SP#) claims in order to more clearly distinguish them:

SP1) "everything in which a change is [is divisible], for the division of one will divide all."

SP2) "divisibility…belongs directly to the changing thing;"

SP3) "as regards their being finite or infinite, all will be similarly disposed;"

SP4) "infinity belongs directly to the changing thing."

---

dissertation writer to ensure this, though we often fail.

[2] ὡσαύτως δὲ δειχθήσεται καὶ τὸ μῆκος διαιρετόν, καὶ ὅλως πᾶν ἐν ᾧ ἐστιν ἡ μεταβολή (πλὴν ἔνια κατὰ συμβεβηκός, ὅτι τὸ μεταβάλλον ἐστὶν διαιρετόν)· ἑνὸς γὰρ διαιρουμένου πάντα διαιρεθήσεται. καὶ ἐπὶ τοῦ πεπερασμένα εἶναι ἢ ἄπειρα ὁμοίως ἕξει κατὰ πάντων. ἠκολούθηκεν δὲ μάλιστα τὸ διαιρεῖσθαι πάντα καὶ ἄπειρα εἶναι ἀπὸ τοῦ μεταβάλλοντος· εὐθὺς γὰρ ἐνυπάρχει τῷ μεταβάλλοντι τὸ διαιρετὸν καὶ τὸ ἄπειρον. τὸ μὲν οὖν διαιρετὸν δέδεικται πρότερον, τὸ δ' ἄπειρον ἐν τοῖς ἑπομένοις ἔσται δῆλον.

This passage apparently marks a division some line of thought: (SP1) and (SP2) have already been established ("that divisibility does so we have shown before…"), while the argument for (SP4), at least, is forthcoming ("that infinity does so will be made clear in what follows").

So where shall we find arguments for (SP1) and (SP2)? (SP2) is easy to locate: no other passage in *Physics* 6 besides the partwise argument at 6.4 234b10-20 discusses the changing thing itself and its divisibility. There are, on the other hand, plenty of appealing candidates for (SP1) in *Physics* 6—6.1, 6.2, and 6.4 all contain independent (indeed, redundant) arguments about the mutual divisibility of the aspects of change. But Aristotle says in the first lines of this passage "in the same way it will be shown also that…" and this suggests that the argument for (SP1) immediately precedes the passage. So Aristotle probably means to indicate the arguments beginning at 6.4 234b21, in which he argues for the co-divisibility of the changing thing, change, time, and changing. These arguments are hypothetical, and they only go so far as to show that *if* one aspect of change is divisible, the others are as well. But since he has already established by a categorical argument that the changing thing is divisible—in 6.4 234b10-20—he simply asserts the divisibility of all. So the arguments for (SP1) and (SP2) are both found in 6.4. Together they show that every aspect of change is mutually divisible, and that the divisibility of these aspects "follows from" (ἠκολούθηκεν) the direct or immediate divisibility of the changing thing. I'll call the whole line of thought, confined to 6.4 and addressed to theses (SP1) and (SP2), the "divisibility argument."

Besides the divisibility argument, Aristotle also mentions theses (SP3) and (SP4), which are parallel to (SP1) and (SP2) respectively, but have to do with "infinity" rather than divisibility. What is meant by "infinite" here? He does not think that the changing thing, or any other aspect of change, can possibly be infinite in extent. He does argue in 6.2 and 6.7 that if (*per imposibile)*

any one aspect is infinite in extent then every other must be so. But he also asserts here in 6.4 that every changing thing is indeed infinite, and so he cannot therefore mean infinite in an extensive sense. Aristotle distinguishes two senses of "infinity" in *Physics* 6.2. In line with our own usage, something may be "infinite in respect of its extremities" (κατὰ…τοῖς ἐσχάτοις) as the natural numbers are, or, contrary to our everyday usage, "infinite in respect of divisibility" as a (finite) continuous line is. Aristotle uses "infinite" (ἄπειρον) in both these senses in *Physics* 6, but here in 6.4, where every changing thing is said to be infinte, he must mean "in respect of divisibility." Let this stand then as a preliminary gloss of "infinity" in 6.4-6. "Preliminary" because I think Aristotle ultimately means something more than just "infinitely divisible."

Aristotle does not say where he argues for (SP3) in this passage, and he promises an argument for (SP4) "in what follows" (ἐν τοῖς ἑπομένοις). But where? In *Physics* 6.6 237b3-22, we find this passage:

> So it is clear also that what has become was becoming before, and what is becoming must previously have become, to the extent that it is divisible and continuous. … For something infinite belongs directly to what becomes and what perishes, because it is continuous. …It is clear, then, that what has become was becoming previously, and what is becoming must have become; for all magnitudes and all periods of time are always divisible. Therefore, whatever a thing may be in, it is not in it primarily.[3] (6.6 237b3-22)

Note the parallel phrasing in this passage and in the one from 6.4:

6.4 234b3-5: "For divisibility and infinity belongs immediately (εὐθὺς γὰρ ἐνυπάρχει...τὸ ἄπειρον) to the changing thing…that infinity does so will be made clear in what follows."

[3] φανερὸν οὖν ὅτι καὶ τὸ γεγονὸς ἀνάγκη γίγνεσθαι πρότερον καὶ τὸ γιγνόμενον γεγονέναι, ὅσα διαιρετὰ καὶ συνεχῆ,…εὐθὺς γὰρ ἐνυπάρχει τῷ γιγνομένῳ καὶ τῷ φθειρομένῳ ἄπειρόν τι συνεχεῖ γε ὄντι,…φανερὸν οὖν ὅτι καὶ τὸ γεγονὸς ἀνάγκη γίγνεσθαι πρότερον καὶ τὸ γιγνόμενον γεγονέναι· πᾶν γὰρ μέγεθος καὶ πᾶς χρόνος ἀεὶ διαιρετά.

6.6 237b14-15: “For something infinite belongs immediately (εὐθὺς γὰρ ἐνυπάρχει…ἄπειρόν τι) to what becomes and what perishes, because it is continuous.”

So I take the promised argument for (SP4) to have been concluded by the end of 6.6—though it is still unclear where it begins.

This leaves (SP3). I think that there is no very good candidate for an argument for (SP3) in *Physics* 6. Or rather, the two arguments that discuss the mutual infinity or finitude of the aspects of change are in the wrong place. The first would be 6.2 233a21-b15, but it is unlikely that Aristotle is thinking of that text. First, we would expect some reference back to it, and second, 6.2 and 6.4 are substantially redundant as regards the co-divisibility of change, time, etc.. It would be strange to find Aristotle giving a new argument in 6.4 for this co-divisibility but relying on what he said in 6.2 (without any back reference) when it comes to their mutual infinity. The second candidate would be 6.7, but 6.7 does not discuss the right kind of infinity—that chapter is wholly occupied by bodies, changes, times, and magnitudes that are infinite in extent. But as I’ve just argued, this is not the sort of infinity Aristotle can be referring to here. So I surmise that the argument for (SP3) is not explicit: we are to infer (and we may do so at the end of 6.4) that if A and B are co-divisible, and A is infinitely divisible, then B must be infinitely divisible too.

We now have a sense of the scope and rough structure of the argument with which Aristotle intended to revise the theory of natural continua found in *Physics* 3-4. He divides his discussion into two parts, one about the divisibility of the aspects of change and one about their infinity (in respect of divisibility). Within the first part, consisting of 6.4, Aristotle will show that (SP1) the aspects of change are mutually divisible, and that (SP2) their divisibility follows from the

---

ὥστ’ ἐν ᾧ ἂν ᾖ, οὐκ ἂν εἴη ὡς πρώτῳ.

divisibility of the changing thing, which is divisible in a direct or immediate way. I believe this argument is also supposed to suffice to show that (SP3) if any aspect of change is infinite in respect of divisibility, all are. Finally, before the end of 6.6, we should find an argument to the effect that (SP4) the infinity of all the aspects of change follows from the direct or direct or immediate infinity of the changing thing.

I will sketch what I take to be the main inference in each of the two arguments. The argument concerning divisibility (SP1 and SP2) goes thus:

> i) Aristotle shows that the changing thing is divisible categorically (in the so called "partwise" argument at 6.4 234b10-20, discussed in my chapter 2)
>
> ii) He then argues that every other aspect of change is divisible hypothetically—given the divisibility of one aspect of change, the others are shown to be divisible as well (6.4 234b21-235a34).
>
> iii) Aristotle concludes that if one aspect of change can be shown to be divisible categorically, while the others can only be shown to be divisible hypothetically, then the former aspect of change must be divisible immediately, and the divisibility of the others must follow from this one (6.4 234a35-b5)

The argument concerning infinity (SP 4) goes thus:

> iv) Aristotle has already shown that the changing thing is divisible (6.4 235a25-34), along with the other aspects of change, and in 6.6 he shows that it is also homogeneous (6.6 236b19-32)
>
> v) On the basis of the principle (inherited from the Eleatic tradition) that whatever is divisible and homogeneous is infinitely divisible, he infers that the changing of a changing thing is infinitely divisible, and that a changing thing has changed infinitely

many times (6.6 236b32-237a17)

vi) *a fortiori* everything that is coming to be has already come to be infinitely many times—and therefore something infinite belongs to everything that comes to be (6.6 237b3-22).

Here is how I will proceed: I begin with the divisibility argument (i.e. 6.4), by way of a discussion of a similar (even redundant) set of arguments in *Physics* 6.1-2. These two chapters provide some important context for the development of Aristotle's views on the divisibility of the aspects of change. I will show that 6.4 represents Aristotle's third approach to this topic within *Physics* 6, one which builds upon the strategies found in 6.1-2, while marking a shift in his aims. I then discuss the much more complicated and difficult "infinity argument." In the course of this discussion, I will also offer some brief remarks about the relationship between *Physics* 6 and *Physics* 8.8. As I noted in my first chapter, these texts are often thought to conflict with one another. I will not attempt to reconcile them, but I will try to show that *Physics* 6.4-6 is a plausible successor to that discussion.

The Divisibility Argument and its Precursors

In chapter two, I discussed the significance of the partwise argument as a categorical rather than a hypothetical argument for the divisibility of the changing thing. The remainder of 6.4 does indeed consist of such hypothetical arguments, e.g. in 6.4 234b21-235a10 it is argued that a division in the changing thing will produce a division in its change…assuming we *can* make a division in the changing thing. This strategy, the pairing of a categorical argument for the divisibility of *one* aspect of change with a set of hypothetical arguments for the divisibility of every other, is found also in *Physics* 6.1-2.

I suggest that 6.1-2 represents a relatively early stratum in *Physics* 6 (in fact, two distinct strata) which is associated with the theory of time and change found in *Physics* 3 and 4. When I argued, in my first chapter, that 6.4-6 is a late addition to the *Physics*, I left open the question of the relationship between 6.4-6 and the rest of *Physics* 6. Since what follows requires some speculation along these lines, I will summarize my sense of how the first half of *Physics* 6 may have come together. This sort of an account must, of course, remain speculative, and besides what follows, I defend it on the grounds that I believe it best illuminates the relationships between the various parts of *Physics* 6. I distinguish three strata in *Physics* 6.1-4:

-a "first text" consisting of 6.1 231a21-b20 and 6.2

-a "second text" intended as an addition to the first, consisting of 6.1 231b21-232a2.

-a "third text" consisting of 6.4-6 (and probably including 6.3 as well), not intended as a continuation of 6.1-2. I will briefly explain how I arrive at these distinctions, starting with the distinction between the first and second texts on the one hand, and the third text on the other.

I have proposed, in my first and third chapters, that when discussing the question of the structure of time and change in *Physics* 3-4, Aristotle characteristically frames things in terms of the relationship between change (κίνησις), time (χρόνος), and magnitude (μέγεθος).This is because Aristotle approaches this question entirely in terms of locomotive change, where "magnitude"—which is most primitively divisible and continuous—denotes the spatial path of a locomotion.[4]

Physics 6.4-6 abandons this framing in favor of the more expansive list of the aspects of change at 6.4 234a13-17. This is for good reason: Aristotle is motivated to supply this revision precisely because he no longer saw the question "why are change and time

[4] See chapter four of this dissertation.

divisible/continuous?" as a question answerable in terms of locomotive changes alone, and only locomotive changes and changes of size have magnitude.[5] And so "magnitude" (μέγεθος) appears rarely in 6.4-6, and not at all in 6.4. But in *Physics* 6.1-2, which together comprise both the first and the second texts, above, Aristotle remains focused on time, change, and magnitude as mutually divisible continua. This suggests that 6.1-2 is allied with the pre-revision theory of *Physics* 3-4, rather than with 6.4-6. Recall that in *Physics* 4.11, Aristotle explains the continuity of time and change in terms of magnitude:

> And since the moving thing moves from and to something, and since all magnitude is continuous, the motion follows the magnitude. For because the magnitude is continuous, the motion is also continuous, and because the motion is so, so is the time[6] (4.11 219a10-13)

As I will show in what follows, both the first and the second texts center the discussion of the divisibility of the aspects of change beginning on the case of magnitude: in both cases, it is magnitude that is shown to be categorically divisible, and change and time are shown to be divisible on this basis.

The arguments of 6.1-2 also overlap considerably with those of 6.4: both 6.1-2 and 6.4 try to show that a) if one aspect of change is assumed to be divisible, any other can be shown to be divisible, and b) at least one aspect of change can be shown to be divisible categorically. But nowhere in 6.4 does Aristotle make a note of these redundancies, nor does he acknowledge his

[5] I have discussed the (I think false and anachronistic) attribution to Aristotle of intensive or qualitative magnitudes of change in previous chapters, but it is worth noting now how Aristotle puts the distinction between changes involving continuous magnitudes and those that don't, for which see *Physics* 6.5 236b8-10, 6.6 237a29-b3, where I read "change in what is not continuous, namely in contraries and in contradictories" (ἐν τοῖς μὴ συνεχέσιν, οἷον ἔν τε τοῖς ἐναντίοις καὶ ἐν ἀντιφάσει·) to refer to alteration and generation/destruction respectively.

[6] ἐπεὶ δὲ τὸ κινούμενον κινεῖται ἔκ τινος εἴς τι καὶ πᾶν μέγεθος συνεχές, ἀκολουθεῖ τῷ μεγέθει ἡ κίνησις· διὰ γὰρ τὸ τὸ μέγεθος εἶναι συνεχὲς καὶ ἡ κίνησίς ἐστιν συνεχής, διὰ δὲ τὴν κίνησιν ὁ χρόνος·

arguments in 6.1-2 in any other way.[7] This suggests that Aristotle did not intend for 6.4 to be read alongside 6.1-2 as part of a continuous line of thought.[8]

Though I do not discuss it in detail, it is worth mentioning that *Physics* 6.3 probably belongs with 6.4-6: its main conclusions, that the now is indivisible, and that nothing can be changing or resting in a now, are prerequisites to the arguments in the subsequent chapters, and Aristotle's opening discussion of the now "not according to something else, but according to itself and primarily"[9] (233b33-34) closely echoes the language of primary time found in *Physics* 6.5-6.

Now, what about the distinction between what I am calling the first (6.1 231a21-b20 and 6.2) and second texts (6.1 231b21-232a2)? Here too, there are signs of different strata. At 6.1 231b18-20, Aristotle has just concluded his abstract discussion of continua, arguing that they cannot be composed of indivisible points. He then turns to a more concrete discussion of time, change, and magnitude, at 231b18-20:

> The same argument applies to magnitude, to time, and to motion: either all of these are composed of indivisibles and are divisible into indivisibles, or none are. This may be made clear as follows.[10]

Aristotle here introduces an argument for the claim that if any one aspect of change is divisible or indivisible, all are so. But what follows this in 6.1 is not the advertised argument. The remainder of 6.1, my second text, is instead a complex *reductio*: if magnitude and motion are

[7] Cf. Hasper's (*Continuity*, pp. 110-115) discussion of various redundancies found in *Physics* 6, including those I've described here.

[8] Redundant arguments are not unusual in Aristotle's work, but they tend to be organized alongside one another (often separated by phrases like "And again…" (ἔτι δὲ). What we find in 6.1-4 is quite different: complete arguments or lists of arguments, after which Aristotle moves on to a different topic, followed by another redundant set of arguments.

[9] …μὴ καθ' ἕτερον ἀλλὰ καθ' αὑτὸ καὶ πρῶτον…. Cf. 6.5 235b33-34 By 'primary' I mean a thing's being such-and-such not because something different than it is such-and-such." (λέγω δὲ πρῶτον ὃ μὴ τῷ ἕτερόν τι αὐτοῦ εἶναι τοιοῦτόν ἐστιν.) and 6.6 236b20-21 "…but 'the time in which it changed' is meant both primarily and according to something different" (λέγεται δ' ἐν χρόνῳ μεταβάλλειν καὶ ὡς ἐν πρώτῳ καὶ ὡς καθ' ἕτερον).

composed of indivisibles, then what is in motion will at the same time be at rest. This argument aims to establish not the hypothetical claim that every aspect of change must be composed of divisibles or indivisibles if any is, but rather the categorical conclusion that magnitude and change cannot be composed of indivisibles. Moreover, this *reductio presupposes* that if any aspect of change is composed of indivisibles, all are. So it appears that 231b18-20 cannot be introducing the argument that immediately follows it.

6.2, on the other hand, begins with an immediate reference back to the first half of 6.1

> …for we have shown that it is impossible for anything continuous to be composed of indivisibles,[11] and every magnitude is continuous… (232a23-25).

It is here that we find the argument that matches the description at 231b18-20: Aristotle shows that if any one aspect of change is divisible only into divisibles, then all are. In short, 6.1 231a21-b20 and 6.2 look to be philosophically continuous with one-another, while 6.1 231b21-232a22 looks like an insertion into that line of thought.

In what follows, I hope to make this conjecture more plausible by showing how it follows a plausible philosophical narrative. Namely: Aristotle wrote the first text taking for granted (as he does throughout *Physics* 3 and 4) that magnitudes are divisible continua. Perhaps through an encounter with a contemporary interlocutor, this assumption is at some point called into question (though never doubted by Aristotle himself) and so Aristotle indulges in a proof of the

---

[10] τοῦ δ’ αὐτοῦ λόγου μέγεθος καὶ χρόνον καὶ κίνησιν ἐξ ἀδιαιρέτων συγκεῖσθαι, καὶ διαιρεῖσθαι εἰς ἀδιαίρετα, ἢ μηθέν. δῆλον δ’ ἐκ τῶνδε.

[11] Aristotle’s word is “ἀτόμων” here. One may take this to suggest that Aristotle is thinking of atomic magnitudes, of the sort discussed in the second text, but I think that this is a mistake. Aristotle often uses “ἄτομον” to refer points or instants, e.g. “for the now is indivisible, as a point in a line” *De Caelo* 300a14 (τὸ γὰρ νῦν τὸ ἄτομον οἷον στιγμὴ γραμμῆς ἐστιν.). See also Miller “Atomists,” 105. We should read “ἀτόμων” here to mean “points” as it is used in 6.1 231a21-b18 (also part of my “first text”). The reason for this is that the argument from 231b21-232a22 does not show that, in general, continua cannot be composed out of indivisibles, but rather that there can be no indivisible motions/magnitudes/times. The only argument in 6.1 that raises a question about the composition of continua is the part that belongs to the “first text,” 6.1 231a21-b18.

divisibility of time, change, and magnitude. This is the second text. Finally, Aristotle at some point decides to revise his explanation of the continuity of the aspects of change, and writes the third text, including 6.4-6. This new text adapts the strategy of the first two, while abandoning their focus on locomotion and magnitude.

Divisibility in the First Text

6.1 231a21-b18 and 6.2 on my accounting represents Aristotle's initial foray into the question of topological nature of, and relationship between the aspects of change (here, magnitude, time, and change). I characterize this first text as follows. It is allied with *Physics* 3-4, in the sense that it focuses on time, change, and magnitude in answering questions about the structure of change and the aspects of change. It assumes that magnitudes are continua as a matter of definition (though it does not assume that continua are divisible only into divisible parts), and it was written to provide the resources for a response to Zeno's "dichotomy" paradox.

Aristotle describes Zeno's dichotomy at 6.2 233a21-31 thus:

> it is impossible for a thing to pass over or severally to come in contact with infinite things in a finite time.

and at 6.9 239b11-14

> The first asserts the non-existence of motion on the ground that that which is in locomotion must arrive at the half-way stage before it arrives at the goal.[12]

This is a very sparing way of putting the puzzle. The argument appears to be as follows:

1) in traversing a magnitude, a moving thing must first reach a half-way point before it reaches its goal,

[12] πρῶτος μὲν ὁ περὶ τοῦ μὴ κινεῖσθαι διὰ τὸ πρότερον εἰς τὸ ἥμισυ δεῖν ἀφικέσθαι τὸ φερόμενον ἢ πρὸς τὸ τέλος,

2) but a half-way point is also a goal,

3) and so a moving thing must reach, which is to say, pass over or come into contact with, an infinite number of points before it reaches any goal.

4) It is absurd that anything should pass over or come into contact with an infinite number of points in a finite time.

4) therefore, nothing can traverse a magnitude in a finite time.

Aristotle's reply to this paradox in 6.2 begins with the confirmation of one of Zeno's own premises: the magnitude of a change is an infinitely divisible continuum.

> Since every magnitude is divisible into magnitudes—for we have shown that it is impossible for anything continuous to be composed of indivisibles, and every magnitude is continuous[13]… (6.2 232a23-25).

Aristotle is referring here to the arguments in the first half of 6.1 (231a21-b18), which show that continua cannot be composed of points. Briefly, two things are continuous when they share a boundary,[14] but points cannot have boundaries distinct from their other parts: if they do touch, then they are simply in the same place. Following this introduction, Aristotle then (6.2 232a25-233a12) argues that if magnitude is divisible, time must be so as well, on the grounds that for any given motion, there is possible a quicker or slower motion over the same magnitude, or in the same time.

My distinction between the first and the second text pays an important dividend here. It has been argued by Fred Miller in his 1982 paper "Aristotle Against the Atomists," that Aristotle's

---

περὶ οὗ διείλομεν ἐν τοῖς πρότερον λόγοις.

[13] Ἐπεὶ δὲ πᾶν μέγεθος εἰς μεγέθη διαιρετόν (δέδεικται γὰρ ὅτι ἀδύνατον ἐξ ἀτόμων εἶναί τι συνεχές, μέγεθος δ' ἐστὶν ἅπαν συνεχές)

[14] 6.1 231a21-22

arguments for the co-divisibility of time and magnitude in 6.2 are circular. Specifically, Miller[15] says that the demonstration that time is continuous appears to assume that it is so. Aristotle asks us to imagine two bodies, a quicker and a slower, moving alongside one another during a given time t. In that time, the faster one must cover a greater distance. Further, there must be a smaller time than t, t', in which the quicker body must also cover a greater distance than that traversed by the slower body in t, since the termination of the slower body's motion and that of the faster body in t cannot be contiguous: there is a point between them that the faster body reaches in less time than t. Finally, the faster body must in some time even smaller than t', t'', cover the same ground covered by the slower in t.

Throughout this argument Aristotle always assumes he can reach for a time less than a given time. And so on the assumption that this argument is written to refute (perhaps among others) the purveyor of indivisible magnitudes and periods of time, I think Miller is right: the argument is question begging. Any such atomist will refuse Aristotle's unargued assumption that there is always a possible slower or a faster motion than any given motion, smaller time than a given time, and smaller distance than a given distance.

The preceding chapter contains an argument (6.1 231b21-232a22) that seems attuned to the possibility of an indivisible magnitude or time, and so Miller appears well justified in thinking that this argument should be attentive to that possibility as well. But the argument that deals with indivisible magnitudes/times/changes in 6.1, my "second text," is not a part of Aristotle's original line of thought in Physics 6 at all.[16]

---

[15] Miller "Atomists", 109

[16] My position also resolves Bostock's related complaint (*Space*, 167), that "if we assume that the motions in question are continuous, this is no doubt a fair conclusion [i.e. that if the magnitude of a motion is divisible, so is the time]. But if we suppose instead that the motions are cinematographic then the conclusion is easily avoided." On my account, Aristotle does respond to an interlocutor with something like a cinematographic view of motion, only not in the "first text" which is aimed exclusively at Zeno. The appearance of a mistake here is due only to the fact that the

Instead, we should read the apparently circular argument in 6.2 232a23-b20 as responding specifically to Zeno's conception of magnitude and time, or at any rate the conception of these that Aristotle takes to be implicit in the dichotomy paradox.[17] Zeno does not think that it is impossible for a moving body to reach an infinity of mid-points in a finite time because he thinks of time as a series of indivisible, extended periods, but because he thinks of time, naively, as a series of nows. I say "naively" because I think he has no particular commitment as to the topology of a now: Zeno is working from the intuition that every time was, is, or will be now, and that time consists in this succession. This naive conception very naturally leads to the thought that after any now, there must be a next one, and a next one, and so on, for how else is time to go on? I take this view to be captured squarely in one of Zeno's other paradoxes, the Arrow, which Aristotle describes at *Physics* 6.9 239b5-7:

> For if, he says, everything is always resting or moving when it is against what is equal, and the flying thing *is* always in the now, then the flying arrow is motionless.[18]

Aristotle's response to this paradox is to say:

> But this is false, for time is not composed from indivisible nows, just as no other magnitude is[19] (6.9 239b7-9).

Aristotle is quick to dismiss it, but it's worth appreciating how powerful Zeno's intuition is. Zeno will agree (indeed, his dichotomy requires) that spatial magnitude is a continuum, and infinitely divisibile into smaller magnitudes. But why would it pre-theoretically occur to Zeno that *time* can be thought of in the same way? The successiveness of time stands as a serious

---

order of the text makes it seem as if Aristotle is *already* engaged with the atomist in 6.2, when in fact 6.2 is an argument against an anti-atomist, and someone who is as committed as Aristotle is to the infinite divisibility of motion, namely Zeno.

[17] Aristotle addresses Zeno explicitly at 233a21.

[18] εἰ γὰρ αἰεί, φησίν, ἠρεμεῖ πᾶν ἢ κινεῖται ὅταν ᾖ κατὰ τὸ ἴσον, ἔστιν δ' αἰεὶ τὸ φερόμενον ἐν τῷ νῦν, ἀκίνητον τὴν φερομένην εἶναι ὀϊστόν.

obstacle to any theory that would suggest that nows may be densely ordered, which is what is required if magnitude and time as to be seen as analogous. Indeed, in *Physics* 8.8 263a4-b9, Aristotle seems to acknowledge the force of this intuition as the real root of Zeno's paradoxes. Addressing Zeno explicitly at 263a4-5 ("The same approach must be used when replying also to Zeno's argument…")[20], Aristotle says:

> But, although this solution is adequate as a reply to the questioner (the question asked being whether it is impossible in a finite time to traverse or count an infinite number of units), nevertheless as an account of the fact and the truth it is inadequate. For suppose the distance to be left out of account and the question asked to be no longer whether it is possible in a finite time to traverse an infinite number of distances, and suppose that the inquiry is made to refer to the time itself (for the time contains an infinite number of divisions)[21] (8.8 263a15-21)

Zeno's dichotomy, by Aristotle's lights, rests on a pre-theoretic conception of time as a succession of nows: Zeno assumes that an infinity of nows must constitute an infinitely long time because he assumes that nothing that comes in a succession could be densely ordered, and times comes in a succession. And so insofar as 6.2 is written to respond to that paradox, Aristotle does not take himself to be burdened with refuting the theory of indivisible time periods. Zeno possesses no such theory.[22] Instead, Aristotle takes himself to be demonstrating that if motions may be faster or slower (a thesis Zeno has no reason to reject) then we must have some way to understand the idea of an *amount* of time. And if there can be an amount of time, there can be a

---

[19] τοῦτο δ' ἐστὶ ψεῦδος· οὐ γὰρ σύγκειται ὁ χρόνος ἐκ τῶν νῦν τῶν ἀδιαιρέτων, ὥσπερ οὐδ' ἄλλο μέγεθος οὐδέν.
[20] τὸν αὐτὸν δὲ τρόπον ἀπαντητέον καὶ πρὸς τοὺς ἐρωτῶντας τὸν Ζήνωνος λόγον
[21] ἀλλ' αὕτη ἡ λύσις πρὸς μὲν τὸν ἐρωτῶντα ἱκανῶς ἔχει (ἠρωτᾶτο γὰρ εἰ ἐν πεπερασμένῳ ἄπειρα ἐνδέχεται διεξελθεῖν ἢ ἀριθμῆσαι), πρὸς δὲ τὸ πρᾶγμα καὶ τὴν ἀλήθειαν οὐχ ἱκανῶς· ἂν γάρ τις ἀφέμενος τοῦ μήκους καὶ τοῦ ἐρωτᾶν εἰ ἐν πεπερασμένῳ χρόνῳ ἐνδέχεται ἄπειρα διεξελθεῖν, πυνθάνηται ἐπ' αὐτοῦ τοῦ χρόνου ταῦτα (ἔχει γὰρ ὁ χρόνος ἀπείρους διαιρέσεις),

more and a less. A Zenoist could (and apparently some did) go on to give an analysis of the idea of an amount of time in terms of indivisible periods of time. But we have no reason to think Zeno himself did so, and no one who did would be likely to retain Zeno's entirely necessary premise that magnitudes of space are infinitely divisible.

So if we recognize that the argument of 6.1 231b21-232a6—which is occupied with the question of indivisible periods and magnitudes—is a later insertion, then we need not think of the arguments in 6.2 as circular. These arguments are not trying to refute the sophisticated theorist of indivisible manitudes and motions; they are instead trying to replace a pre-theoretical approach to quantities of time with a theoretical one (wherein quantities of time are analyzed as continua). This hypothesis about the construction of these chapters also brings into greater focus Aristotle's aims: the "first text," a part of an original draft of what would become *Physics* 6, is there to extend Aristotle's doctrine in *Physics* 3 and 4, about the relationship between time, change, and magnitude, so as to furnish a response to Zeno.

But it is here that Aristotle first develops the strategy that we will see carried on through the second and third texts: set up some arguments showing that the divisibility of one aspect of change implies the divisibility of the others, and then find some way to claim categorically that one of these aspects of change is indeed divisible. In the case of the first text, the task of finding a categorical argument is very quick: Aristotle takes it to be perfectly obvious that spatial magnitudes are continua. So all he needs to do is show that continua are infinitely divisible, on the grounds that they cannot be composed of points, and then the arguments of 6.2 will suffice to show that all aspects of change are infinitely divisible continua.

Then, at some point, Aristotle confronts the theory of indivisible lines, and its physical

[22] In saying this, I agree with Sorabji's analysis of Zeno's metaphysics of time in Sorabji "Atomists," 44-48.

progeny: indivisible magnitudes, times, and motions. This view is described and then attacked in the pseudo-Aristotelioan (but peripatetic) On Indivisible Lines. The target of this work is thought to be Aristotle's contemporary, Xenocrates, the elected scholarch of Plato's Academy after the death of Plato's nephew Speusippus.[23] The author of this treatise cites Zeno's paradoxes as part of the motivation for the theory, which suggests that anything having size is composed of a finite number of parts having positive size, which are themselves indivisible.[24]

The "first text," structured as it was by the engagement with Zeno, is not apt to respond to this new interlocutor: the discussion of continua in 6.1 231a21 only refutes the constitution of continua by points. The arguments in 6.2 are unable to challenge someone who thinks that quantities of time might composed of indivisible periods, since they were written to challenge only the pre-theoretical view that time is composed of a succession of nows. This new interlocutor will accuse Aristotle of a false dichotomy in 6.1 231a21-b18: Aristotle says there that continua are composed either exclusively of divisible parts or (what turns out to be impossible) of point-like indivisibles. But he does not consider that continua may be composed of *indivisible but extended parts.* This calls for a new line of argument.

Divisibility in the Second Text

The second text consists of the long argument starting at 6.1 231b21 and ending with a coda on the mutual divisibility of time and magnitude at 232a18-22. Here, an indivisible is not

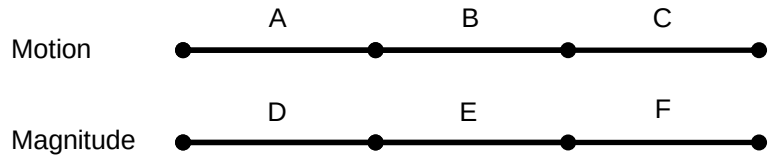
[23] Netz, Reviel. *Scale, Space, and Canon in Ancient Literary Culture*. Cambridge: Cambridge University Press, 2020: 325

[24] This academic atomism should not be conflated with the "naturalistic" atomism of Democritus (Aristotle discusses the contrast in *On Generation and Corruption* 1.2). The atomic magnitudes of Xenocrates are *conceptually* indivisible, justified as they are in terms of the Form of the Line. By contrast, there is little evidence to suggest that Democritus held that anything but atomic bodies were indivisible. See Sorabji "Atomists" and especially Hasper, Peiter Sjoerd. "The Foundations of Presocratic Atomism." Sedley, David, ed. Oxford Studies in Ancient Philosophy 17: 1999: 1-14.

necessarily extensionless. This is made clear with the introduction of indivisible magnitudes at 231b1; an extensionless magnitude is more or less a contradiction in terms. Beginning with the assumption the magnitude, time, and motion of a given subject are all composed of indivisibles,[25] Aristotle presents us with picture that is not ruled out by his immediately preceding reflections on the constitution of continua, in 6.1a21-b18. Since these indivisibles have extension, they can touch at their limits and constitute larger continua (where this word "continuum" must now be understood in a non-Aristotelian way).

> If a magnitude is composed of indivisibles, the motion over that magnitude will also be composed of corresponding indivisible motions: e.g. if the magnitude ABC is composed of the indivisibles A, B, C, each corresponding part of the motion DEF of Z over ABC is indivisible (231b21-25).

Figure 8: motion-magnitude isomorphism



Each indivisible motion occurs in an indivisible time over an indivisible magnitude. Aristotle then introduces the *moving* and *having moved* of the moving thing, Z.

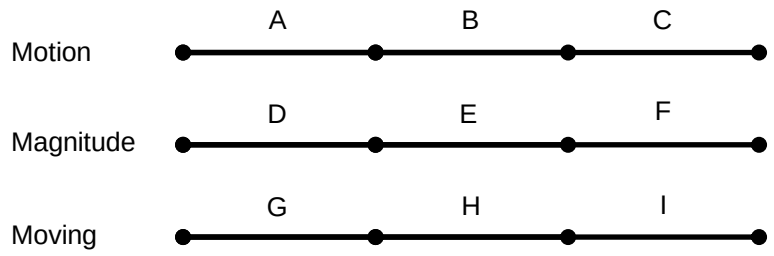
> Since when motion is present there must be something that is moving, and if something is moving, a motion is present, therefore the moving will also be composed of indivisibles.
>
> So Z traversed A when its motion was D, B when its motion was E, and C similarly when

[25] White 1992, 253-8 finds this argument to be guilty of begging the question, on the grounds that it assumes what it claims to prove at 231b18-20. On my reading, the argument does not have this flaw, since 231b18-20 does not refer to this argument at all. I can also claim this to my advantage: nowhere in the argument from 231b21-232a17 does Aristotle speak as if he is trying to prove the mutual divisibility or indivisibility of time, motion, and magnitude. He does discuss this at the end of the chapter, at 232a18-22, but by way of a new argument (one that seems to me to be clearly a shorthand for what is found in my "first text", *Physics* 6.2.

its motion was F[26] (231b25-28).

So we are to add a third row to our diagram, so as to include the moving of the moving thing corresponding to each part of its motion (I've added some letter designations):

Figure 9: motion-magnitude-moving isomorphism



Aristotle then introduces a principle: nothing can be moving to F and have moved to F at the same time.

> Now if something moving from here to there cannot at the same time be moving and have moved to that to which it was moving when it was moving (e.g. if a man is walking to Thebes, he cannot be walking to Thebes and at the same time have walked to Thebes); and, as we saw, Z was moving over the partless section A in virtue of the presence of the motion D. Consequently, if it has passed through later than it was passing through, it [i.e. A][27] will be divisible (for when it was passing through, it was neither resting nor had it passed but was in between) while if it is passing through and has passed through at the same time, then that which is walking, when it is walking, will have walked there and

[26] εἰ δὴ παρούσης κινήσεως ἀνάγκη κινεῖσθαί τι, καὶ εἰ κινεῖταί τι, παρεῖναι κίνησιν, καὶ τὸ κινεῖσθαι ἔσται ἐξ ἀδιαιρέτων. τὸ μὲν δὴ Α ἐκινήθη τὸ Ω τὴν τὸ Δ κινούμενον κίνησιν, τὸ δὲ Β τὴν τὸ Ε, καὶ τὸ Γ ὡσαύτως τὴν τὸ Ζ.

[27] For "it will be divisible" we have διαιρετὴ ἂν εἴη, and so while the subject of εἴη is unclear, we know it must be feminine. This means that it could either be the motion (ἡ κίνησις) or the indivisible magnitude A, for which Aristotle has been using the feminine article, presumably with an implied "the way" (ἡ ὅδος) which is common to Greek. I have sided with Hasper, *Metaphysics* (2003) 167 and Wagner *Physikvorlesung 150* in taking Aristotle to mean the magnitude A, over Furley, *Two Studies* 119, and White, *Continuous* 253-254, who both read the subject as the motion D. Neither Hasper nor Wagner explains, so I will: the reason that the subject is likely to be the magnitude A is that if we ask "in between what" in reference to the explanatory (γὰρ) sentence that follows, the answer is most naturally "the limits of A", and this most directly demonstrates the divisibility of A.

will have moved to that to which it is moving[28] (231b28-232a6).

Hence, things must occur thus: first, Z is at rest and has not yet traversed A. Then, Z is moving across A, after which Z has traversed A. But when Z is still moving across A, it can be at neither end of A, and so it must "be in between" (μεταξὺ ἦν).

I want to make two observations at this point. First, we see Aristotle here making use of a distinction between moving and motion: the atomist is still on safe ground to the extent that Aristotle wants to correlate the motion D with the magnitude A. Aristotle can close his trap only when he has gotten the atomist to admit that if Z is undergoing the motion D, it is also at the same time *moving*. It is the fact that Z is moving without yet having moved across A that allows Aristotle to conclude that A must be divisible. This is because, while Z is moving, it cannot yet have moved over A, nor can it be in the state of rest prior to its motion. It must be "in between." Second, this argument takes the kinematic approach characteristic of *Physics* 3 and 4: Aristotle is concerned with motion, time, and magnitude, and he totally ignores the question of the divisibility of Z.[29] The result is an argument surprisingly close to the partwise argument at 6.4 234b10-20, but which says nothing about the divisibility of the moving body.

Aristotle anticipates that his interlocutor might opt at this point to jettison the notion that Z is ever moving.

> And if a thing is in motion over the whole ABC and its motion is DEF, and if it is not moving at all over the partless distance A but has moved over it, then the motion will consist not of motions but of moves, and will take place by a thing's having moved

[28] εἰ δὴ ἀνάγκη τὸ κινούμενον ποθέν ποι μὴ ἅμα κινεῖσθαι καὶ κεκινῆσθαι οὗ ἐκινεῖτο ὅτε ἐκινεῖτο (οἷον εἰ Θήβαζέ τι βαδίζει, ἀδύνατον ἅμα βαδίζειν Θήβαζε καὶ βεβαδικέναι Θήβαζε), τὴν δὲ τὸ Α τὴν ἀμερῆ ἐκινεῖτο τὸ Ω, ᾗ ἡ τὸ Δ κίνησις παρῆν· ὥστ' εἰ μὲν ὕστερον διεληλύθει ἢ διῄει, διαιρετὴ ἂν εἴη (ὅτε γὰρ διῄει, οὔτε ἠρέμει οὔτε διεληλύθει, ἀλλὰ μεταξὺ ἦν), εἰ δ' ἅμα διέρχεται καὶ διελήλυθε, τὸ βαδίζον, ὅτε βαδίζει, βεβαδικὸς ἐκεῖ ἔσται καὶ κεκινημένον οὗ κινεῖται.

[29] It's worth contrasting this argument to a similar one at 6.10 240b20-241a6, where Aristotle does not ignore the

without moving (232a6-9).

Subsequent atomists embrace this possibility[30], but Aristotle treats it as a bald absurdity: he never does try to defend the idea that when something undergoes a motion, it must be moving.

Then, at the end of 6.1, we find a very brief and somewhat puzzling remark, echoing the arguments of 6.2:

> And if length and motion are thus indivisible, it is similarly necessary that time also be indivisible, that is to say be composed of indivisible nows; for if all is divisible and bodies of equal velocity will cover less in less, the time must also be divisible; and if the time in which a thing is carried over A is divisible, A must also be divisible[31] (232a18-22).

Aristotle's argument seems to be that if every magnitude and every motion over a magnitude is divisible, then when we take a motion over a given time *t* and divide it, the dividend must be a smaller motion in less time. It is hard to see how Aristotle could regard this as adequate on its own: he is arguing for the same conclusion at which 6.2 232a23-b20 is aimed, and appears to make use of a similar consideration of the speed of a body. But it is worth noting that the "second text" incorporates, even if briefly, the whole strategy laid out in the first text: a categorical argument for the divisibility of one aspect of change (here, the magnitude, in the long argument from 231b21-232a6) followed by a hypothetical argument for the divisibility of the other aspects of change given the divisibility of this one (232a18-22). This shows that the second text is a reflection on and a development of the first, despite taking up a new topic meeting new

---

divisibility of the moving subject, and in fact makes it central to his argumentation.

[30] Notably, Diodorus Cronus: see Sedley, David. "Diodorus Cronus and Hellenistic Philosophy." *The Cambridge Classical Journal* 23, 1977: 74-120. and White, Michael "What worried the crows?." *The Classical Quarterly* 36, no. 2, 1986: 534-537.

[31] ὁμοίως δ' ἀνάγκη τῷ μήκει καὶ τῇ κινήσει ἀδιαίρετον εἶναι τὸν χρόνον, καὶ συγκεῖσθαι ἐκ τῶν νῦν ὄντων ἀδιαιρέτων· εἰ γὰρ πᾶσα διαιρετός, ἐν τῷ ἐλάττονι δὲ τὸ ἰσοταχὲς δίεισιν ἔλαττον, διαιρετὸς ἔσται καὶ ὁ χρόνος. εἰ

philosophical demands.

The "second text" clearly builds on the first, and whatever editor put them together (very possibly Aristotle) did not do so as carelessly as the discontinuity at 231b18-20 suggests. The first and second texts have very different aims: the first responds to Zeno and the second is written to respond to an atomist in the style of the target of *On Indivisible Lines.* But they make use of a common set of strategies, such as the mix of categorical and hypothetical arguments for divisibility. We also find these strategies appearing in 6.4. We can get a sense, then, for what book 6 of the *Physics* is: a kind of staging ground for a set of related but distinct philosophical projects, united by a common set of conceptual and methodological tools.

I've argued that 6.4-6 was written to revise Aristotle's theory of natural continua. Why does Aristotle stage this revision *here* in *Physics* 6 as opposed to somewhere else? Not because *Physics* 6 was originally or entirely devoted to this purpose, but because *Physics* 6 is where the tools necessary to explain the revision are found.

Divisibility in the Third Text, 6.4

Physics 6.4 consists of five distinct arguments, prior to the signpost passage at 6.4 235a35-b5.[32] These are:

-234b10-20- the partwise argument; that all changing things are divisible,

-234b21-235a10- changes are divisible according to divisions in the changing thing, relative to that change,

---

δ' ὁ χρόνος διαιρετὸς ἐν ᾧ φέρεταί τι τὴν Α, καὶ ἡ τὸ Α ἔσται διαιρετή.

[32] "In the same way it will be shown also that the length is divisible, and generally everything in which a change is (though some only accidentally, because the changing thing is divisible), for the division of one will divide all. Also as regards their being finite or infinite, all will be similarly disposed. And the divisibility of all things especially—and also the infinity—has followed from the changing thing. For divisibility and infinity belong immediately (εὐθὺς γὰρ ἐνυπάρχει) to the changing thing. That divisibility does so we have shown before; that infinity does so will be

-235a10-24- that a change is divisible according to its time, and its time divisible according to that change,

-235a25-34- that the changing of the changing thing is divisible according to its change.

I have discussed the partwise argument in detail in chapter two, and I have discussed the others in schematic terms at the end of chapter four. I focus now on how these arguments are related, or specifically, how Aristotle intends to draw out theses (1) and (2) from them:

1) "everything in which a change is [is divisible], for the division of one will divide all."

2) "divisibility…belongs directly to the changing thing;"

We may read (1) as the collective result of the various arguments in 6.4 prior to the signpost. The first, the partwise argument, establishes that one of the aspects of change is in fact divisible, namely the changing thing. The remaining all argue that given the divisibility of one aspect of change, the divisibility of another can be demonstrated. And so Aristotle concludes that all are in fact divisible.

But what do we make of (2)? The partwise argument shows that the changing thing *is* divisible into parts, but it says nothing about divisibility belonging to the changing thing "directly" (εὐθύς). The answer, I believe, lies in the *way* in which each of the aspects of change is shown to be divisible. Specifically, each of the arguments in 234b21-235a34 are hypothetical: they show that one aspect of change is divisible given the divisibility of another. The partwise argument, however, does not depend on the divisibility of anything else. I take Aristotle to be operating implicitly on the following argument:

i) if some aspect of change A can be shown to be divisible *hypothetically*, because another aspect B is divisible, and

---

made clear in what follows."

ii) B can be shown to be divisibile *categorically*, that is without assuming the divisibility of any other aspect C, then

iii) the divisibility of A follows from the immediate divisibility of B.

Hence, (2) is established by observing the relationship between the arguments for the divisibility of each aspect of change. Every aspect of change can be shown to be divisible hypothetically, by assuming the divisibility of another. One, however, the changing thing, can be shown to be divisible categorically. Because of this, the divisibility of the changing thing is direct, and the divisibility of the other aspects of change follow from this.

6.4 contrasts with 6.1-2 in two ways. First, 6.4 does not present a *dialectical* argument. In the first text (6.1 231a21-b20 and 6.2), Aristotle is arguing against Zeno and in the second (6.1 231b21-232a22) against an Academic atomist, and in both cases he permits himself the premises necessary to refute them: premises they would or should be willing to accept—such as, in Zeno's case, the infinite divisibility of magnitude. In 6.4, by contrast, Aristotle is arguing against no one: the aim here is rather to develop a new explanation of the structure of natural continua. And so he must look for a categorical argument for the divisibility of an aspect of change in the soil, as it were, rather than in the course of a dialectical exchange with his interlocutor.

Second, both texts in 6.1-2 were written as an extension of Aristotle's theory of continua from *Physics* 3-4, and so they could rely on that theory. I mean that once Aristotle has shown that the aspects of change are all divisible, his work in refuting Zeno or the atomist is done. He needn't explain *why* they are divisible, especially if he has already done so in *Physics* 4.11 219a10-19. As we have seen, Aristotle indicates the dialectical nature of his response to Zeno, at least, in his reference to that text in *Physics* 8.8 263a15-21. 6.4 is written, by contrast, precisely to replace that theory, and so it must produce rather than stand upon a more fundamental theory

of continua.

The "third text", 6.4-6, therefore constitutes a kind of reflection on the strategy of mixed categorical and hypothetical arguments developed in the first two texts. Whereas in 6.1-2 this strategy served only to show *that* the aspects of change are divisible, Aristotle uses this strategy in 6.4 to explain *why* they are divisible.

The Infinity Argument

By the end of 6.6, Aristotle takes himself to have established the conclusion that the aspects of change are "infinite" because the changing thing is immediately or directly so. Given what we saw in 6.4, we might expect a parallel approach: Aristotle will somehow show that all the aspects of change are infinite if any one is, and he will show, categorically, that the changing thing itself is infinite. This is not what we find, however.

Instead, Aristotle presents two essays, 6.5 and 6.6, on the kinematic significance of something's having changed and of something's changing, respectively. By "kinematic significance" I mean that he describes the relationship between having changed or changing and the time of a change, its magnitude, or the changing thing. Aristotle draws a lesson from these essays: whatever is changing has already changed, infinitely many times. Earlier I glossed the "infinity" that belongs to the changing thing as "infinity in respect of divisibility" following the distinction at 6.3 233a17-21. But I take the notion of infinity in *Physics* 6.6 to be somewhat richer. I'll begin by discussing just what I think Aristotle means by "infinity" in 6.4-6, and then I'll turn to a survey of his argument for this claim.

Imagine I draw a line, 30cm in length, across a page in a single and continuous motion. You may wait for me to finish, or interrupt me at any time, and regardless I will have drawn only one

line. The only difference will be in its length. But the consequence of Aristotle's discussion in 6.6 is that as the line is being drawn, it has been drawn infinitely many times. We have the resources now to make sense of this.

A generation (and let us call my line-drawing a generation, for the sake of simplicity) is a μchange: it is a change between exactly two states, and involves no intermediates. As we saw in chapter two, the parts of a μchange are the changes of the parts of the changing thing, i.e., in this case, the generation of those parts. Now, something can be said to change, non-accidentally, because a part of it has changed: in this case it has changed *kata mere,* or in virtue of a part. So when I say "the line that is coming to be has already come to be" I mean that it "has already come to be in virtue of the fact that a part of it has come to be." Indeed, the line has already come to be infinitely many times—because infinitely many parts of it have come to be. These parts are never *present* at the same time and in the same sense: if I have drawn half the line so far, then the first quarter of the line is now present only as a part.[33] And so we should not infer that Aristotle believes that there is an infinite collection of changes, times, magnitudes, or parts of a changing thing. When Aristotle concludes the argument of 6.4-6, he says:

> For something infinite belongs directly to what becomes and what perishes, because it is

[33] I avoid the language of potentiality and actuality because Aristotle does so: these terms appear nowhere in *Physics* 6, and I assume this is a deliberate choice on Aristotle's part (I discuss this briefly at the end of this chapter). I have no firm answer as to *why* Aristotle does not use his usual metaphysical panoply, but I will note another interesting passage in which he leaves these tools behind: *Generation and Corruption* 1.2. He is there discussing the argument for atomism, an argument closely connected with the issues discussed in *Physics* 6. The argument suggests that no body can be infinitely divisible, if it is then divided completely, nothing will remain. Aristotle considers a number of responses, including one that deploys the distinction between actual and potential divisions: "On the one hand, then, it is in no way absurd that every perceptible body should be indivisible as well as divisible at any and every point. For the second predicate will attach to it potentially, but the first actually" (316b16-26). But Aristotle quickly sets this aside, on the grounds that what ever is potential is possibly actual, such that the body could end up actually divided at every point. When Aristotle finally concludes his presentation of the problem at 317a1 and begins in on his own solution, the metaphysical apparatus of potentiality and actuality are absent. Cf. Miller, Fred D. "Aristotle's Critique of the Atomists' Proof of Indivisible Magnitudes." Forthcoming, 2021: 10

continuous[34] (237b14-16).

Something infinite belongs to what comes to be in just this sense: everything that is coming to be encompasses, in a sense, an infinity of beings which have come to be before it, and which now are parts within it. The changing thing, or "what comes to be and passes away" is infinite in an immediate way because it is only in the changing thing that this infinity of completions cum parts are real, concrete physical beings, albeit in a way that is logically and ontologically dependent on the whole of which they are parts. It is tempting to use the word "matter" here, though Aristotle does not.

I wish to clearly distinguish this sense of "infinity" from one we might otherwise have expected. We might have thought, perhaps following Plato or Heraclitus, that the changing thing is characterized by infinity (ἄπειρον)—a Greek word that can as easily denote a lack of definition or determination—in the sense of an indefinite or indeterminate flux.[35] There is no definite or determinate way, one might say, that a changing thing is while it is changing. I think Aristotle's discussion of the infinity belonging to a changing thing pulls in precisely the other direction: the changing thing is infinite not because it is in some hazy flux of change, but because it incorporates infinitely many moments of completion and determination. Aristotle's war on Heraclitus is perhaps nowhere hotter than in *Physics* 6, where even the infinity of change is given structure and made ready for intelligibility.

I now turn to his argument. Aristotle builds to this claim about the infinity of the changing thing through a penultimate conclusion, presented just prior to the passage we have just been discussing:

So that whatever has changed was changing, and whatever is changing has changed, and

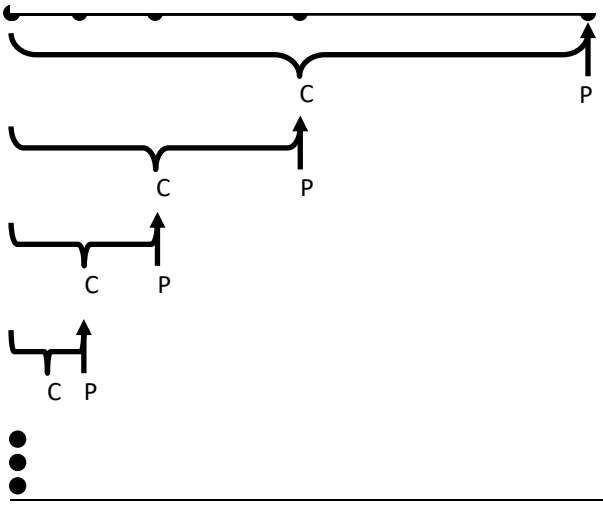
[34] εὐθὺς γὰρ ἐνυπάρχει τῷ γιγνομένῳ καὶ τῷ φθειρομένῳ ἄπειρόν τι συνεχεῖ γε ὄντι

> a changing is preceded by a having changed and a having changed by a changing, and one can never take something primary. The cause of this is that partless things cannot be contiguous with partless things. For the division is infinite, as in the case of the increasing and decreasing lines[36] (237b3-9).

Aristotle's explanatory remark—about increasing and decreasing lines—helpful, so far as it connects his thought about changing and having changed with the constitution of a geometrical line.

The "increasing and decreasing lines" here refers to a convergent series by addition or by division.[37] We should imagine something like this, where "C" stands for "the changing thing is changing" and "P" stands for "the changing thing has changed" and the arrows and brackets point to times on the time line when it is true to say of something that "C" or "P":

Figure 10: divisions in changing



[35] See e.g. *Philebus* 24-28

[36] ὥστε ἀνάγκη τὸ μεταβεβληκὸς μεταβάλλειν καὶ τὸ μεταβάλλον μεταβεβληκέναι, καὶ ἔσται τοῦ μὲν μεταβάλλειν τὸ μεταβεβληκέναι πρότερον, τοῦ δὲ μεταβεβληκέναι τὸ μεταβάλλειν, καὶ οὐδέποτε ληφθήσεται τὸ πρῶτον. αἴτιον δὲ τούτου τὸ μὴ εἶναι ἀμερὲς ἀμεροῦς ἐχόμενον· ἄπειρος γὰρ ἡ διαίρεσις, καθάπερ ἐπὶ τῶν αὐξανομένων καὶ καθαιρουμένων γραμμῶν.

[37] Cf. Ross *Physica*, 652 Aristotle discusses convergent series briefly in *Physics* 3.7 206b4-206b12. A convergent series by addition: suppose we begin with a length of one meter, and add a half meter to it, and then a half of a half, and so on. The line will "increase" but the total length of the line will never exceed two meters. A convergent series by division: suppose we begin with a two meter line, and remove one quarter of a meter from it, and then one half of one quarter, and then a half of a half of a quarter, and so on. The line will "decrease" but it will never be shorter than

This picture of the division of a change depends on three principles, which we may then hunt after in 6.5-6, in order to get a sense for the structure of the argument.

I) the time[38] in which something *has changed* is an indivisible now.

II) any given period in which a thing is changing is divisible and homogeneous

III) any time in which something is changing is terminated by a time at which it has changed.

These are the conditions on which the pictured division can go on indefinitely in such a way as to produce the same structure, as it were, at every division. Every division must produce a period of changing terminated by an instant at which the changing thing has changed. If, *contra* (I), the time in which something has changed ("P", above) were a divisible magnitude, then some multiple of that magnitude would exhaust the whole time in which the changing thing is supposedly changing, and so the divisions would have to come to a stop when there was no more time for something's having changed. If, *contra* (II), there were periods in which the changing of a changing thing could not be divided, and divided *into periods in which it is changing*, then we could likewise not guarantee the infinity of divisions implicit in the picture above. Finally, if *contra* (III), some period of changing is not terminated by something's having changed, then the whole structure of a change will not be reproduced at each division: we will divide the change into a part at the termination of which the changing thing has not (yet) changed.

The first of these principle is established at 6.5 235b32-236a6, one of the primary time arguments discussed in the last chapter. This argument is distinctive in that Aristotle does not argue that there is no primary time in which something has changed, but only that there is no

---

one meter.

divisible primary time.

> Now the time primarily in which that which has changed has changed must be indivisible. By 'primary' I mean a thing's being such-and-such not because something different than it is such-and-such. For let AC be divisible, and let it be divided at B. If on the one hand it has changed in AB or again in BC, AC cannot be the primary thing in which it has changed. If, on the other hand, it was changing in each of the two singly (for it must either have changed or be changing in each of them singly), it must have been changing in the all of the whole too; but our assumption was that it had changed in that. The same argument applies if we suppose that it changes in one part and has changed in the other; for then we shall have something prior to what is primary. As a result, that in which a thing has changed will not be divisible. It is also evident, therefore, that that in which that which has ceased to be has ceased to be and that in which that which has come to be has come to be are indivisible[39] (6.5 235b32-236a6).

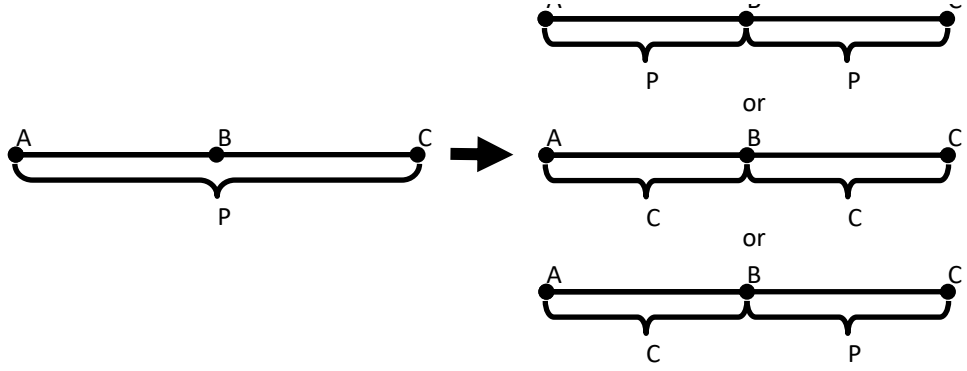
This is, as I have said, a reductio argument. Aristotle begins by assuming that the primary time of something's having changed in the divisible time AC, dividing it at B. The aim of the argument is to show that there could not possibly be a primary time in which something has changed, in the sense of having completed a change. We may diagram the argument as follows:

---

[38] Specifically the "primary" time, a concept I discussed in my last chapter.

[39] ἐν ᾧ δὲ πρώτῳ μεταβέβληκεν τὸ μεταβεβληκός, ἀνάγκη ἄτομον εἶναι. λέγω δὲ πρῶτον ὃ μὴ τῷ ἕτερόν τι αὐτοῦ εἶναι τοιοῦτόν ἐστιν. ἔστω γὰρ διαιρετὸν τὸ ΑΓ, καὶ διῃρήσθω κατὰ τὸ Β. εἰ μὲν οὖν ἐν τῷ ΑΒ μεταβέβληκεν ἢ πάλιν ἐν τῷ ΒΓ, οὐκ ἂν ἐν πρώτῳ τῷ ΑΓ μεταβεβληκὸς εἴη. εἰ δ' ἐν ἑκατέρῳ μετέβαλλεν (ἀνάγκη γὰρ ἢ μεταβεβληκέναι ἢ μεταβάλλειν ἐν ἑκατέρῳ), κἂν ἐν τῷ ὅλῳ μεταβάλλοι· ἀλλ' ἦν μεταβεβληκός. ὁ αὐτὸς δὲ λόγος καὶ εἰ ἐν τῷ μὲν μεταβάλλει, ἐν δὲ τῷ μεταβέβληκεν· ἔσται γάρ τι τοῦ πρώτου πρότερον· ὥστ' οὐκ ἂν εἴη διαιρετὸν ἐν ᾧ μεταβέβληκεν. φανερὸν οὖν ὅτι καὶ τὸ ἐφθαρμένον καὶ τὸ γεγονὸς ἐν ἀτόμῳ τὸ μὲν ἔφθαρται τὸ δὲ γέγονεν.

Figure 11: the primary time in which something has changed



The initial assumption is on the left: the subject has changed in the divisible time AC. Aristotle then asks: what does this entail about the parts of this time, AB and BC?

Aristotle suggests three possibilities: the subject has changed (P) in both parts, is changing (C) in both parts, or is changing in one part and has changed in the other.[40] In none of these cases can there be a primary time in which it has changed. Recall from the last chapter that an important (and inexplicit) premise in this argument is that there can be no time in which something is changing to F and has changed to F. And so when Aristotle says that in a given part of AC, the subject is changing, he means this to exclude the possibility that it has changed in this part. We may therefore read the possibility in which the subject is changing in both parts of AC to be one in which it has not changed in either part. The remaining two possibilities, in which it has changed in both parts or in only one, rule out AC's being the primary time in which it has changed: no primary time of an event can contain a part that is also a time of that event.

Aristotle then concludes that the primary time in which something has changed is an indivisible "now." He does not explain why he thinks it goes without saying that there can be a

[40] "C" and "P" are recycled from the above diagram concerning the "increasing and decreasing lines."

primary time in which something has changed, but the only two principles constraining the kinematic interpretation of "having changed" mentioned in Physics 6 are a) that the time in which something has changed to F be disjoint with and after the time in which it is changing to some state F (6.1 232a2-6), and b) that the (primary) changing thing be wholly in that to which it has changed when it has changed (6.5 235b6-32). Both of these conditions can be satisfied if we say that something has changed in the terminating moment of a stretch of time in which it was changing.

So much for (I). On to the second and third, both of which are defended in *Physics* 6.6. The second, that a changing thing is changing in any part of the (primary) time in which it is changing, is the aim of the opening argument in 6.6, at 236b19-32. As I discussed in my last chapter, what this sort of argument shows is that the event in question is *homogenous.* Aristotle goes on to lay out the consequences of this homogeneity in the rest of 6.6: the changing of the changing thing is a period terminated by its having changed, divisible infinitely into periods terminated by the thing's having changed.

It will be useful to note that the inference from divisibility and homogeneity to infinite divisibility is part of a long philosophical tradition. In an Eleatic argument quoted at length by Simplicius:

> For in addition, since it is in every way alike, if it is divisible it will be divisible in all ways alike, but not here, yes, and there, no. Let it be divided then in every way: it is clear then again that nothing will be left, but it will have gone away, and if it should come together, again it will come together out of nothing. For if anything is going to remain, it will not have been entirely divided. So that, he says, from these things it is clear that

Being is something indivisible and without parts and one[41]. (Simplicius *In Phys.* 140)

The Eleatic[42] is arguing that the One, the solitary cosmic being, must be indivisible. He infers as follows:

1) the One is "in every way alike,"

2) if something is in every way alike and divisible, then it is divisible in all ways alike,

3) if it is divisible in all ways alike, then it may be divided in all ways alike, and then it will be divided into nothing,[43]

4) the One cannot be nothing, and so

5) the one is not divisible.

Here, then, we essentially have *modus tollens*: if the One is homogeneous, or "in every way alike," *and* divisible, then an absurdity follows: if we imagine a *complete* division, then nothing of any size will remain. It is homogeneous, and so it must not be divisible. Porphyry's account is lent credence by Aristotle's discussion of Eleatic and atomistic arguments in *On Generation and Corruption.* Aristotle discusses an argument very close to this one, if not identical to it, at *GC* 1.2 315a15-317a13, and says at 316b27-316b34 that this argument provoked the following response from atomists within the tradition of Leucippus and Democritus:

The necessary consequence—especially if coming-to-be and passing-away are to take place by association and dissociation respectively—is that a body must contain atomic

[41] καὶ γὰρ δὴ ἐπεὶ πάντῃ ὅμοιόν ἐστιν, εἴπερ διαιρετὸν ὑπάρχει, πάντῃ ὁμοίως ἔσται διαιρετόν, ἀλλ' οὐ τῇ μέν, τῇ δὲ οὔ. διῃρήσθω δὴ πάντῃ· δῆλον οὖν πάλιν ὡς οὐδὲν ὑπομενεῖ, ἀλλ' ἔσται φροῦδον, καὶ εἴπερ συστήσεται, πάλιν ἐκ τοῦ μηδενὸς συστήσεται. εἰ γὰρ ὑπομενεῖ τι, οὐδέ πω γενήσεται πάντῃ διῃρημένον. ὥστε καὶ ἐκ τούτων φανερόν φησιν, ὡς ἀδιαίρετόν τε καὶ ἀμερὲς καὶ ἓν ἔσται τὸ ὄν.

[42] Simplicius is quoting Porphry, who attributes this argument to Parmenides, but Stephen Makin has convincingly argued that the author is Zeno, see Makin, Stephen. "Zeno on Plurality" Phronesis 27 no. 3, 1982: 223-238

[43] I omit the complexities of this step, because they are outside the scope of this chapter. But there is a rich body of literature on this argument as it appears in GC 1.2. For a survey of this literature and an important contribution to it, see

magnitudes which are invisible.[44]

The Democritian agrees with the Eleatic by accepting the inference from homogeneity and divisibility to infinite divisibility, as well as the *reductio*'s conclusion that an infinitely divided entity would be non-existent, but he denies the homogeneity of most natural beings. Atoms themselves are homogeneous (and therefore indivisible) but every other sort of body is compounded from atoms, and so is not homogeneous: large bodies contain a finite multitude of natural division-points, at the places where atoms touch.

Aristotle himself also accepts the inference from homogeneity and divisibility to infinite divisibility, but he denies that infinite divisibility entails that the whole is, after all, nothing.[45] It is true, he says, that if a body is divisible and homogeneous (at least in relation to the possibility of division) then it is divisible in any place. But this does not mean that a complete division of the body is possible, because every body is divisible only once. Once it has been divided, we now have to bodies, each of which can be divided anywhere (but again, only once) and so on. In *Physics* 6, then, we find Aristotle adapting this longstanding line of argument to his own purposes, defanged of paradox, in order to show that the changing of the changing thing is an infinitely divisible event. He has argued in *Physics* 6.4 235a25-34 that changing is divisible, and so it remains to show that it is homogeneous. That is the purpose of the primary time argument at 6.6 236b19-32.

Subsequent to that argument, he turns in 236b32-237a17 to the third principle: *any* time in which something is changing is terminated by a moment at which it has changed. If something is

[44] Ἀνάγκη ἄρα ἄτομα ἐνυπάρχειν μεγέθη ἀόρατα, ἄλλως τε καὶ εἴπερ ἔσται γένεσις καὶ φθορὰ ἡ μὲν διακρίσει ἡ δὲ συγκρίσει.

[45] Aristotle explains his response, which is subject to much interpretive controversy, at *GC* 1.2 317a3-317a12. For a reading parallel to mine, see Miller 2021. See also Hasper, Pieter Sjoerd. "Aristotle's diagnosis of atomism." *Apeiron* 39, no. 2, 2006: 121-128, who discusses the contribution of homogeneity to this argument explicitly.

changing throughout the divisible time AC, then it must be changing in any part of that time. So if the changing thing was changing throughout AC, then it was changing throughout AB, were B is a division within AC. Aristotle argues, at 236b32-237a17, that the changing thing must then *have changed* at the instant B. Aristotle is clear that the changing thing does not come to a rest at the time B. It moves continuously throughout AC, and yet it counts as having moved at B, and indeed, at any of the *infinitely many* divisions to be found between A and C. Hence, "every changing thing has changed infinitely many times"[46] (6.6 234a11).

Aristotle gives three arguments for the claim that "every changing thing must have changed before," from 236b32-237a17. This is the second, which is most articulate for our purposes:

> Again, if we say that it has changed in the whole time XR or in any part of that time, then by taking the extreme now of the time (for this is what definition, and a period of time is what is between nows), then it may likewise be said to have changed at every other such now. But the division is the extreme of the half. Therefore it will also have moved in the half, and generally in any of the parts; for as soon there is a cut, there is always a time defined by the nows. Since, then, every time is divisible, and what is between the nows is time, then every changing thing has changed infinitely many times[47] (237a3-11).

Here we see the foundation for my diagram relating to Aristotle's remark about "increasing and decreasing lines" from 6.6 237b3-9. The argument goes as follows. Suppose a time (XR) in which something has changed. The *primary* time in which it has changed is the terminal instant R. Now, we may arbitrarily find any other instant between X and R, and thereby mark off a

[46] ἅπαν τὸ μεταβάλλον ἄπειρα ἔσται μεταβεβληκός.
[47] ἔτι δὲ εἰ ἐν τῷ παντὶ χρόνῳ τῷ XP κεκινῆσθαι λέγομεν, ἢ ὅλως ἐν ὁτῳοῦν χρόνῳ, τῷ λαβεῖν τὸ ἔσχατον αὐτοῦ νῦν (τοῦτο γάρ ἐστι τὸ ὁρίζον, καὶ τὸ μεταξὺ τῶν νῦν χρόνος), κἂν ἐν τοῖς ἄλλοις ὁμοίως λέγοιτο κεκινῆσθαι. τοῦ δ' ἡμίσεος ἔσχατον ἡ διαίρεσις. ὥστε καὶ ἐν τῷ ἡμίσει κεκινημένον ἔσται καὶ ὅλως ἐν ὁτῳοῦν τῶν μερῶν· ἀεὶ γὰρ ἅμα τῇ τομῇ χρόνος ἔστιν ὡρισμένος ὑπὸ τῶν νῦν. εἰ οὖν ἅπας μὲν χρόνος διαιρετός, τὸ δὲ μεταξὺ τῶν νῦν χρόνος, ἅπαν τὸ μεταβάλλον ἄπειρα ἔσται μεταβεβληκός.

corresponding change and a period of time in which the subject is changing. At this division, then, we likewise have an instant at which some subject has completed a change. Since these are instants, they cannot exhaust the whole period, and so we can keep on finding intermediate instants indefinitely. Hence, the changing thing has changed an infinite number of times.

Thus Aristotle has prepared the way for his conclusion at 6.6 237b3-22: if every changing thing has changed infinitely many times, then applying this principle to generation, everything that is coming to be or has come to be will have already come to be (in reference to its parts) infinitely many times. In this sense, generated bodies "contain something infinite," namely the infinity of completions, the result of each incorporated ultimately as the extended parts of the body. In the same sense a change contains something infinite: an infinity of changes incorporated into the whole as parts, and similarly with time, the magnitude of a locomotion, and so on.

"The Infinite Fracturing Of Change"

Having described the "infinity" argument, I want, now, to turn to some concerns we might have with Aristotle's reasoning, and particularly with the last step I've just discussed. For it is there that we might start to become seriously uncomfortable with Aristotle's apparent willingness to divide changes, times, and magnitudes up indefinitely, what Waterlow calls the "infinite fracturing of change."[48] We will feel this especially if we are used to his approach in *Physics* 3.4-8 and in 8.8. Both of those texts in some way state and argue from what Jacob Rosen has called 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

[48] Waterlow, *Nature*, 146

actuality."[49] With this doctrine in mind, we might object that Aristotle is guilty of equivocation in the just cited argument: the instant at the end of a change, which is actual, and the merely potential instants within it are not at all equivalent, and where the actual one might mark a point at which the subject has changed, the merely potential instants do not. In mounting this objection, we would cite a principle along these lines: something can be said to have changed only at an actual moment in a change, and therefore only at its final moment.

Aristotle articulates this principle at *Physics* 8.8 262a22-25, and applies it in what follows that passage. There, Aristotle is occupied with the question: "can rectilinear locomotions (as opposed to the rotational motion of the heavens) be continuous?" where "continuous" here means that the motion should go on forever, without any pause or intermission and eternally. No, Aristotle says, because the universe is finite in size, and so any rectilinear motion would have to turn back at some point; such a turning back would always require the body to come to a rest for some period of time.

Aristotle sets out his argument by invoking the potentiality doctrine. One might think that the point at which a body turns back is no different than any other division in its motion: why should it need to come to a stop there, if it does not need to come to a stop at any of the infinitely many divisions we might draw in any stretch of motion? Aristotle objects that this would conflate merely potential divisions in a change with actual divisions:

> we have three points, beginning, middle, and end; and the middle is both beginning and end relatively to each of the others, being one in number but two in definition. We have further the distinction between the potential and the actual. So in the straight line any one of the points lying between the two extremes is potentially a middle-point; but it is not

[49] Rosen, Jacob. "*Physics* V-VI versus VIII: Unity of Change and Disunity in the *Physics*" in *Aristotle's Physics*: *A*

> actually so unless that which is in motion divides the line by coming to a stand at that point and beginning its motion again: thus the middle-point becomes both a beginning and an end, a beginning of the latter part and an end of the first part[50] (8.8 262a19-26)

Aristotle here clearly accepts the notion that a midpoint may act as a division, and even as the limit of the two lines that it divides. The remark that the point is "one in number but two in definition" is not idle: this shows that Aristotle by no means thinks that the dividing point is, as it were, a *break* in the line, such that the two dividends are separated. Such a division does not interfere with the continuity (in the sense pertaining to its topology) of the line, because the division is only potential: there is in fact no division in the line until the dividends are separated from one another. In short, there is no such thing as an actual middle-point: if the line which the middle-point divides remains intact, then the division remains merely potential. If the division were actual, then what it divides would no longer be continuous, and so it would not be a middle-point but an end-point.

Aristotle then applies this reasoning to motion specifically:

> This is the case e.g. when A in the course of its locomotion comes to a stand at B and starts again towards C; but when its motion is continuous A cannot either have come to be or have ceased to be at the point B: it can only have been there at a now, and not in any period of time except the whole of which the now is a dividing-point. To maintain that it has come to be and ceased to be there will involve the consequence that A in the course of its locomotion will always be coming to a stand; for it is impossible that A

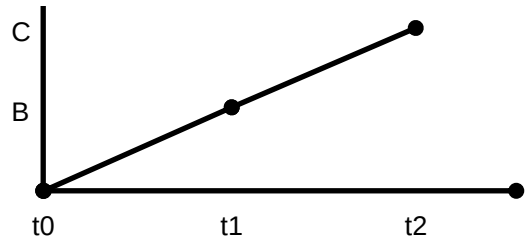
Critical Guide Ed. Mariska Leunissen. Cambridge: Cambridge University Press, 2015: 218

[50] ἀρχὴ δὲ ἥδε. τριῶν γὰρ ὄντων, ἀρχῆς μέσου τελευτῆς, τὸ μέσον πρὸς ἑκάτερον ἄμφω ἐστίν, καὶ τῷ μὲν ἀριθμῷ ἕν, τῷ λόγῳ δὲ δύο. ἔτι δὲ ἄλλο ἐστὶν τὸ δυνάμει καὶ τὸ ἐνεργείᾳ, ὥστε τῆς εὐθείας τῶν ἐντὸς τῶν ἄκρων ὁτιοῦν σημεῖον δυνάμει μέν ἐστι μέσον, ἐνεργείᾳ δ' οὐκ ἔστιν, ἐὰν μὴ διέλῃ ταύτῃ καὶ ἐπιστὰν πάλιν ἄρξηται κινεῖσθαι· οὕτω δὲ τὸ μέσον ἀρχὴ γίγνεται καὶ τελευτή, ἀρχὴ μὲν τῆς ὕστερον, τελευτὴ δὲ τῆς πρώτης

should simultaneously have come to be at B and ceased to be there, so that the two things must have happened at different points of time, and therefore there will be the intervening period of time: consequently A will be in a state of rest at B, and similarly at all other points, since the same reasoning holds good in every case[51] (8.8 262a26-b8)

This passage has been taken, most of all by Waterlow, to suggest a substantial conflict between Physics 8.8 and the argument we have been discussing in 6.6. Aristotle seems to deny here what he affirms in 6.6, namely that the changing thing has changed at the midpoint, even if it does not come to a rest there. In 8.8, Aristotle apparently holds that something "has come to be at B" only if it remains at rest in B for some period of time. But this conflict is explained by another one: Aristotle argues for the claim that a moving body can only come to be somewhere if it comes to a rest there from the premise that there is a instant in which it leaves B.

Figure 12: arriving and departing



Aristotle's thought is that the time of the motion from the origin to B is t0-t1, while the motion from B to C must be t1-t2. Supposing that the body has arrived at B at t1, we would also be required to say that it has left B at some time. When? Aristotle says that the only possible answer

[51] (λέγω δ' οἷον ἐὰν φερόμενον τὸ Α στῇ ἐπὶ τοῦ Β καὶ πάλιν φέρηται ἐπὶ τὸ Γ). ὅταν δὲ συνεχῶς φέρηται, οὔτε γεγονέναι οὔτε ἀπογεγονέναι οἷόν τε τὸ Α κατὰ τὸ Β σημεῖον, ἀλλὰ μόνον εἶναι ἐν τῷ νῦν, ἐν χρόνῳ δ' οὐδενὶ πλὴν οὗ τὸ νῦν ἐστιν διαίρεσις, ἐν τῷ ὅλῳ [τῷ ΑΒΓ]. (εἰ δὲ γεγονέναι τις θήσει καὶ ἀπογεγονέναι, ἀεὶ στήσεται τὸ Α φερόμενον· ἀδύνατον γὰρ τὸ Α ἅμα γεγονέναι τε ἐπὶ τοῦ Β καὶ ἀπογεγονέναι. ἐν ἄλλῳ ἄρα καὶ ἄλλῳ σημείῳ χρόνου. χρόνος ἄρα ἔσται ὁ ἐν μέσῳ. ὥστε ἠρεμήσει τὸ Α ἐπὶ τοῦ Β. ὁμοίως δὲ καὶ ἐπὶ τῶν ἄλλων σημείων· ὁ γὰρ αὐτὸς λόγος ἐπὶ πάντων. ὅταν δὴ χρήσηται τὸ φερόμενον Α τῷ Β μέσῳ καὶ τελευτῇ καὶ ἀρχῇ, ἀνάγκη στῆναι διὰ τὸ δύο ποιεῖν, ὥσπερ ἂν εἰ καὶ νοήσειεν.) ἀλλ' ἀπὸ μὲν τοῦ Α σημείου ἀπογέγονε τῆς ἀρχῆς, ἐπὶ δὲ τοῦ Γ γέγονεν, ὅταν τελευτήσῃ καὶ στῇ.

here is "at t1," which leads to the absurd conclusion that the body has arrived and left the same point in the same instant.

But, as many scholars have noted, this argument depends on the premise that there is a moment when the body has left B, and in *Physics* 6.5 236a7-27, Aristotle precisely denies this premise:

> Now, the sense [of "having changed"] according to the end of a change is something that exists (for a change may come to an end and there is an end of a change, which has been shown to be indivisible, being a limit). But that sense of "having changed" according to the beginning does not exist at all. For there is no such thing as the beginning of a change, nor any time primarily in which something is changing[52] (6.5 23610-14).

Aristotle not only denies that there is any time corresponding to the beginning of a change, he also, at *Physics* 6.5 235b6-32, gives a different answer to the question "when has the body left B?" His answer here is: when it has *completed* a change into an adjacent place, and so some time after the moment in which it has wholly come to be in B.[53]

I can see no way to resolve the apparent conflict between these texts that preserves the philosophically important features of both.[54] I have already argued that 6.4-6 is a late addition to the body of work we know as the *Physics*, and so I am inclined to think 6.6-4 and 8.8 were written at different times, and with different interests in mind. There are some good reasons to think that 6.4-6 was the later text, in addition to what we have already discussed in chapter one.

---

[52] τὸ μὲν οὖν κατὰ τὸ τέλος τῆς μεταβολῆς πρῶτον λεγόμενον ὑπάρχει τε καὶ ἔστιν (ἐνδέχεται γὰρ ἐπιτελεσθῆναι μεταβολὴν καὶ ἔστι μεταβολῆς τέλος, ὃ δὴ καὶ δέδεικται ἀδιαίρετον ὂν διὰ τὸ πέρας εἶναι)· τὸ δὲ κατὰ τὴν ἀρχὴν ὅλως οὐκ ἔστιν· οὐ γὰρ ἔστιν ἀρχὴ μεταβολῆς, οὐδ' ἐν ᾧ πρώτῳ τοῦ χρόνου μετέβαλλεν.

[53] The span of time between the moment the body has come to be wholly in B and the moment in which it has left it is occupied by the motions of the parts of the body out of B, understood as a part-by-part locomotion described in chapter 3.

[54] But see Bowen, "Unity" for an attempt to reconcile these texts. Bowen does so by supposing that Aristotle need not accept the premises on which his arguments in 8.8 are based, because they are *reductio* arguments.

First, and briefly, if 6.4-6 was written later, and was understood by Aristotle to be in conflict with what he says in 8.8, then we would expect Aristotle to provide some remediation for the damaged 8.8 argument. That is to say, we should expect to find a new argument for the claim that rectilinear motion cannot be infinite, one which not depend on the premises in 8.8 that Aristotle now contradicts in 6.5. We do find, quite out of place, just such an argument at the end of 6.10, at 241a26-b12.

Second, the premises upon which some of the arguments in 8.8 rely, and which come into conflict with *Physics* 6.4-6, are not defended in 8.8. The idea that there must be an instant at which something begins to move is raised without explanation, as if it were common sense. Were 8.8 later, and written with some awareness of what was said in 6.4-6, we would expect Aristotle to show that in fact there are good grounds for thinking that there is an instant when a moving thing ceases to be in its resting state, despite the arguments in *Physics* 6. On the other hand, if 6.4-6 is the later text and represents a shift in Aristotle's understanding of the metaphysics of change, then the same expectation will apply. We should expect to see some refutation of the premises of the 8.8 argument, and as I have discussed, we find exactly that: in 6.5 Aristotle denies that there is any time at which a change begins, and says that something has left a given condition at the end, rather than at the beginning, of a change. Aristotle also discusses the kinematic significance of "coming to a stand" (ἵστασθαι) at 6.8 238b23-30.[55]

In my introduction, I mentioned a standing puzzle in modern scholarship on *Physics* 6 and 8.8. If we assume, due to the reference at 263a11, that 8.8 is the later text, how can we explain its simplicity on the very questions where *Physics* 6 is precise and explicit? I mean especially the question of how changes might be divided into sub-changes, the temporality of something's

[55] *Physics* 6.8 refers back to 6.6, and makes use of the schematism of the primary time argument discussed in

beginning to change, and so on. The answer, I suggest is that *Physics* 8.8 was not written after, but before *Physics* 6.4-6 and 6.8. This removes the need to explain any oversight in 8.8, and it explains Aristotle's special attention to questions of beginning to change, coming to a stand, and so on in *Physics* 6.

Conclusion

Let us take stock. Aristotle aims in 6.4-6 to offer a new theory of natural continua, one which can replace the theory given in *Physics* 3 and 4. He locates this new theory in *Physics* 6 because it is there that he has, by engaging with Zeno and with Academic atomists, developed the concepts and tools necessary to formulate this new theory.

The heart of Aristotle's new theory is the body of the changing thing. This, he says, is divisible and infinite in an immediate way, while the divisibility and infinity of everything else in nature depends upon this. Aristotle divides his argument for this theory into two parts. In the first, he shows that the changing thing explains the divisibility of all the other aspects of change, and in the second, he shows that it explains the infinity of all the other aspects of change.

In the "divisibility" argument, Aristotle relies on a strategy developed in the "first text", 6.1 231a21-b18 and 6.2: he combines a categorical claim concerning the divisibility of one aspect of change with a hypothetical argument for the divisibility of another. Whereas in the first text this strategy was dialectical—the categorical claim could be supplied by the point of agreement between himself and Zeno—Aristotle now treats it as a way to find something akin to a first principle. If the changing thing can be shown to be divisible categorically, while the other aspects only hypothetically, then the changing thing can stand as the explanatory ground for the

chapter 4, so I assume it was written alongside or after 6.4-6.

structure of all natural continua.

But how to show, absent any dialectical context, that one aspect of change is categorically divisible? Here Aristotle borrows from what I have called the "second text," 6.1 231b21-232a22. Instead of leaving his kinematic analysis merely in terms of motion, time, and magnitude (as he does in the first text, and in *Physics* 4.11), Aristotle introduces a new consideration, i.e. the moving of the moving thing. And so in 6.4, Aristotle argues that if something is changing, a part of it must be in that from which it is changing and a part of it must be in that to which it is first changing. He then makes use of hypothetical arguments for the divisibility of the other aspects of change and concludes (SP1 and SP2) that every aspect of change is indeed divisible, and that the divisibility of all is explained by the immediate divisibility of the changing thing.

Aristotle then turns to the question of the *infinity* of the changing thing, by which we are to understand an infinity of divisibility. Aristotle here breaks new ground, further developing his understanding of the kinematic significance of the moving or changing of a changing thing. He builds on an Eleatic argument in which he has shown substantial interest, in *On Generation and Corruption* book 1. Aristotle argues that every changing thing must have already changed infinitely many times, and therefore that everything that is coming to be must already have become (or rather, the parts of it must have become) infinitely many times. From this, Aristotle concludes that (SP4) "something infinite" belongs immediately to every generated body.

Bibliography

Aquinas, Thomas. *Commentary on Aristotle's Physics.* Tr. Richard J. Blackwell, Richard J. Spath, W. Edmund Thirlkel. South Bend: Dumb Ox Press, 1999.

Barnes, Jonathan, *Aristotle Posterior Analytics.* Oxford: Clarendon, 1975

—(ed.) *The Complete Works of Aristotle.* Princeton: Princeton University Press, 1984.

Bostock, David. *Space, time, matter, and form: Essays on Aristotle's Physics*. Oxford: Oxford University Press, 2006.

Bowin, John. "Aristotle on the Unity of Change: Five Reductio Arguments in Physics viii 8." *Ancient Philosophy* 30, no. 2, 2010: 319-345.

Burnet, J. "Parmenides" in *Platonis Opera* 2 Oxford: Oxford University Press, 1967

Carraro, Nicola. "Aristotle's Embryology and Ackrill's Problem." *Phronesis* 62, no. 3, 2017: 274-304.

Coope, Ursula. *Time for Aristotle: Physics IV. 10-14*. Oxford: Oxford University Press, 2005.

Gill, Mary L., & Ryan, Paul. *Parmenides.* Indianapolis: Hackett Classics, 1996.

Glasner, Ruth. "An early stage in the evolution of Aristotle's physics." *Studies in History and Philosophy of Science Part A* 81, 2020: 24-31.

Graham, Daniel. *Aristotle Physics VIII*. Oxford: Clarendon Aristotle Series, 1999.

Gregory, Andrew. "Aristotle, dynamics and proportionality." *Early Science and Medicine* 6, no. 1, 2001: 1-21.

Hasper, Pieter Sjoerd. "Aristotle's diagnosis of atomism." *Apeiron* 39, no. 2, 2006: 121-156.

—*The Metaphysics of Continuity: Zeno, Democritus and Aristotle*. PhD diss., University of Groningen, 2003.

—"The Foundations of Presocratic Atomism." Sedley, David, ed. Oxford Studies in Ancient Philosophy 17: 1999: 1-14.

Heinaman, Robert. "Alteration and Aristotle's Activity-Change Distinction," *Oxford Studies in Ancient Philosophy* 16, 1998: 227-57.

Hussey, Edward. *Aristotle: Physics, Book III and IV*, Oxford: Oxford University Press; Clarendon Aristotle Series, 1983.

Johansen, Thomas Kjeller. *Aristotle on the sense-organs*. Cambridge: Cambridge University Press, 1997.

Jope, James. "Subordinate demonstrative science in the sixth book of Aristotle's Physics." The Classical Quarterly 22, no. 2, 1972: 279-292.

Kirwin, Christopher. *Aristotle Metaphysics Books Γ, Δ, and E.* Oxford: Oxford University Press; Clarendon Aristotle Series, 1993.

Lettinck, Paul. *Aristotle's Physics and its Reception in the Arabic World.* New York: Brill, 1994.

Mach, Ernst. *Principles of the Theory of Heat.* Dortrecht: D. Reidel Publishing Company, 1986.

Makin, Stephen. "Zeno on Plurality" Phronesis 27 no. 3, 1982: 223-238

Miller, Fred D. "Aristotle's Critique of the Atomists' Proof of Indivisible Magnitudes." Forthcoming, 2021.

—"Aristotle against the Atomists." Infinity and continuity in ancient and medieval thought (1982): 87-111.

Morison, Benjamin. "Primary Time in Aristotle's Physics 6." *Oxford Studies in Ancient Philosophy* 45, 2013: 149-93.

Murphy, Damian. "Alteration and Aristotle's Theory of Change in *Physics* 6." *Oxford Studies in Ancient Philosophy* 34, 2008: 185-218.

Netz, Reviel. *Scale, Space, and Canon in Ancient Literary Culture*. Cambridge: Cambridge University Press, 2020.

Owen, G. E. L. "Tithenai ta phainomena." *Logic, Science and Dialectic*, ed. Martha Nussbaum. Ithaca: Cornell University Press 1986.

Philoponus, *On Aristotle's Physics* 5-8. Ed. Richard Sorabji. Tr. Paul Lettinck, J.O. Urmson. London: Bloomsbury, 2014.

Rosen, Jacob. "*Physics* V-VI versus VIII: Unity of Change and Disunity in the *Physics*" in *Aristotle's Physics*: *A Critical Guide* Ed. Mariska Leunissen. Cambridge: Cambridge University Press, 2015.

—"Motion and Change in Aristotle's Physics 5. 1." *Phronesis* 57, no. 1, 2012: 63-99.

Ross, William D. *Aristotelis Physica.* Oxford: Clarendon Press, 1967.

Russell, B. “Mathematics and the Metaphysicians” in *Mysticism and Logic.* North Chelmsford: Courier Corporation, 2013.

Sedley, David. "Diodorus Cronus and Hellenistic Philosophy." *The Cambridge Classical Journal* 23, 1977: 74-120.

Sherry, David. “On Instantaneous Velocity” *History of Philosophy Quarterly*, Vol. 3, No. 4, 1986: 391-406

Simplicius. *Simplicius: On Aristotle Physics 1.3-4* Ed. Richard Sorabji. Tr. Pamela Huby, C.C.W. Taylor. London: Bloomsbury 2011.

—*Simplicius: On On Aristotle Physics 6* Ed. Richard Sorabji. Tr. David Konstan. London: Bloomsbury 2014.

—*Simplicius: On On Aristotle Physics 8.1-5.* Ed. Richard Sorabji. Tr. Istvan Bodnár, Michael Chase, Michael Share. London: Bloomsbury 2014.

Sorabji, Richard. “Aristotle on Colour, Light and Imperceptibles,” *Bulletin of the Institute of Classical Studies* 47, 2004: 129-140.

—, “Atoms and Time Atoms.” In *Infinity and Continuity in Ancient and Medieval Thought*. Ed. Norman Kretzmann. Ithaca: Cornell University Press, 1982: 37-86

— and Norman Kretzmann. "Aristotle on the Instant of Change." *Proceedings of the Aristotelian society, Supplementary* 50 (1976): 69-114.

Strobach, Niko. *The Moment of Change. A Systematic History in the Philosophy of Space and Time.* Dordrecht: Kluwer Academic Publishers, 1998.

Themistius. *On Physics 5-8,* Tr. Robert Todd. London: Bloomsbury, 2014.

Wagner, Hans. *Aristoteles: Physikvorlesung.* Berlin: Akademie Verlag, 1995.

Wardy, Robert. *The Chain of Change. A Study of Aristotle’s Physics VII.* Cambridge: Cambridge University Press, 1990.

Waterlow (Broadie), Sarah. *Nature, change, and agency in Aristotle's Physics: a philosophical study*. Oxford: Oxford University Press, 1988.

White, Michael J. *The Continuous and the Discrete: Ancient physical theories from a contemporary perspective.* Oxford: Clarendon Press, 1992.

—"What worried the crows?." *The Classical Quarterly* 36, no. 2, 1986: 534-537.