Aristotle on the Order and Direction of Time

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In Book IV, Chapter 11 of the *Physics*, Aristotle claims that 'the before and after' exists in time because it also exists in change, and it exists in change because it also exists in magnitude, and, further, that 'time follows change' and 'change follows magnitude'.[1] This is usually taken to mean that moments of time correspond to momentary stages of changes, and that momentary stages of changes correspond to points in magnitudes, so that time derives its 'before and after' from that of change, and change from that of magnitude.[2] But this is widely thought to land Aristotle in the following difficulty: If Socrates walks between points A and C, for instance, he can either proceed from point A to point

1 *Ph* IV 11, 219a14-19, cf., 219b15-6, 220b24-6.

2 As Hussey suggests, a clear but anachronistic way to state this is to say that there is a continuous function or mapping from what are before and after in magnitude onto what are before and after in change and from what are before and after in change onto what are before and after in time that preserves the before and after of each of the series. (Edward Hussey, *Aristotle's Physics III & IV* (Oxford: Oxford Clarendon Press 1983), 144. As Bostock and Sorabji have pointed out, what are before and after in change must be 'momentary stages' of a change, since Aristotle claims at *Physics* IV 11, 219a22-6 that these can function as boundaries of a change. (David Bostock, 'Aristotle's Account of Time', *Phronesis* 25 (1980) 148-169, 150; Richard Sorabji, *Time, Creation And The Continuum: Theories In Antiquity And The Early Middle Ages* (Ithaca, NY: Cornell University Press 1983), 85.) A 'momentary stage' of a change, if we are to honor Aristotle's prohibition on change at an instant, is not a momentary change but a momentary state of affairs, or a momentary event, where an event is defined as 'the having of some property'. For this conception of an event, see, for instance, J. Kim, 'Events as Property Exemplifications', in Stephen Laurence and Cynthia Macdonald, eds., *Contemporary Readings in the Foundations of Metaphysics* (Oxford: Blackwell 1998), 310-326, 311.

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C, or from point C to point A, but it seems that one cannot decide which of these two directions apply to the motion without importing a time reference. In other words, to say that Socrates moves from point A to point C is just to say that he is at point A prior to the time at which he is at point C.[3] So the derivation of the before and after in time is circular because we cannot specify the direction of a change without invoking the temporal relations of its stages. Similarly, the derivation of the before and after in change is circular because we cannot even give sense to the notion of a direction of a magnitude without designating it as the path of some change. In her book *Time for Aristotle*, Ursula Coope says, 'the fact that this view is so obviously unsatisfactory should lead us to question the interpretation that attributes it to Aristotle.'[4] I agree.

Coope proposes two interpretations to acquit Aristotle of these circularities. First she suggests that Aristotle might be interested in accounting for the orders of time and change but not their directions. In the example I just gave, suppose that Socrates walks between points A and C, but through point B this time, and that 'O', 'P', and 'Q' denote the kinetic stages Socrates being at point A, Socrates being at point B, and Socrates being at point C respectively. We can give the order of the motion by claiming that P is between O and Q, but give its direction by claiming that Socrates proceeds from O through P to Q.[5] Thus, the direction of a change is an asymmetry, i.e., the change proceeding in the

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3 This objection is due to Owen, (G.E.L. Owen. 'Aristotle on Time', in P. Machamer and R. Turnbull, eds., *Motion and Time, Space and Matter* (Columbus: Ohio State University Press 1976) 3-27, 24.), but also see Julia Annas, 'Aristotle, Number and Time', *Philosophical Quarterly* 25 (1975) 97-113, 101n11; Denis Cornish, 'Aristotle's Attempted Derivation of Temporal Order From That of Movement and Space', *Phronesis* 21 (1976) 241-251, 241; Richard Sorabji, *Time, Creation And The Continuum,* 86; Sarah Broadie (Waterlow), 'Aristotle's Now', *Philosophical Quarterly* 34 (1984) 104-128, 119n22.

4 Ursula Coope, *Time for Aristotle : Physics IV.11-14* (Oxford: Oxford University Press 2005) 69-75

5 A clear but anachronistic way to state this distinction is to say that a series has an order but not a direction if and only if it can be described by the ternary *betweenness* relation, '*b* is between *a* and *c*', but not by a binary relation that is transitive, asymmetric, and connected, e.g., '*a* is prior to *b*'. A series has both an order and a direction if and only if it can be described by both of these relations. McTaggart also distinguishes between the order of a series and its direction. The A- and B- series are ordered and directed, while the C-series is ordered but not directed. (J. E. McTaggart, 'The Unreality of Time', *Mind* (1908) 456-473, 462).

sequence O-P-Q, but not Q-P-O, while its order is not, since being P being between O and Q is consistent with the change proceeding in either of these directions. On this interpretation, the 'before and after in time' depends upon the 'before and after in change' and the 'before and after in change' depends upon the 'before and after in magnitude' only when the series of points, momentary stages, and instants are each viewed as having orders but not directions or asymmetries.[6] This dissolves the circularities by making it no longer necessary to determine the direction of any of the series, and seems plausible in the case of magnitude, since assigning one direction or another to a magnitude seems, prima facie, arbitrary. But it is less attractive in the cases of change and time, which *do* possess obvious asymmetries that Aristotle gives considerable attention to elsewhere.[7] So Coope proposes a second interpretation that at least attributes to Aristotle an explanation of asymmetries in time and change. In the sequel, I will focus on this second interpretation, and leave aside the first. I will consider criticisms of this interpretation by Stephen Makin, add criticisms of my own, and propose an alternative interpretation that I think fares better. Finally, having established that Aristotle's derivations of the directions of time and change are not viciously circular, I will consider the separate, but related problem of how the temporal orders and directions derived from individual changes can together constitute a single, globally consistent order and direction of time.

I

In her second, 'more promising' interpretation, Coope proposes that the direction or asymmetry of change is to be explained, according to Aristotle, by means of an analogy with magnitude. In *Physics* IV 11,[8] Aristotle says, 'since the before and after is in magnitude, it is necessary that the before and after is also in change, by analogy with the things there (ἀνάλογον τοῖς ἐκεῖ).' Coope suggests that the analogy referred to

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6 I shall, hereafter, talk of a series having a direction and being asymmetric interchangeably.

7 See, e.g., *de Int* 9, *EN* VI 2, 1139b7-9 and *Cael* I 12, 283b13-14, for the claim that the future is contingent while the past is not.

8 *Ph* IV 11, 219a16-8

by ἀνάλογον τοῖς ἐκεῖ is an analogy between 'the relations of positions on a line and the relations of stages in the change'.[9] This analogy, Coope argues, is suggested by the sense of priority described in *Metaphysics* Δ 11 as primary, viz., the prior being able to exist without the posterior but the posterior not being able to exist without the prior, e.g., as 'the half line is prior to the whole line'. Just as half lines may exist without whole lines, Coope claims, 'some parts of the change can occur though (because of interference) the rest of the change does not.' The key step in Coope's proposal is the claim that every change part produced by an interruption of a given change will share a common boundary, viz., the origin of the change, and, given this fact, one can define an asymmetric series of change parts in which every prior change part is a proper part of every posterior change part. The asymmetric series of the stages of a change, then, is just the series of boundaries of proper change parts that starts with the common boundary (the origin) and proceeds through the other boundaries of the change parts in a sequence that is determined by the transitive and asymmetric part-whole relation in which the change parts stand.

Makin however, in a critical study of Coope's book, objects that if an interruption is implicitly something that happens to a change *while* it is occurring and *after* it has started, then Coope's account is covertly temporal, and 'the before/after in change will not be genuinely non-temporal.'[10] What Coope needs to do, argues Makin, is to show that her claims still hold for interruptions that are more neutrally characterized as 'interferences' resulting in 'incomplete occurrences'. But, argues Makin, incomplete occurrences produced by interference need not always share a common origin. Makin claims, for example, that they do not share a common origin in the case of an examination that is incomplete, in one instance because it is delayed at its start, and in another instance because it is stopped while in progress.

Coope, herself, considers an analogous case involving locomotion: Socrates walks from point A to point C through point B, and his walk can be interfered with either by stopping him at point B after he has set out from point A, or transporting him to point B, where he continues on to point C. Coope rules out the latter as a genuine counter-example

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9 Ursula Coope, *Time for Aristotle*, 72

10 Stephen Makin, 'Critical Study: About Time for Aristotle', *The Philosophical Quarterly* 57 (2007) 280-293, 287

because, on her interpretation of Aristotle, by causing the journey to start further along its path, one is not interfering with the *same* journey that, in an alternate scenario, is stopped while it is in progress. Since the identity of a change depends on its proceeding from 'from something to something' (219a10-11),[11] Coope argues, Socrates must be moving from point A to point C in any motion that results from interfering with a motion from point A to point C. This is the case for Socrates when he is halted at point B because he actually starts at point A and, even though he does not reach point C, he is still moving to point C because, according to the definition of change in *Physics* III 1, his motion is governed throughout by a partially actual potential to be at point C.[12] But this is not the case for Socrates when his walk is made to begin at point B instead of point A.

But, claims Makin, if this line of argument were applied to the case of the examination rendered incomplete by a delay in starting, 'we cannot say that [the student] turns in an incomplete exam, and — stranger still — that what she actually does is turn in a complete sub-exam.'[13] The relevant point, of course, is not about the incompleteness of the script handed in, but about the incompleteness of the process that produced it, viz., the examining. So, to be clear, we should rephrase Makin's objection as the claim that in Coope's view, if the examining is rendered incomplete by a delay in starting, we cannot say that the student undergoes an incomplete examining and — stranger still — that what she actually undergoes is a complete sub-examining.

But this misses Coope's point. She is not committed to denying that the student who is delayed in starting her exam undergoes something that can be described as an incomplete examining. If I understand her correctly, she is, rather, committed to denying that this incomplete examining is a part of *the very same* complete examining of which the other incomplete examining (i.e., the one that is stopped while in progress) is a part because this incomplete examining (i.e., the delayed one) is not to

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11 Cf. *Ph* VII 1, 242b37-8, which says that a change 'is numerically the same if it proceeds from something numerically one to something numerically one.'

12 Coope adopts Kosman's interpretation of Aristotle's definition of change in *Ph* III 1, so that the ἐντελέχεια in ἡ τοῦ δυνάμει ὄντος ἐντελέχεια, ᾗ τοιοῦτον (201a10-11) is translated as 'actuality' instead of 'actualization', and the δυνάμις implied by δυνάμει is a potentiality *to be at* a goal state, not a potentiality *to be moving to* a goal state (L.A. Kosman, 'Aristotle's definition of motion', *Phronesis* 14 (1969) 40-62).

13 Stephen Makin, 'Critical Study', 287

and from the same termini. Makin's example of the examination, then, is on all fours with Coope's example of Socrates' walk, since Coope is also committed to denying that Socrates' motion from point B to point C is a part of *the very same* motion from point A to point C of which his motion from point A to point B is a part because the motion from point B to point C is not to and from the same termini.

This, as I said, follows from the claim that Socrates must be moving from point A to point C in any motion that results from interfering with a motion from point A to point C, which, in turn, is supposed to follow from Aristotle's view that the identity of a change depends on its proceeding from 'from something to something'. But is this last inference actually valid? It would be if a change resulting from interference were thought to be somehow the *same* change that it would be if it were not interfered with (perhaps by being the same change under a different description). But Coope makes it clear that the change resulting from interference is supposed to be a *part* of this change, not identical to it.[14] Obviously, the proper parts of a motion from point A to point C, as a rule, do not proceed from point A to point C in the sense that they begin and end at points A and C.[15] As Coope points out, there is another sense in which Socrates is moving *to* point C in these change parts, viz., by possessing a partially actual potential, throughout the change, to be at point C, but this does not tell us why each change part must also be *from* point A.

So why claim that Socrates must be moving from point A to point C, or more particularly, from point A, in every part of a motion from point A to point C? I can see no other reason than the fact that these change parts are parts of a motion from point A to point C. When he makes his complete walk from point A through point B to point C, Socrates is moving from point A to point C during his motion from point A to point B as well as during his motion from point B to point C *because* each of these motions is part of a larger motion from point A to point C. In fact, for Socrates to be moving from point A to point C in a motion from point A to point B or point B to point C *just is* for these motions to be part of a larger motion from point A to point C. But then, to be argu-

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14 Ursula Coope, *Time for Aristotle*, 79

15 See *EN* X 3, 1174b2 ff., which says that while 'the whence and whither give [changes] their form' (1174b2-5), the form of the parts of a change is different from the form of the whole *because* their termini differ.

ing that a motion from point B to point C is not a part of a motion from point A to point C because Socrates is not moving from point A to point C during it, is just to be arguing that a motion from point B to point C is not a part of a motion from point A to point C because it is not a part of a motion from point A to point C.

As I said, Coope's claim is that Socrates is moving from point A to point C in every part of a motion from point A to point C *that results from interfering with a motion from point A to point C*. So on Coope's view, when the motion from point A to point C is interfered with, the full motion from point A to point C becomes a *counterfactually* existing motion, and the question becomes whether or not the motion resulting from the interference is a part of this counterfactually existing motion. Or perhaps, more precisely, the question should be whether or not the motion resulting from the interference *would have been* a part of this counterfactually existing motion *in this counterfactual situation*. If this is the correct way to describe matters, then the question is not whether Socrates is moving from point A to point C in his actual truncated motion, but whether he *would have been* moving from point A to point C *if the motion had not been interfered with*. And as I argued, this just amounts to the question of whether Socrates' actual truncated motion from point B to point C would have been a part of this uninterrupted motion. Coope, however, seems to want the actual truncated motion resulting from interference to be a part of a counterfactually existing motion, not counterfactually but actually: 'what is left when we interrupt a change should be regarded as a part of *the very change that would have occurred if there had been no interruption*.'[16] Likewise, she wants the subject of the actual truncated motion to be moving between the termini of the counterfactually existing motion not counterfactually but actually. I do not see what sense can be made of this view and Coope herself expresses qualms about it: 'When the change is interrupted, the complete change never occurs. Because of this, it is not entirely obvious that what does occur can be regarded as a part. How can something be a part if there is never an existing whole of which it is a part?'[17] Here the analogy with a line fails, since after a line is divided, it at least has a history of being a part of the whole line from which it was cut. But the very fact that a

16 Ursula Coope, *Time for Aristotle*, 79

17 Ibid., 79

motion is interrupted ensures that there never was an actual whole motion of which the interrupted motion was a part.

There is another problem with Coope's analogy between parts of a change and parts of a magnitude. A key claim in Coope's interpretation is that just as half lines may exist without whole lines, 'some parts of the change can occur though (because of interference) the rest of the change does not.'[18] But, according to Aristotle, half lines *as* half lines do not exist without whole lines. This is because the parthood of a half line in a whole line is restricted by the requirement that the half line share the form of the whole line, which it can only do so long as it is undivided from the whole line. The half line has these properties because it is a material part, and it is clear from *Metaphysics* Δ 11, from which Coope draws her analogy, that the half line is to be so construed.[19] So if we follow through with the analogy between parts of a motion and parts of a magnitude, it would seem that interrupted motions do not exist as parts of a motion. But Coope's construction of the asymmetric series of the stages of a change depends upon these stages being boundaries of interrupted motions that stand in part-whole relations.

Finally, there are two problems associated with Coope's interpretation of what it means for the elements of one of these series to 'follow' another, one of which has been pointed out by Makin, and another, which has not, and which might be turned into an advantage for Coope's interpretation if it is solved. Coope argues that when Aristotle claims that time follows change and change follows magnitude, he is asserting a form of explanatory dependence in which certain structural features of time hold, e.g., its order and direction, *because* the same fea-

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18 Ursula Coope, *Time for Aristotle*, 73

19 In *Metaph* Δ 11, Aristotle says that the half line is prior to the whole line, not *simpliciter*, but in potentiality (κατὰ δύναμιν), because the half line can exist without the whole line after the whole line is destroyed. The κατὰ δύναμιν clearly casts the half line as a potential or material part of the whole line, but according to *Metaph* Z 10, when a whole line is destroyed by being divided into its material parts, the material parts remain parts 'only in name' (1035b24-5). In footnote 14 on p. 68 of *Time for Aristotle*, Coope says that 'Aristotle must be presupposing that the part in question [in *Metaph* Δ 11] has been marked out in some way,' making it, I assume, an actual part. But this does not square with Aristotle's claim that the half line is prior to the whole line κατὰ δύναμιν. According to Makin, 'Critical Study', 285, this is where Coope 'ducks' the issue of how the priority κατὰ δύναμιν/κατὰ ἐντελέχειαν distinction in *Metaph* Δ 11 relates to the priority of change parts that she proposes.

tures of change hold, and that certain structural features of change hold *because* the same features of magnitude hold. Indeed, as Coope points out, Aristotle explicitly claims this is the case with continuity by using the preposition διά: 'for through (διά) the magnitude's being continuous, the change too is continuous but through the change, the time.'[20] But Coope takes explanatory dependence to be grounded in ontological dependence, and as Makin points out, she does not find a uniform way to specify the ontological dependence of change on magnitude and time on change. She employs the criterion of *Metaphysics* Δ 11[21] to characterize the ontological priority of magnitude over change, viz., the fact that a magnitude can exist without a change going on over it but not vice versa,[22] but appeals to Aristotle's claim that time is 'something of change' to characterize the ontological priority of change over time. Neither of these criteria suit both cases, because, as Coope admits, change is not 'something of' magnitude, and as Makin points out, change cannot exist without time.[23]

A second problem with Coope's interpretation of the *following* relation arises because, while on her view, change derives its direction by means of an analogy with magnitude instead of by following it, Aristotle still says twice that change follows magnitude.[24] Since, on Coope's view, the function of the *following* relation is to explain structural features of the continua that it relates, this must mean that change derives its order by following magnitude but not its direction. Thus, change, by following magnitude, derives only a subset of the formal properties that time derives by following change. But how precisely, does the *following* relation accomplish this selective transmission of properties? It is not clear how construing this relation to be one of ontological dependence, as Coope does, gives her the resources to answer this question.

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20 *Ph* IV 11, 219a12-3

21 *Metaph* Δ 11, 1019a3-4

22 Coope also employs a variation on this, where a single magnitude can be the path of various changes.

23 A caveat: Aristotle says that change cannot exist without time at *Ph* 222b30-223a4 and 232b20-3, but then seems to contradict himself at *Ph* IV 14, 223a22-8, where he says that in the absence of souls, change would exist but not time.

24 *Ph* IV 11, 219b15-6, 220b24-6

II

If the question can be answered, however, this result has the advantage of allowing magnitude to be an ordered but undirected series described by a *betweenness* relation,[25] which, as I said, is a plausible assumption in itself. It also provides an answer to the charge that Aristotle's derivation of the before and after in change from the before and after in magnitude is viciously circular: Since the alleged circularity arises from deriving the direction of change from magnitude, not from deriving its order, the circularity never arises.

Coope opts for taking the explanatory dependence implicit in the *following* relation to be grounded in ontological priority rather than epistemological priority because she claims that epistemological priority is not asymmetric as applied to time and change: We come to be aware of certain features of time by coming to be aware of corresponding features of change, but we also become aware of certain features of change by becoming aware of corresponding features of time. This sort of epistemological priority is what Aristotle calls priority in perception in *Metaphysics* Δ 11. But there is another type of epistemological priority mentioned in this same chapter called 'priority in formula', and this type of priority breaks down into two sub-types. One sub-type is the priority of universals over individuals, which corresponds to the familiar 'more knowable *simpliciter*' of *Physics* I 1 and *Posterior Analytics* I 2. The other sub-type of priority in formula applies to the components of accidental compounds. In accidental compounds such as the musical man, an accident like musicalness may be prior in formula and therefore, prior in knowledge, to the compound, while being posterior in being, since 'musicalness cannot exist unless there is someone who is musical.'[26] Aristotle says much the same thing in *Metaphysics* M 2[27] to make the point that priority in substance does not necessarily track priority in formula. Whiteness is prior to the white man in formula since the white man is compounded from these two, but it is not prior in substance since whiteness cannot exist separately.

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25 Coope seems to imply that this is what she has in mind in footnotes 21 and 22 on pp. 72-3, of *Time for Aristotle*.

26 *Metaph* Δ 11, 1018b36-7

27 *Metaph* M 2, 1077b1-11

This is particularly relevant in the present case because changes, regarded as entities, are accidental compounds, and the formulas of changes reflect this. The formula of a change will contain an agent, a patient, a medium in which the change takes place, and a pair of contraries marking the limits, within this medium, to and from which the change proceeds.[28] Thus, magnitude is prior to change in formula and, according to *Metaphysics* Δ 11, in knowledge also, because it is included in the formula of a change but not *vice versa*. Change is prior in formula to time because change is included in the formula of time but not *vice versa* (time is 'something of change'[29]). But while change is prior to time ontologically, magnitude need not be prior to change ontologically.[30]

So I suggest that the explanatory priority of the *following* relation is a priority in formula. Magnitude is prior in formula to change, change is prior in formula to time, and the *following* relation, or the continuous mapping from what are before and after in magnitude onto what are before and after in change and from what are before and after in change onto what are before and after in time is a mapping that is based on the elements in the formulas of these entities. The benefits of this interpretation are that it provides a uniform way to specify the dependence of time on change and change on magnitude as well as a rationale for claiming that change derives from magnitude only a subset of the formal properties that time derives from change. Since being prior in formula is a matter of the thing that is prior having its formula *included* in the formula of the thing that it is prior to, and if we assume that there is a one-to-one correspondence between the parts of a formula and the parts of a form,[31] then the formal properties denoted by a prior thing's formula will be a subset of the formal properties denoted by the formula of the thing which it is prior to.

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28 See, e.g., *Ph* V 4, 227b3-8a19 and VII 1, 242b31-42 which give the criteria for a change to be 'one change'.

29 *Ph* IV 11, 219a9-10

30 This allows for the possibility that ontological priority could be determined, as Coope suggests on *Time for Aristotle*, page 42, by how closely related to particular substances an entity is, in which case, positions in a magnitude, understood as places, could be viewed as less closely related to particular substances than changes are [place being, according to Aristotle 'the boundary of the containing body at which it is in contact with the contained body' (*Ph* IV 4, 212a6)]. Makin suggests this possibility in 'Critical Study', 283.

31 See, e.g., *Metaph* Z 10, 1034b20 ff.

So if the formula of magnitude is included in the formula of change, and the formulas of points in a magnitude are included in the formulas of momentary kinetic stages, and there are other elements in the formulas of changes and momentary kinetic stages besides specifications of kinetic media and points within these media, then change can derive its order from magnitude, but its direction from some other feature of change besides its medium. But since this feature is not explicitly identified in Aristotle's discussion of time in *Physics* IV 10-14, one will need to infer it, somehow, from what Aristotle says there. Coope's strategy is to infer it from his remark that change is always 'from something to something', combined with the discussion of priority in *Metaphysics* Δ 11 and the definition of change in *Physics* III 1. But as I have argued, there are problems with Coope's use of the concept of an interruption, and, moreover, her approach is needlessly complicated since under a widely held reading of *Physics* III 1, Aristotle's definition of change by itself entails an intrinsic direction.[32] If, as this interpretation suggests, each change is governed by a single, partially actual potential to be in some goal state, and this potential becomes more completely actual as the change progresses toward this goal state, then the direction of a change is just the direction toward the actuality of the potentiality that governs it. Stage P is before stage Q in a change, in other words, just in case the potential governing the change is more completely actual relative to some goal state at Q than at P.

Deriving the asymmetry or direction of change directly from the definition of change, besides being simpler, also has a much more straightforward textual justification than Coope's approach: When Aristotle says that time follows change and change follows magnitude in *Physics* IV 11, I simply assume that he is using the word 'change' as he

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32 For this interpretation of Aristotle's definition of change see L.A., Kosman, 'Aristotle's definition of motion'; Jaakko Hintikka, 'Aristotle on Modality and Determinism', *Acta Philosophia Fennica* 29 (1977) 58-77; J. Owens, 'Aristotle — motion as actuality of the imperfect', *Paideia: Special Aristotle Issue* (1978) 120-132; Mary Louise Gill, 'Aristotle's Theory of Causal Actions in Phys. III 3', *Phronesis* 25 (1980) 129-147; Sarah Broadie (Waterlow), *Nature, Change and Agency In Aristotle's Physics* (Oxford: Oxford Clarendon Press 1982), 112-119. For the explicit claim that Aristotle's definition of change by itself implies an intrinsic direction see Sarah Broadie (Waterlow), 'Instants of Motion in Aristotle's Physics VI', *Archiv Für Geschichte Der Philosophie* 65 (1983) 128-146, 137-8, and *Nature, Change and Agency In Aristotle's Physics*, 123, 130-1, 136. Also see Mary Louise Gill, *Aristotle on Substance: The Paradox of Unity* (Princeton, NJ: Princeton University Press 1989), 184, 194.

has defined it in *Physics* III 1. And this is a very plausible assumption, in the light of the plan of inquiry laid out at the beginning of Book III: Aristotle tells us, there, that since the subject of his inquiry is nature, and nature is a principle of change, the first thing to be investigated is change, but since certain other things like infinity, place, and time are presupposed by change, these things must be examined in turn. The discussion of time in Book IV, then, is to be understood as an adjunct to the discussion of change in Book III, which, in turn, is to be understood as an adjunct to the discussion of nature in Book II.

Another benefit of deriving the intrinsic direction of change from the definition of change is that it ensures the generality of the asymmetry, and this will be required of any successful attempt to acquit Aristotle of the alleged circularities because he took time to follow change *in general*, and not just locomotion. Commentators have generally missed this fact, and assumed that Aristotle derives the order and direction of time from the order and direction of locomotion in *Physics* IV 11. But Coope argues convincingly that when Aristotle says 'change follows magnitude' and 'time follows change', the context makes it clear that change is *not* to be taken as strictly locomotion.[33] The purpose of *Physics* Book IV, Chapter 11 is clearly to determine the relationship between time and change quite generally, which includes alteration and growth, and probably also generation and destruction, in addition to locomotion. As Coope puts it, Aristotle argues that 'there can be no time unless there is some kind of change or other, not that there can be no time without spatial change,' and indeed, the first example adduced for this claim is an alteration: the perception of change within the soul.[34] It seems reasonable to assume, then, that when he goes on to give the details of the relationship between change and time in terms of locomotion that locomotion is also only an example, and that he is making a claim about the relationship between time and change quite generally, not just between time and locomotion.[35] Finally, Coope points out that there is a closely related passage in Book III, which claims the depen-

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33 Ursula Coope, *Time for Aristotle,* 51. Cf. Bostock, who argues for a similar claim ('Aristotle's Account of Time', 151.)

34 *Ph* IV 11, 219a4-9

35 Coope might also have added that Aristotle gives us indirect confirmation of this when he argues that time is not just the number of locomotion but of change in general at *Physics* IV 14, 223a29-33.

dence of the infinite divisibility of time on the infinite divisibility of change and the infinite divisibility of change on the infinite divisibility of magnitude, and which explicitly takes change to encompass alteration and growth:

> The infinite is not the same in magnitude and change and time, in the sense of a single nature, but the posterior depends on the prior, e.g. change is called infinite in virtue of the magnitude along which something changes or alters or grows, and time because of the change. (I use these terms for the moment. Later I shall explain what each of them means, and also why every magnitude is divisible into magnitudes.) (*Ph* III 7, 207b22-7)[36]

This passage makes no mention of substantial change, but as Coope points out, Aristotle tells us at the end of Book IV, Chapter 10 'we need not distinguish at present between κίνησις and μεταβολή.' The distinction between the words κίνησις and μεταβολή, which can both be translated as 'change', appears in *Physics* V 1 and establishes a sense of the word κίνησις that excludes substantial change, with μεταβολή referring to each of the four types of non-accidental change, including change in substance (viz., change in substance, change in size, change in quality, and change in place). Since we are explicitly told *not* to take κίνησις in this more restricted sense, it is reasonable to suppose that time follows change in the case of substantial change as well. Finally, when Aristotle describes the before and after in change in Chapter 11 of his 'philosophical dictionary', *Metaphysics* Δ, the example he chooses is biological growth, not locomotion.[37] At least one commentator[38] has, on this ground, taken the passage to be irrelevant to the purposes of *Physics* IV 11, on the assumption that Aristotle is deriving the order and direction of time from locomotion there, not from change in general, but *Metaphysics* Δ 11 can also be adduced as evidence that the 'before and after in motion' in *Physics* IV 11 should be construed more broadly than simply locomotion.

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36 Unless otherwise noted, the translations of Aristotle in this paper are from J. Barnes (ed.), *The Complete Works of Aristotle: The Revised Oxford Translation* (Princeton 1995).

37 *Metaph* Δ 11, 1018b19-21

38 Sarah Broadie (Waterlow), 'Aristotle's Now', 115n16

An immediate, and fairly obvious concern with this approach, however, is whether or not, by speaking of goal states in connection with Aristotle's definition of change, we are thereby committing him to the view that change as such involves final causes.[39] Put another way, we need to decide whether the goal states implied in *Physics* III 1 are to be identified with final causes, and if not, we then need to decide how they are to be distinguished from them. But clearly, if the definition of change in this chapter is a definition of change as such, then we cannot identify the goal states implied there with final causes because, in *Physics* II 8,[40] for instance, Aristotle distinguishes between changes that are and are not for the sake of something. One option is to deny the antecedent and assume that the definition of change in *Physics* III 1 is not a definition of change as such, but Aristotle gives no indication that this is what he intends. My suggestion, rather, is that the goals implied in this chapter are τέλη of a more general sort than final causes, since, as Sarah Broadie points out, the idea of an intrinsic direction of change in *Physics* III 1 is 'of logical significance', following merely from the fact that the phrase ' "potentially — " demands a single filling.'[41] As Aristotle would say, he is speaking λογικῶς in this chapter, completing an abstract and formal account of the structure of change as such that begins in Book I, Chapter 7 with the requirement that every change, at the very least, is a change from a privation, to a form, by a subject, and then merely adds to this in Book III, Chapter 1 the concepts of potentiality and actuality, and the coordinate concepts of incompleteness and completeness: A form is an actuality that a substance has the potentiality to attain, and a change is the incomplete actuality of this potentiality. Since every potentiality is defined in terms of the single actuality for which it is a potentiality, potentialities are goal-directed by definition. And since each change is defined in terms of a single potentiality, change is also goal-directed by definition. Hence, the goal-directedness of change, on the level of abstraction of *Physics* III 1, is just a formal or definitional property that follows from the fact that each change is

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39 Monte Johnson raises precisely this question in his *Aristotle on Teleology* (Oxford: Oxford University Press 2005), 135.

40 *Ph* II 8, 198b16 ff.

41 Sarah Broadie (Waterlow), *Nature, Change and Agency In Aristotle's Physics,* 128, 131

defined in terms of a single potentiality, which is, in turn, defined in terms of a single actuality.

But since this is the case, and if one agrees with Coope that the dependence of the direction of time on the direction of change is supposed to be an explanatory dependence, then a new sort of problem arises: If the intrinsic direction of change merely falls out of Aristotle's definition of change, and if this is all there is to his account of it, then the explanation of the direction of time that derives from this account will be as vacuous and uninformative as Molière's *virtus dormativa*.[42] What is needed, in order to give explanatory content to Aristotle's account of the direction of time, is to add to the λογικός account of the intrinsic direction of change in *Physics* III 1, a φυσικός account of the same asymmetry.

Both Sarah Broadie and Mary Louise Gill have pointed out the need for such an account, and Broadie conceives of this explanatory content as a basis for determining the goal state of a change that is not ex post facto. Broadie argues that, if each change is defined in terms of a single potentiality for a single goal state, there needs to be some basis for determining this goal state other than the fact that the change happens to end up in it, otherwise the change would have no 'fully determinate description' while it is occurring.[43] In this case, the changing thing, while it is changing, would just be expressing a potentiality to be other than it is. But Gill points out that even the mere expression of a lack is consistent with a description that is this indeterminate.[44] Broadie casts this indeterminacy as an incoherence in the definition of change itself since actualities, or even partial or incomplete actualities imply determinacy, and change is supposed to be an incomplete actuality. But I think this confounds the indeterminacy of a definition with the definition of an indeterminacy. Aristotelian changes are clearly *not* indeterminate in that they lack an intrinsic direction that can be specified while they are occurring. Rather, the definition of change must be indeterminate regarding the ultimate basis for this direction since it can be specified in various ways, and, indeed Broadie and Gill suggest different ways to specify it.

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42 Michael White makes essentially this complaint about Aristotle's definition of motion (*The Continuous and the Discrete* (Oxford: Oxford Clarendon Press 1992), 113).

43 Sarah Broadie (Waterlow), *Nature, Change and Agency In Aristotle's Physics,* 131

44 Mary Louise Gill, *Aristotle on Substance: The Paradox of Unity,* 193

Broadie suggests that it is the goal-directedness of natures that ultimately accounts for the intrinsic direction of change in the *Physics*. Aristotelian natures, defined as principles of motion, are akin to capacities in that they are causes, are internal to their subjects, and have their expression or actuality in certain activities, but they are distinguished from capacities insofar as the activities they express are essential, proper, and non-accidental to the subjects to which they belong.[45] Thus, changes governed by natures ultimately get their goal-directedness or intrinsic direction from the normative status of the activities they express for members of the subject's natural kind. The relative proximity to the goal state of changes governed by natures, then, represents the degree of *perfection* of the subject of the change *qua* the sort natural substance that it is. In the light of the following passage, however, Gill suggests that it is an agent or an efficient cause that ultimately imposes a goal-directedness or an intrinsic direction upon a change by transmitting a form to the patient:

> ... change is the fulfillment of the changeable as changeable, the cause being contact with what can move, so that the mover is also acted on. The mover will always transmit a form, either a "this" or such or so much, which, when it moves, will be the principle and cause of the change, e.g. the actual man begets man from what is potentially man. (*Ph* III 2, 202a3-11)

On Gill's view, a state is singled out as being *the* goal of a change by representing the complete or most complete transmission of a form by the agent, that already has the form, to the patient that does not. The form transmitted may be 'either a "this" or such or so much', but in each case, the relative proximity to the goal state of these changes represents the degree of *assimilation* of the patient to the agent. I will follow A.C. Lloyd in calling this Aristotle's 'transmission theory of causation'.[46]

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45 For the claim that natures are principles of motion, see *Ph* II 1, 192b12-23. Aristotle says that natures are in the same genus as capacities at *Metaph* Θ 8, 1049b8-9. For the claim that 'the source or principle is the cause of all that exists or arises through it' see *EE* II 6, 1222b30-1. For the internal status of natures, see *Ph* II 1, 192b13, 22, 193a29, b4, *Metaph* Λ 3, 1070a8. For the claim that natures express activities that are essential, proper, and non-accidental to the subjects to which they belong see *Ph* II 1, 192b22-3, VIII 4, 255a26, 29-30.

46 A. C., Lloyd, 'The Principle that the Cause is Greater than its Effect', *Phronesis* 21

That Aristotle took the intrinsic direction of change to derive ultimately from causal principles such as nature and agency is, I think, highly plausible. But if we consider the sorts of changes that natures and the transmission theory of causation explain, it becomes evident why he could build neither of them into his definition of change. Since neither explains the intrinsic direction of *every* type of change, to do so would leave some types of change with an intrinsic direction that cannot be specified while the change is in progress. Natures obviously cannot explain the intrinsic direction of unnatural changes, and the transmission theory of causation is generally thought not to apply to locomotion,[47] partly because, in the passage just quoted from the end of *Physics* III 2, only changes in substance, quantity, and quality are said to involve the transmission of form,[48] and partly because of the prima facie implausibility of the agent and the patient becoming alike in place in every type of locomotion.[49] Aristotle, I suspect, deliberately refrained from including causal principles in his definition of change because no single causal principle will explain the intrinsic direction of every type of change.

This attributes to Aristotle a concern not to leave any type of change with an unexplained intrinsic direction. One can debate, of course, whether Aristotle saw the problem that Broadie points out, since there are no texts where Aristotle explicitly addresses it. But the fact that he did not leave such an explanatory lacuna at least speaks for the plausibility of this attribution. It can be shown, in fact, that non-accidental changes as a class may be divided without remainder into sub-classes

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(1976) 146-156. See also Alexander P. Mourelatos. 'Aristotle's rationalist account of qualitative interaction', *Phronesis* 29 (1984) 1-16, and S. Makin, 'An ancient principle about causation', *Proceedings of the Aristotelian Society* 91 (1990/91) 135-52.

47 Broadie recognizes this about natures, and on the assumption that only natures can fill this explanatory role, claims that Aristotle must be defining only natural change in the *Physics* instead of change as such. (Sarah Broadie (Waterlow), *Nature, Change and Agency In Aristotle's Physics*, 95, 99-102, 105-6, 119, 121, 127-31.) Gill, on the other hand, seems to forget that the transmission theory of causation does not apply to locomotion, and interprets Aristotle as building this principle into a revised definition of change at the end of *Physics* III 3. (Mary Louise Gill, *Aristotle on Substance: The Paradox of Unity*, 194, 204-7.)

48 *Ph* III 2, 202a3-11

49 Simplicius cites this implausibility as the reason for the absence of locomotion in the passage at the end of *Physics* III 2 (*in Phys* 438, 24-35).

of changes that have Aristotelian causal explanations for their intrinsic directions. For the most part, Aristotle explains the intrinsic direction of natural or unforced changes by invoking natures, and the intrinsic direction of unnatural or forced changes by invoking the transmission theory of causation. Exceptions to this generalization are natural or unforced self-changes due to a τέχνη and forced locomotions, which require other principles to explain their intrinsic direction. Self-changes due to a τέχνη get their intrinsic direction from the characteristic product, in terms of which the τέχνη is defined. Forced locomotions inherit their intrinsic direction from the intrinsic direction of the motion of the moved mover that is causing the motion because, in forced motions, the thing moved is compelled to move with the same motion as the moved mover.

Aristotle tells us that the class of genuine changes divides without remainder into the disjoint sub-classes of natural and unnatural changes: Every change is either natural or unnatural,[50] and, presumably, no changes are both natural and unnatural and no changes are neither natural nor unnatural. From the fact that Aristotle often either glosses unnatural change as forced change or offers being forced as a sufficient condition for a change being unnatural,[51] I infer that a change is unnatural if and only if it is forced. It is apparent that forced changes, in Aristotle's view, are incomplete actualities of activities which are not essential, proper, and non-accidental to their subjects, *and* that have an external efficient cause.[52] From this, it follows that unforced, i.e., natural changes, are incomplete actualities of activities which either *are* essential, proper, and non-accidental to their subjects (i.e., have natures as their principles), *or* which have an internal efficient cause, *or* both. Natural or unforced changes that have natures as their principles will get their intrinsic direction, as Broadie suggests, from the normative status of their goals,[53] and this class of changes will include as a subset

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50 *Ph* VIII 4, 255b31-2, *Cael* II 13, 295a3-4, III 2, 301b19-20

51 *Ph* V 6, 230a29-30, VIII 4, 254b13-14, 255a29, b32-3, *Cael* III 2, 301b21-2; *Rhet* I 11, 1370a9

52 *Ph* V 6, 230a29-b9, VIII 3, 253b34-5, VIII 4, 255a2-3, b32-3

53 This will include changes that have efficient causes that are external to the subject of change as well as ones that have internal ones like nutrition and growth since the natural motions of simple bodies have external efficient causes as well as natures as their principles, i.e., principles of being changed in their character-

unforced changes that are for the sake of something. The only sort of natural or unforced change that does not have a nature as its principle would appear to be self-changes that are due to τέχναι, as in the case of the self-healing doctor.[54] But this type of change, as I said, will get its intrinsic direction from the characteristic product of the τέχνη together, perhaps, with the intention of the craftsman to either bring about this product or its privation.

As *Physics* V 6 claims, the remaining class of genuine or non-accidental changes that are forced or unnatural sub-divides into those in respect of place, substance, quantity, and quality. Of these, it is evident that the latter three, according to Aristotle, instantiate the transmission theory of causation, and therefore get their intrinsic directions from the agent or efficient cause that imposes a goal upon a change by transmitting a form to the patient. This follows from the fact that the transmission theory of causation applies to all changes, whether natural or forced, insofar as they involve distinct agents and patients, and the transmission of a form from an agent to a patient. Since, as Aristotle insists in *Physics* VIII 4, everything that is changed is changed by something, every change should involve a distinct agent and patient. Aristotle's discussions of substantial change in *Metaphysics* Z 7-9[55] and alteration in

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istic ways (In *Physics* VIII 4, 255b24-6a3, Aristotle tells us that τὰ κοῦφα καὶ τὰ βαρέα, which I take to be the simple bodies, have principles of motion, but 'not of moving something or causing motion' (οὐ τοῦ κινεῖν οὐδὲ τοῦ ποιεῖν) but of suffering it (τοῦ πάσχειν). Since Aristotle defines a nature in at least one place (*Ph* II 1, 192b21-2) as 'a principle or cause of *being moved* and of being at rest (ἀρχῆς τινὸς καὶ αἰτίας τοῦ κινεῖσθαι καὶ ἠρεμεῖν),' I think it is plausible to assume that the 'principles of being moved' in *Physics* VIII 4 are the natures of simple bodies. (ἀρχὴ τοῦ κινεῖσθαι, at 192b21, is morphologically either middle or passive, but is most likely meant as passive. See Helen Lang, *The Order of Nature in Aristotle's Physics* (Cambridge: Cambridge University Press 1998), 40 ff.)). We are also told, in *Physics* VIII 4, 255b24-6a3, that τὰ κοῦφα καὶ τὰ βαρέα 'are moved either by that which brought [them] into existence and made [them] light and heavy, or by that which released what was hindering and preventing [them],' i.e., they are moved by external efficient causes.)

54 Aristotle claims that τέχναι are capacities rather than natures. See *Ph* II 1 and *Metaph* Δ 12 and Θ 8 on the distinction between capacities and natures. Whereas the agent and patient are essentially related in self-changes due to natures, they are only accidentally related in self-changes due to capacities.

55 In the generation of a man by a man, or more generally, in non-spontaneous biological generation, the parent organism creates another organism of a synonymous type by transmitting a substantial form that it already possesses in actuality to the

Generation and Corruption I 7[56] make it clear that these types of change, as such, involve the transmission of form. Aristotle's remark at the end of *Physics* III 2 that 'the mover will always transmit a form,' which may be a 'so much' as well as 'a this' or 'a such' seems to imply the same for changes in size, although, if one surveys the applications of this principle to growth and diminution scattered throughout the corpus, the transmission itself appears to enter indirectly into the process and not always in the same manner for different types of growth and diminution. By 'indirectly', I mean that, unlike the case of alteration, a thing does not become larger or smaller by somehow receiving a larger or smaller quantitative form directly from an agent. In growth and diminution, rather, a thing becomes larger or smaller as a concomitant to the transmission of some qualitative or substantial form in the processes of

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matter of generation (*Ph* III 2, 202a9-10; *GC* I 5, 320b19-20; *GA* I 22, 730b19-23, II 1, 734a30-1, 735a20-1; *Metaph* Z 7, 1032a24, Z 8, 1033b31-2, 1034a4-5, Z 9, 1034b17, Θ 8, 1049b25, 29, Λ 3, 1070a5.). In *Metaphysics* Z 7-9, the principle is also applied to generation by a τέχνη, so that a craftsman (the agent) creates an artifact (the patient) with a form that is synonymous with the form of the τέχνη he possesses in potentiality by transmitting this form to the materials out of which the artifact is built. (The craftsman's τέχνη may also be considered an efficient cause. cf. *Metaph* Λ 3, 1070b28-30. See also *GA* I 22, 730b14-9; *Metaph* Z 7, 1032b11-17, Z 9, 1034a23-30, 1034a33-b4, Λ 3, 1070a29-30, 1070b33.)

56 In alteration, an agent produces a property in a patient by transmitting a synonymous qualitative form to the patient that the agent already possesses, either in actuality or in potentiality. If the effect is produced by a τέχνη, then the transmitted form must pre-exist potentially in the soul, e.g., health in the body is produced by the form of health or the medical τέχνη pre-existing potentially in the soul (*Metaph* Z 7, 1032b11-17, Z 9, 1034b18-19, Λ 3, 1070a29-30, b28, b33.). If the effect is not produced by a τέχνη, then the synonymous qualitative form must pre-exist in actuality (*Ph* III 2, 202a9-12, VIII 5, 257b9-12; *GC* I 7, 323b29-4a14; *DA* II 5, 417a17-20, II 12, 424a17-24; *Metaph* A 1, 993b24-6.). One of Aristotle's favorite examples of the transmission of qualitative form is the phenomenon of one object heating or cooling another (See e.g., *GC* I 7, 324a10-24, cf. 324b11-2.). It is interesting to note that Aristotle has spotted, here, the same temporal asymmetry that we would account for with the Second Law of Thermodynamics, and which is invoked in a number of modern reductive theories of temporal direction: the fact that bodies in contact tend to heat or cool each other until the temperature of both bodies is equalized. It is also interesting to note that Aristotle seeks to explain decay, which we also explain by means of the Second Law of Thermodynamics, as a process of desiccation and cooling (See *Long* 5, 466a17-b2, *Juv* 23, 479a8-23, *GA* V 1, 780a14-22, V 3, 783a34-b10, V 4 *passim*.). Since desiccation is explicable as a concomitant to the active power of cooling (*GC* II 2, 329b24 ff.), this makes the asymmetry of decay ultimately explicable by Aristotle's transmission theory of causation.

combustion, nutrition, mixture, heating or cooling.[57] Nonetheless, since the ultimate causal mechanism for growth and diminution can invariably traced to some transmission of form, the intrinsic direction of this type of change can ultimately be explained by the transmission theory of causation.

Locomotion, as I said, does not seem to involve the transmission of form, so instead of invoking the transmission theory of causation to

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57 The transmission of qualitative form, for instance, can indirectly result in growth by rarefaction, since rarefaction is a concomitant (*Metaph* Z 9, 1034a34-b1) of the transmission of the qualitative form heat to air (the patient) by something that is hot (the agent). (*Ph* IV 9, 217b8-10. cf. *Topics* VI 8, 146b20-35; *Mete* I 3, 340a25-b3, I 4-5 passim, II 8, 367a20 ff. Cf. also *Ph* VII 3, 246a4-9 which imply that rarefaction and condensation do not require elemental transformation.) The transmission of a substantial form, on the other hand, can also indirectly result in growth by accession of matter, which, may take the form of organic growth, as in the growth of a biological organism, or inorganic growth, as in growth resulting from mixture or combustion. Natural generation and growth by the accession of matter are kindred processes in the respect that each involves the transmission of a substantial form to a substrate that does not survive the transmission, (*GC* I 5, 322a6) and in fact, the same faculty transmits the substantial form in both generation and growth in ensouled beings (*DA* II 4, 416a19, *GA*, II 1, 735a16-19). But whereas in natural generation, the transmission of the substantial form is the change in question, in growth by accession of matter, it *results* in the change in question. In growth by accession of matter, a substance, whether organic or inorganic, grows by transmitting a substantial form that it already possesses in actuality to τροφή, so that the τροφή, having taken on this form, accedes to the growing substance. (*Ph* III 2, 202a9-12, 'That which is increased, although in a sense it is increased by what is like itself, is in a sense increased by what is unlike itself: thus it is said that contrary is nourishment to contrary; but one thing gets attached to another by becoming like it.' (*Ph* VIII 7, 260a30-2); cf. *GC* I 5, 322a3-4 and *DA* II 4, 416b4-8 for organic growth.) In organic growth by accession of matter, a soul (the agent) grows its body (the patient) by transmitting the substantial form of flesh to τροφή (the instrument), so that the τροφή, having become flesh, accedes to the body. (The nutritive soul has an 'ἀρχή of growth'. See *GC* I 5, 321b6-7, 321b33-2a16; *DA* II 4, 416a19 ff., cf. *Ph* VIII 5 on instruments/moved movers.) Inorganic growth by accession of matter can result from either mixture or combustion. In the former case, e.g., the growth of wine, this occurs when the wine (the agent) transmits the substantial form of wine to water (the patient), so that the water, having become wine, accedes to the wine (*GC* I 5, 321a35-b2, 322a9-10, I 10, 328a24-8). In the latter case, the growth of fire occurs when the fire (the agent) transmits the substantial form of fire to wood (the patient), so that the wood, having become fire, accedes to the fire (*GC* I 5, 322a10-11, 14-16, II 8, 335a16-18; *Mete* II 2, 355a3-5; *DA* II 4, 416a10-12, 25-7. To be precise, Aristotle thinks that it is the water in the wood that is the τροφή for fire.).

explain the intrinsic direction of forced locomotion, Aristotle invokes the principle that forced locomotion invariably, and perhaps even by definition, requires the thing moved to be moved with the same locomotion as the moved mover that moves it. This is entailed by the requirement in *Physics* VII 2 that the moved mover and the thing moved in a forced locomotion be in contact as long as this motion is in progress, so that the moved mover must accompany the thing moved throughout its motion. This doctrine is also the basis for Aristotle's claims in the same chapter that all forced locomotion can be reduced to pushing and pulling and that the locomotions of the moved mover and the thing in forced motion start and end simultaneously.[58]

So in general, the intrinsic direction of a forced locomotion of a thing will derive from the motion of the moved mover that forces it to move, and this motion, in turn, will be either natural or forced. If it is natural, then its intrinsic direction, as well as the direction of the forced locomotion it causes will derive from either a nature or a τέχνη. If it is forced, then its motion will derive from the motion of the moved mover that forces *it* to move, and this motion, in turn, will be either natural or forced. *Physics* VII 1 and VIII 5 tell us that every chain of moved movers and things forced to move by them must terminate in an unmoved mover, and *De Caelo* III 2 tells us that every chain of forced locomotions must terminate in some natural locomotion.[59] Thus, for instance, a soul can move a limb, which will be the first moved mover in some series of movers and things forced to move, or a natural elemental locomotion

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58 *Ph* II 3, 195b16-20 and VIII 10, 266b33-267a2. Cf. *Cael* I 2, where Aristotle claims 'By force, of course, [a simple body] may be brought to move with the motion of something else different from itself ...' (269a7-9). While this passage, by itself, does not imply that in all cases of forced locomotion, what is moved takes on the motion of what moves it, this is nonetheless implied by the requirement of contact and the reduction of forced locomotion to pushing and pulling in *Physics* VII 2 [under which, presumably, even forced motions such as 'being squeezed out' (τὸ ἐκθλίβεσθαι, see e.g., *Mete* I 4, 342a9-10) can be subsumed].

59 In *Cael* III 2, Aristotle argues that there can be no truly disorderly change, as Plato describes in the *Timaeus*, because every chain of constrained causation must terminate in some natural change. 'If there is no ultimate natural cause of change and each preceding term in the series is always moved by constraint, we shall have an infinite process' (300b14-15): '... a finite number of causes would produce a kind of order, since absence of order is not proved by diversity of direction in changes' (301a1-3).

can initiate a similar causal change by forcing some other substance to move contrary to its nature.[60]

Finally, projectile motion, as a species of forced locomotion, appears to proceed by means of, as Sorabji calls them, a series of 'no-longer-moved movers',[61] viz., portions of air that take up the action of the first mover after it has lost contact with the projectile.[62] *De Caelo* III 2 claims that, at least in the case of upward and downward projectile motions, the air does this *qua* light and *qua* heavy. The idea seems to be that since air can be, by nature, either heavy or light, depending on whether it is cool or hot respectively, it can either propel something upward if it is hot, or downward if it is cool. So once the projectile has left the grip of the first mover, upward and downward projectile motion will derive its direction and intrinsic asymmetry from the natural upward or downward motion of the air. There are obviously many problems with this 'theory',[63] not the least of which is the issue of how it is supposed to generalize beyond upward and downward projectile motion, but we are concerned, here, more with Aristotle's intentions than whether he had a successful theory of projectile motion. The point for our purposes is that Aristotle seems to try to explain projectile motion as somehow forced upon the projectile by the natural motion of the medium through

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60 Cf. *MA* IV, 700a15 ff 6, 700b10ff. which claims that living things are the ultimate source of all change. See also *DA* III 12, 434b22-5a10 which describes chains of locomotions and analogous chains of alterations.

61 R. Sorabji, *The Philosophy of the Commentators: 200-600 AD, A Sourcebook, Volume 3, Logic and Metaphysics* (London: Duckworth 2005), 351

62 See *Ph* VIII 10, esp. 267b12-3, and *Cael* III 2, 301b22-30.

63 For example, as Sorabji points out, there is the question why air should sometimes impede projectile motion (e.g., see *Physics* IV 8, 215a28 ff.) and sometimes aid it and what this has to do with the air being hot or cool. There is also the question of how this is supposed to square with the denial in *Physics* VIII 4 that the elements are self-movers. Philoponus justly ridicules the theory on the ground that if air pockets really had such a power, they should manifest it in the absence of a thrower, but they do not, even if ten thousand bellows were to brought to bear on the projectile. (Philoponus, *in Phys* 641,13 ff.) In fact, this 'theory' of projectile motion is so obviously unsatisfactory that at least one modern commentator has argued that it isn't a theory at all, but a statement of 'certain general constraints which any theory [of projectile motion] will have to satisfy' (Edward Hussey, 'Aristotle's Mathematical Physics: A Reconstruction', in Lindsay Judson, ed., *Aristotle's Physics: A Collection of Essays* (Oxford: Oxford University Press 1991), 213-242, 231).

which it passes, and this makes the intrinsic direction of projectile motion ultimately derivable from this natural motion.

III

So every change, as a change, is intrinsically asymmetric by definition, but as the particular type of change that it is, the ultimate explanation of this asymmetry rests on one or another of Aristotle's causal principles: either natures, the transmission theory of causation, or the requirement that the last mover in a forced locomotion must remain in contact with the thing moved as long as the locomotion is in progress. This ensures that when Aristotle derives the direction of time from the direction of change, it does not result in a vicious circularity. But it does not ensure that there is a single, unique time line with a globally consistent direction, and in fact, Aristotle's manner of deriving the before and after in time would seem to suggest that it does not. If each change has its own before and after that is defined by the particular goal state for which it is an incomplete actuality, and the before and after in time is derived from these befores and afters in change, what is to prevent the derivation of a distinct before and after in time from each change? Or more generally, if time is the 'number of change in respect of the before and after',[64] if every 'before and after in change' is, in and of itself, only relative to the goal states of particular changes, and there are no changes apart from particular changes,[65] then there might be a time for every change. Aristotle recognizes this danger himself in the following passage:

> But other things as well may have been changed now, and there would be a number of each of the two changes. Is there another time, then, and will there be two equal times at once? Surely not. For a time that is both equal and simultaneous is one and the same time, and even those that are not simultaneous are one in kind. (*Ph* IV 14, 223b1-4)

The last line, here, heads off the possibility of multiple simultaneous times by claiming that if two times are equal and simultaneous, then

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64 *Ph* IV 11, 219b2

65 *Ph* IV 10, 218b10 ff.

they are one in number. (And apparently, if the times are just equal, i.e., of equal duration, but not simultaneous, they are one in kind.) Aristotle repeats this claim at *Physics* IV 11, 219b10 but drops the ἴσος και because, in this passage, he is talking about 'nows', which are duration-less: 'every simultaneous time is the same'. What Aristotle gives us, here, are criteria of identity that allow us to identify nows as well as temporal periods derived from different changes: the simultaneity of nows; the simultaneity and equality of temporal periods.

But one might think there is something odd about these criteria. One does not usually speak of times as simultaneous. One usually speaks of changes or stages of changes as simultaneous. One way to deal with this oddness is to claim that Aristotle misspoke, and meant to say that if two *changes or stages of changes* are simultaneous, then they are at one and the same time.[66] But this, in addition to making Aristotle implausibly careless by misspeaking twice, takes his criteria of identity for times and turns them into useless tautologies. A better option, I think, is to find an interpretation for the word 'time' that makes the claim less odd, and there is a straightforward way to do this for the formulation of the criterion at 219b10 where 'times' are to be construed as 'nows'.

In *Physics* IV 11, Aristotle makes the following claim twice: ᾗ ... ἀριθμητὸν τὸ πρότερον καὶ ὕστερον τὸ νῦν ἔστιν.[67] There are two philosophically significant options for interpreting this sentence. One option is to take it to claim that the now's existence or being what it is somehow depends on the countability of the before and after in change, e.g., 'it is insofar as the before and after [in change] is countable that the now is [what it is].'[68] Another option is to take the sentence to identify the now with the before and after in change considered as countable, e.g., 'the now is the before and after [in change], considered as count-

66 See, e.g., Ursula Coope, *Time for Aristotle,* 114.

67 *Ph* IV 11, 219b23-8

68 This is Coope's translation (Ursula Coope, *Time for Aristotle,* 128). Coope reads an implied ἔστιν in the relative clauses starting with ᾗ where τὸ πρότερον καὶ ὕστερον is the subject and ἀριθμητὸν is the predicate, and the predicate of ἔστιν in the main clause is also implied i.e., [what it is]. But since the upshot of Coope's interpretation is that 'every now that we count *is* a potential division in the before and after in some change or other' (my emphasis) Hussey's translation of 'the now is the before and after [in change], considered as countable' is not only consistent but more to the point. (cf. 223a28: χρόνος δὲ ταῦτ' ἐστὶν ᾗ ἀριθμητά ἐστιν).

able.'[69] Taking the sentence in the latter way makes the claim that 'all simultaneous times are the same' less odd because it *does* claim the simultaneity of stages of changes, since, on this interpretation, nows just *are* momentary stages of changes under a certain description. It also makes good philosophical sense, because, if understood in this way, Aristotle's criteria of identity give us the ability to make informative identity statements about nows derived from different changes. Suppose, for instance, that Socrates walks between points A and B, that Coriscus walks between points C and D, and that 'P', 'Q', 'R', and 'S' denote the momentary kinetic stages Socrates being at point A, Socrates being at point B, Coriscus being at point C, and Coriscus being at point D respectively. If we know that stages P and S are simultaneous, then we know that stage P *qua* countable and stage S *qua* countable are different descriptions of the same now, even though the kinetic stages they refer to are elements of distinct, spatially distant changes. In fact, we know this to be true of *any* two simultaneous kinetic stages, no matter how spatially remote they are, because 'the same time is *everywhere* simultaneously.'[70]

This, I believe, is how Aristotle uses the concept of simultaneity to argue for a single, unique timeline. The criteria of identity allow us to collapse, in effect, any simultaneous time lines into one, and the fact that 'the same time is *everywhere* simultaneously' makes sure that no time lines escape the reach of simultaneity. But one might still wonder whether this single, unique time line also has a unique and globally consistent *direction*. Or put another way, if the direction of time is derived from the direction of a plurality of changes, and each change has its own direction that is defined by the particular goal state for which it is an incomplete actuality, what is to prevent these kinetic directions from being inconsistent and resulting in inconsistent directions of time? Coope, for instance, asks, 'What then, is to prevent its turning out that P is before Q in one change, R is before S in another change, but that P is simultaneous with S and Q is simultaneous with R?'[71] My answer, on behalf of Aristotle, is that if the before and after in time follows the before and after in change, if 'every simultaneous time is the same', and if times are simultaneous if and only if they are neither earlier nor later

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69 This is Hussey's translation (*Aristotle's Physics III & IV,* 45).

70 *Ph* IV 12, 220b5-6

71 Ursula Coope, *Time for Aristotle,* 79

than one another, as Aristotle implies in *Physics* IV 10 and *Categories* 13,[72] then a logical contradiction results from these assumptions: Since the before and after in time follows the before and after in change, corresponding to kinetic stages P, Q, R and S there will be nows *p*, *q*, *r* and *s*, such that *p* is earlier than *q*, *r* is earlier than *s*, *p* is simultaneous with *s*, and *q* is simultaneous with *r*. Since 'every simultaneous time is the same', then *p* = *s* and *q* = *r*. But if *q* = *r* and *p* is earlier than *q*, then *p* is earlier than *r*. But since the *earlier than* relation is transitive, and *p* is earlier than *r*, and *r* is earlier than *s*, then *p* is earlier than *s*. But if *p* is earlier than *s*, and if times are simultaneous if and only if they are neither earlier nor later than one another, then *p* cannot be simultaneous with *s*. But we have already deduced that *p* is simultaneous with *s*, so a logical contradiction results.

What this shows, quite generally, is that if the before and after in time is to be derived from the before and after in change by means of a structure-preserving mapping, and the before and after in time is a strict simple or linear order described by an *earlier than* relation,[73] then the before and after in change must be a simple order that is describable by a *prior to or simultaneous with* relation.[74] Coope's example violates the requirement that the before and after in change is a simple order

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72 *Ph* IV 10, 218a25-6, *Cat* 13, 14b24-6

73 In order for the before and after in time to be a strict simple or linear order, the *earlier than* relation that orders it must be transitive, asymmetric, and connected. According to the standard definitions of these properties, the *earlier than* relation is transitive if and only if: if *x* is *earlier than y*, and *y* is *earlier than z*, then *x* is *earlier than z*; the *earlier than* relation is asymmetric if and only if: if *x* is *earlier than y*, then *y* is not *earlier than x*; the *earlier than* relation is connected if and only if: if *x* is neither earlier nor later than *y*, then *x* = *y*. Another familiar example of a strict simple or linear order is the domain of the real numbers ordered by the *less than* relation.

74 In order for the before and after in change to be a simple order, it must be ordered by a *prior to or simultaneous with* relation that is transitive, antisymmetric, and strongly connected. According to the standard definitions of these properties, the *prior to or simultaneous with* relation is transitive if and only if: if *x* is prior to or simultaneous with *y*, and *y* is prior to or simultaneous with *z*, then *x* is prior to or simultaneous with *z*; the *prior to or simultaneous with* relation is antisymmetric if and only if: if *x* is prior to or simultaneous with *y* and *y* is prior to or simultaneous with *x*, then *x* is simultaneous with *y*; the *prior to or simultaneous with* relation is strongly connected if and only if, for every *x* and *y*, either *x* is prior to or simultaneous with *y* or *y* is prior to or simultaneous with *x*. A familiar example of a simple order is the domain of the real numbers ordered by the *less than or equal to* relation.

by contradicting the transitivity of the *prior to or simultaneous with* relation.[75] Intuitively, if transitivity does not hold for the priority of the stages of different kinetic series related by simultaneity relationships, then neither will it hold for the priority of the series of nows which arises from mapping these simultaneous series onto a single time line. Similarly, if the relation ordering the elements of the kinetic series from which the temporal series derives is not strongly connected, i.e., if it is not the case that any two kinetic stages from any single change or pair of changes stand in either a relation of priority or simultaneity, then neither will the relation ordering the series of nows which arises from mapping these simultaneous series onto a single time line be connected (and we will not be able to infer the simultaneity, and therefore, the identity of nows that are neither before nor after each other). So if the relation ordering the before and after in time is connected, the relation ordering the before and after in change must be strongly connected. Why assume that the relation ordering the before and after in time is connected? Common sense, I suppose, since the two assumptions that entail this connectedness seem axiomatic: the assumption that 'every simultaneous time is the same', and the assumption that times are simultaneous if and only if they are neither earlier nor later than one another.

The requirement that the relation ordering the before and after in change be strongly connected implies that being neither before nor after in change is a sufficient condition for simultaneity. But we can readily see why Aristotle could not have taken being neither before nor after in change to *constitute* simultaneity,[76] since if he did, then simultaneity

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75 If P is prior to Q, R is prior to S, P is simultaneous with S, and Q is simultaneous with R, we can deduce that P is prior to or simultaneous with Q, Q is prior to or simultaneous with R, R is prior to or simultaneous with S, and S is prior to or simultaneous with P, but if the relation *prior to or simultaneous with* is transitive, then S is prior to or simultaneous with R, but this is incompatible with the claim that R is prior to S. So transitivity for the *prior to or simultaneous with* relation fails on Coope's example.

76 Leibniz and Reichenbach take such an approach, by defining 'earlier' and 'later' in non-temporal terms, and then defining (rather than describing, as Aristotle does) the simultaneity relation as the relation of being neither earlier nor later. In causal theories of time like Leibniz' and Reichenbach's, simultaneity is reduced to 'the exclusion of causal connection'. See Hans Reichenbach, *The Philosophy of Space and Time* (New York: Dover 1958), 145; Leibniz's definition of simultaneity is 'not qualified by incompatible circumstances,' but it is clear that 'qualified by incompatible

would end up being either intransitive or incoherent. Since the stages in a change are, in and of themselves, 'before and after' only relative to the goal state of the particular change that they are in, then in and of themselves, every stage of every change would be simultaneous with every stage of every other change. But if two stages are related by being before or after in the same change, and are both neither earlier than nor later than, and therefore simultaneous with, some third kinetic stage that is not a part of this change, then by the transitivity of simultaneity, they also must be simultaneous with each other, which conflicts with the original hypothesis. The only way out of this problem is to suppose that kinetic stages are neither before nor after in change if *and only if* they are simultaneous and to take simultaneity to be a primitive fact that is underivable from any others. Since the success of Aristotle's derivation of the before and after in time from the before and after in change requires this assumption, one must suppose Aristotle made it, and the commentators are unanimous that, in fact, he did.[77]

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circumstances' includes being related as cause and effect. See 'Metaphysics Foundations of Mathematics', in Philip P. Wiener, ed. and trans., *G.W. Leibniz, Selections* (New York: Scribner's 1951) 201-216, 201-2.

77 Ursula Coope, *Time for Aristotle,* 4; David Bostock., 'Aristotle's Account of Time', 164; Sarah Broadie (Waterlow), 'Aristotle's Now', 111; Michael Inwood, 'Aristotle on the Reality of Time', in Lindsay Judson, ed., *Aristotle's Physics: A Collection of Essays* (Oxford: Oxford University Press 1991) 151-178, 168