Aristotle on Growth: a Study of the Argument of On Generation and Corruption I 5[1]

Inna Kupreeva

Aristotle's chapter on growth is not among everyone's favourites: it is full of textual and grammatical uncertainties and elliptical arguments, which have provoked a few unflattering remarks from its commentators, ancient and modern.[2] Yet I think it deserves a closer look, because its

1 The first short draft of this paper was given at the APA Central Division meeting in Chicago, 2001. I am grateful to my commentator Mary Louise Gill, to the audience, especially Cynthia Freeland, Victor Caston, and Paul Woodruff for helpful discussion, and to Brad Inwood and Bob Sharples for their comments. Later version benefited from comments by Richard Sorabji and Jim Hankinson. It was not until this paper was finished and accepted for publication that I was able to read Alan Code's chapter in the recent volume of the *Symposium Aristotelicum*, so it was too late for me to take a full account of it (but I am grateful to the author and Frans de Haas for providing me with a copy in advance of publication). Special thanks are owed to Sir John Boardman for his generous help with 'skeletons'. I am responsible for any errors. Translations are mine where not indicated otherwise.

2 E.g. Joachim, *ad* 20a10-2a33: 'The first part (20a10-b34) contains a preliminary and somewhat confused treatment of both topics (viz., the difference of growth from coming-to-be and alteration and the way in which growth takes place — *author*) Thus, the difference of αὔξησις from γένεσις and ἀλλοίωσις is considered, but not adequately stated (20a10-27); and there is an obscure and unsatisfactory discussion whether (and if so, in what sense) the matter out of which things grow is potentially μέγεθος (*20a27-b34).' Cf. C.J.F. Williams 1982, 103 (ad 320a8), and *passim*. Alexander, according to Averroes, accused Aristotle of failing to state a solution to the problem in the demonstrative form. (Averroes, *On Aristotle's* De generatione et corruptione: *Middle Commentary and Epitome*. Trans. S. Kurland. Cambridge, MA 1958, 34.)

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account of form and matter can provide some interesting links between the general theory of change and the theory of substance in Aristotle's natural philosophy and metaphysics.

It is often thought that the concept of 'form-substance' in the *Metaphysics* is a philosophical figure of speech, standing for what a less rhetorically minded thinker of today would call an 'essential property'. The substantial status of form thus understood is due to its conceptual or causal priority, but not to a 'real' priority in the ontological economy of the *Metaphysics*.[3] For form, however indispensable as a cause and a rational account of a thing's being, exists only as a property of a real individual thing. The concept of form originates in the analysis of change in *Physics* I, where matter stands for a continuant, and form for a replaceable instance of a kind with respect to which change happens. 'Form-substance' is a hybrid concept, like 'thing-property'. It is neither sound nor necessary: its functions can be fulfilled no worse by the notion of form as a causally relevant aspect of a thing.[4]

This interpretation of Aristotle's ontology is quite credible. It offers a satisfactory answer to the question of 'what there is', without running into Platonic difficulties with postulating some supernumerary entities only to reduplicate the set of real individuals. But there is one respect in which this interpretation may find itself question-begging, and in which the notion of form may still retain importance credited to it by a less nominalistic reading of the *Metaphysics* Z. It has to do with what we might call the diachronic dimension. The fact that Aristotle's paradigmatic substances in the natural domain are living beings has been widely appreciated by modern scholars. But living beings are not static things; rather they are dynamic entities which constantly exchange matter with their environment, and are changing all the time in many ways. Any individual living being, taken diachronically, is a succession of states involved in many processes of change. What allows us to regard it as a thing rather than a series of events is a certain ontological mechanism by which it retains its 'whatness' throughout all changes. The idea of matter as a continuant, even if it were a correct interpretation of Aristotle's theory of change, clearly would not do to explain persistence in this case.

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3 For the defence of 'conceptual priority', see Gill 1993; for the defence of 'causal priority', see Granger 1997, 111-58.

4 See in particular Granger 1997, Chapter 7, 133-58.

In fact, Aristotle's analysis of growth shows that he would rather identify form — a persistent sensible structure and a functional principle of a living being — as a real continuant in the metaphysically relevant sense. This is the viewpoint I would like to suggest with the following analysis.

The genre of this paper is analytical rather than polemical. My primary goal is to provide a reading of the whole of Aristotle's chapter that would reconstruct its argument, assuming its coherence and agreement with the main points of Aristotle's natural philosophy. This task has been marked as outstanding in the existing commentaries on the text. I will not undertake a decisive argument about the concept of substance in Aristotle's physics: this would not fit either the size or the format of the paper. Still it should be possible to establish some points which taken together can form an interesting and defensible view of form as substance. The philosophical position that thus emerges does not have to disagree with the thesis of the priority of individuals with respect to forms as universal principles and concepts. However, it will almost certainly disagree with the view of sensible forms as properties ontologically dependent on the individuals in which they inhere. What it suggests instead is the notion of natural form as a persistent sensible structure carrying the functional principle and underlying the material components and properties of an individual.[5]

Two parts can be distinguished in the argument of *GC* I 5 that display some differences in the focus of reasoning and are bridged by a characteristic 'fresh start'. In the first part, Aristotle compares growth with other kinds of change (320a10-27), and examines the hypothesis according to which an increase of volume happens by virtue of something that is actually incorporeal but potentially a body (320a27-b34). The main point of his argument is that the matter of growth cannot be separate from things and their properties. I discuss this argument in sections 1 and 2 of the paper. In the second part, after a 'fresh start', (320b34-21a2), Aristotle fine-tunes the concepts to be used, formulates methodological principles (321a2-b10), and outlines his solution of the problem of the nature of growth which involves the form/matter analysis of the body undergoing growth (321b10-22a34). This part is covered by sections 3, 4 and 5.

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5 Cf. Frede 1985.

1 The Manner of Change

Aristotle begins with the question whether growth is different from other kinds of change only in category, or whether there is also difference in the 'manner' of change. The kinds of change (he uses the term μεταβολή which subsumes both substantial and non-substantial change, cf. *Ph* V 1) are distinguished by category — generation is in respect of *substance* (τόδε, οὐσία), growth of *magnitude* (μέγεθος); alteration of an affection (πάθος). The category of change is the one to which its *termini* belong.[6] The process which takes place between the *termini* must have an adequate description, specific enough to capture the categoreal mode of being of the *termini*. This description is to be captured by the notion of 'manner' (τρόπος) of change. The 'manner' in which, for instance, locomotion happens always involves a change of place. But the 'manner' of qualitative alteration does not always involve a change of place, and sometimes does not even involve a time interval between the two states.[7] There must be a certain kinetic pattern that characterises growth as a process of change.

> For obviously that which is being altered does not necessarily change place, nor that which comes to be; but that which grows and diminishes in size [does so], yet by a manner different from that which is carried. For that which is carried (φερόμενον) changes a place as a whole, while that which is growing as [some metal] being beaten. For it is while it remains [stable] that its parts undergo the change of place, though unlike those of a [rotating] sphere: for in this latter case, the parts change to equal place while the whole remains, but the parts of the growing thing always [change to] a larger place, and of a thing diminishing in size, to a smaller. (320a17-25).

That the terms of such a description those of locomotion should not surprise us: the close relation between the mode of being and the characteristic pattern of motion stated in basic terms in Aristotle's system has teleological grounds.[8]

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6 Cf. Waterlow 1982, 105-6.

7 See a recent discussion in Heinaman 1998.

8 Cf. the argument for the priority of locomotion in *Ph* VIII 7, on growth, in particular,

In *Physics* IV 4, growth (together with its opposite of diminution) is consistently treated as one of the two kinds of movement with respect to place (another one being the linear movement of translation).[9] The difference between growth and linear movement is that in the latter case a thing as a whole changes its location, while in the former case the boundaries of a thing do change, but we cannot say that a thing goes anywhere. In this sense it is like a piece of metal that is being beaten by a smith.

Philoponus has pointed out that the analogy is not complete: while in the case of beaten metal one can talk about increase in two dimensions, with simultaneous diminution in the third one, in the case of growth there is a steady increase in all the three dimensions.[10] At this point Aristotle seems to be trying to work out a distinction between the kinetic pattern of growth and those of other types of change with the help of the two-dimensional concept of place. In locomotion, the two-dimensional place of a moving thing does not change its shape nor size, but there is a 'global' change of location by a whole thing which can be accounted for by the complete replacement of a container which constitutes the place of a moving thing. In the beaten metal example, as in the case of growth, there is no complete replacement of container; instead there are multiple partial changes, in the former case, due to a change in both shape and size, in the latter case, due to a change in size only.

260a20-b6. Note also the wording of the distinction between things that have soul and the ones that are soulless in *de An* II 2, where Aristotle speaks about the movement of nourishment, as 'decrease and growth' (413a25: κίνησις ἡ κατὰ τροφὴν καὶ φθίσις καὶ αὔξησις), adding that it is the movement in all directions that makes all growing things appear to be living. Cf. also the role of kinetic pattern in the hierarchy of beings in *Cael* II 12. None of this implies any sort of 'reduction' to locomotion, which would be quite uncharacteristic of Aristotle, as S. Broadie rightly points out (Waterlow 1982, 99). The idea rather seems to be that different 'natural' kinds of motion have distinct corresponding kinetic patterns.

9 *Ph* IV 4, 211a14: ταύτης δὲ [scil. τῆς κινήσεως τῆς κατὰ τόπον] τὸ μὲν φορά, τὸ δὲ αὔξησις καὶ φθίσις.

10 See Philoponus *in GC* 71, 26-31 Vitelli. Philoponus' remark probably builds on Aristotle's own amendment to this illustration, a few lines below (320a24-5). Jim Hankinson points out to me a possible connection between Philoponus' remark and Galen's analogy between the process of growing and balloon-blowing in *nat fac* I 7 (112,23-113,15), II 3 (164,1-5 Helmreich); for further discussion of this analogy, see Kupreeva 2004a, 80.

Aristotle goes on to compare locomotion caused by growth with axial rotation, where there is no 'global' replacement of container either (the 'socket' enclosing the rotating sphere remains the same). The two-dimensional surface of a sphere does not change in either size or shape, and only its parts change their location relative to the inner surface of the 'socket'.

The process of growth does involve change in size; a growing thing proceeds to occupy greater place.[11] But comparison with rotation might suggest some kind of regularity not present in the case of beaten metal: growing thing retains its shape, and the change of growth equally affects each of its perceptible points (this will become important in the subsequent description of the process of growth).

2 Problems With Potential Magnitude

The main *aporia* of the first part of Aristotle's discussion has to do with the nature of the general kind with respect to which the change of growth happens. Aristotle asks whether it is possible to think of a body and magnitude as coming to be from something which is potentially a magnitude and a body, but actually incorporeal and sizeless.[12] The concept of 'potential magnitude' is a systematic construction based on the general principle of the theory of change, according to which any F comes to be from something that is potentially F but actually not F.[13] Substituting a general concept of 'magnitude' for 'F' one would have to say that any magnitude comes to be from something that is potentially a magnitude, but actually not a magnitude. Thus, a superficial reading of the principle of change might render the notion of the matter of growth paradoxical.

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11 C.J.F. Williams, translating τόπος at 320a23-4 by 'space', aptly points out that the Greek word, unlike its English equivalent, can be treated as a mass-term. Nonetheless it is not clear to me that the context requires specifically three-dimensional place: increase and decrease of surface could do as well.

12 320a29: πότερον ἐκ δυνάμει μὲν μεγέθους καὶ σώματος, ἐντελεχείᾳ δ' ἀσωμάτου καὶ ἀμεγέθους γίνεσθαι σῶμα καὶ μέγεθος;

13 Cf. *Ph* I 7, 189b30-90b1, *Metaph* Z 7, 1032b2-6.

It would be possible to eliminate the difficulty simply by saying that what comes to be each time is not a magnitude as such, but a particular magnitude. This is Aristotle's approach to the Parmenidean problem of non-being in *Physics* I 8.[14] But this, by itself, will not yet constitute a solution to a specific problem of growth. There remains the task of a theoretical account for the emergence of the previously non-existent quantity of a thing F. A full story has to be told about this quantity: where it was before it became a quantity of F, how it became F, and of course, what 'it' means all along. The aim of Aristotle's aporetic discussion of the concept of 'potential magnitude' is to outline the principles of his theoretical account by ruling out the unacceptable approaches. It may be noticed that in this part of the argument Aristotle takes 'growth' in the sense of the 'increase of volume', rather than a more specific 'organic growth'.

It is interesting to note that in constructing the paradox, Aristotle exploits a kind of reasoning similar to that used in Zeno's argument against plurality. To support the assumption of his *reductio* according to which the postulated 'many things' all have size, Zeno argues that sizeless things do not exist. If they did, a thing possessed of a magnitude would be composed of sizeless elements.[15] Zeno uses the paradox as an intermediary step in his *reductio*; whereas Aristotle's task is to expose the roots of the paradox, and provide the non-paradoxical reading of the principle.

The refutation is constructed as an elimination of the impossible cases derived by method of division from the main assumption. Assume that the matter of growth is a potential magnitude and body, but actually without a magnitude and incorporeal (this is the main assumption). Now, this description can be taken in two ways: (i) either with respect to matter which is separate by itself, or (ii) with respect to matter inherent in another body.[16] This distinction 'in itself' / 'with respect to another' plays an important role in Aristotle's discussion of being in a

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14 Cf., e.g., 191b13: ἡμεῖς δὲ καὶ αὐτοί φαμεν γίγνεσθαι μὲν μηθὲν ἁπλῶς ἐκ μὴ ὄντος, πὼς μέντοι γίγνεσθαι ἐκ μὴ ὄντος, οἷον κατὰ συμβεβηκός· (ἐκ γὰρ τῆς στερήσεως, ὅ ἐστι καθ' αὐτὸ μὴ ὄν, οὐκ ἐνυπάρχοντος γίγνεταί τι· θαυμάζεται δὲ τοῦτο καὶ ἀδύνατον οὕτω δοκεῖ γίγνεσθαί τι, ἐκ μὴ ὄντος) κτλ.

15 DK 29 B2 (Simpl *in Phys* 139, 5 Diels); cf. McKirahan 1994, 182-4.

16 320a31-4: καὶ τούτου διχῶς ἐνδεχομένου λέγειν, ποτέρως ἡ αὔξησις γίγνεται, πότερον ἐκ κεχωρισμένης αὐτῆς καθ' αὐτὴν τῆς ὕλης, ἢ ἐνυπαρχούσης ἐν ἄλλῳ σώματι;

place.[17] In our case it is probably best understood as referring to the two opposite mechanisms of growth/increase discussed in post-Eleatic physics: combination (σύγκρισις) and dissolution (διάκρισις).[18] (i) will correspond to the mechanism of combination, (here the matter exists 'on its own', dispersed, as it were, prior to being incorporated with other matter), (ii) to the mechanism of 'separation' (here the matter of growth, all of it, is sitting inside some body waiting to be released and take up a greater volume — much like a gas under pressure). This interpretation will explain a partial overlap between (i) and (ii) which would not be expected if both options were taken in a purely logical way.

The difficult text that follows has given rise to several different analyses. The difficulty has to do not so much with the state of the text as with the extremely knotty syntax at 320a34-b3: χωριστὴ μὲν γὰρ οὖσα ἢ οὐδένα καθέξει τόπον ἢ οἷον στιγμή τις ἢ κενὸν ἔσται καὶ σῶμα οὐκ αἰσθητόν· τούτων δὲ τὸ μὲν οὐκ ἐνδέχεται, τὸ δὲ ἀναγκαῖον ἔν τινι εἶναι, where the iterated disjunctive ἢ of the first clause does not match the dichotomic μὲν ... δὲ of the next clause. I give my own analysis and append a summary of scholarly efforts at the end of the article. The translation is:

> For being separable, it will either (ia) occupy no place, unless (ib′) as some point, or (ib″) will be void and imperceptible body. Of these the one (ia) is not possible, and the other (ib) has to be in something.

I follow Verdenius and Waszink in retaining the second ἢ of the MSS bracketed by Joachim. The difficulty of this reading has to do, in part, with the fact that the logical dichotomy at 320b2 sounds unnatural,

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17 Probably also a result of school refinements of the Eleatic dialectical arguments. Cf. *Ph* IV 3, 210a25. Also in Plato, *Prm* 138a.

18 Aristotle invokes this distinction in several different discussions in *GC*. See I 6, 322b7; 8, 325a31-32 (in the description of Leucippus' theory of generation and growth); 325b30 (where γενέσεις are opposed to διακρίσεις); 10, 329a3. As often in his doxography, Aristotle's target here is not a particular historical school of thought, but rather the type of thinking common to several (possibly otherwise very different) schools. In this case he criticizes the view that a magnitude (exemplified by that of a solid body) can come to be by aggregation of some sub-structural units which have independent existence on their own. On these grounds, in *GC* I 8, he treats on a par the theories of Empedocles, Plato and Leucippus.

because it cuts the previous sentence not at its grammatical 'joint', i.e., the third ἡ, but at the second ἡ, which introduces the phrase grammatically subordinate to (ia). Nonetheless, I believe this to be the division intended by Aristotle in the argument that follows, which says that (ia) is impossible *tout court*,[19] while both options under (ib), matter as some kind of a 'point', or matter as 'void', presuppose some kind of 'being in'. I follow Joachim's suggestion that 'imperceptible body' glosses 'void', but take both concepts in a weak sense in which they are used by Aristotle in the previous chapter, where air is given as an example of an imperceptible body (*GC* I 4, 319b18-19).

The way the following argument is introduced (at lines 320b3-5) suggests both the refutation of (ia) and the proof of (ib). According to it, that which comes to be *from* this assumed matter will be 'somewhere', so this matter must also be somewhere: either by itself or accidentally.[20] If A comes to be from B, and A is a 'place-occupier', then B is also a 'place-occupier', either by itself, or accidentally. To understand this claim, we have to supply some meaning for 'A comes to be *from* B'.[21] I believe that the sense Aristotle has in mind here is that of the matter of composition, i.e., not only that of the source, 'from where A comes', but also 'of what A is composed'.[22] 'A comes to be from B' will refer, on this reading, to the process of combination, by which a log comes to be from the sawdust, or, *per impossibile*, something that occupies place comes to be from an aggregation of non-place-occupiers (cf. *GC* I 2, 316a30-b5). The possibility (ib) is where separate matter does occupy place, either without being extended (as a mathematical entity, such as point), or qua

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19 I take 320b3-5: ἀεὶ γάρ που ἔσται τὸ γιγνόμενον ἐξ αὐτοῦ, ὥστε κἀκεῖνο, ἢ καθ' αὑτὸ ἢ κατὰ συμβεβηκός, with Joachim and C.J.F. Williams, as explaining the τὸ μὲν οὐκ ἐνδέχεται. According to Philoponus (77, 8-23 Vitelli), Alexander ventured a shrewd but stylistically certainly far-fetched interpretation of the passage, trying to construe the οὐκ ἐνδέχεται at b3 with the following ἔν τινι εἶναι, and referring τούτων to the two horns of the initial dilemma.

20 See previous note.

21 The list of meanings is to be found in *Metaph* Δ 5, 1023a25; but it does not exhaust all the meanings found in the Aristotelian works. Cf. Bonitz s.v. ἐκ.

22 A different sense, which does not involve 'composition', is considered by Aristotle under the rubric (ii), as we shall see shortly.

void and imperceptible body (in the sense already mentioned).[23] Aristotle's verdict seems to be that both (ib') and (ib'') properly belong under the rubric (ii), by virtue of the way in which matter is construed in both cases.

Having made this assumption, Aristotle proceeds next to rule out the possibility (ii) that the matter of growth might be a pure potentiality inherent in another body, but in a way still 'separate' from it, without being its part or aspect.[24] In the transition from (i) to (ii), the concepts of 'inherence' and 'separation' have been retained, although the meaning seems to have been somewhat modified. In both cases we are talking about separation, but in (i) it is a separation of one thing from another; in (ii), it is a separation of a potentiality inherent in a thing from other properties and aspects of this thing; something like a causal dissociation between the aspects of the same thing.

Aristotle indicates the 'inherence' with the expression ἔν τινι εἶναι, familiar from *Physics* IV 3, where we find a list of eight different meanings.[25] Its intended meaning in our argument corresponds to the 'focal' meaning of the *Physics* list: 'as in a vessel' is another way of saying 'in a place'.[26] It serves the purpose of pointing out that the matter of growth cannot be construed as merely contained in a growing body, without sharing in any of its properties.[27]

Aristotle says that many impossible things will follow from these assumptions. Thus, in the case of evaporation, it will follow that air comes to be from water not because water undergoes a change, but because the matter of air is contained in the water as in a vessel, i.e.,

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23 For the interpretations of imperceptible body by the commentators, see *Appendix* 1, pp. 147-52 below.

24 This is the meaning of the description in the antecedent of the conditional clause κεχωρισμένον οὕτως ὥστε μὴ ἐκείνου καθ' αὐτὸ ἢ κατὰ συμβεβηκὸς τι εἶναι (320b5-6), as is correctly understood by Philoponus.

25 *Ph* IV 3, 210a14-24

26 *Ph* IV 3, 210a24: πάντων δὲ κυριώτατον τὸ ὡς ἐν ἀγγείῳ καὶ ὅλως ἐν τόπῳ.

27 K. Algra's suggestion that this expression in *Physics* IV might go back to Zeno's 'paradox of place' (on which see p. 114 below) is relevant to our text, too (Algra 1994, 50 and n 61). Cf. also Mansfeld 1990b, 259-61.

without being causally dependent on any property of the water. And then,[28] there is nothing to prevent there being infinite matters of increase, and so there is nothing to prevent them from being actualised.

The argument is parallel to the argument against the theories of generation ascribed to Empedocles and Democritus in *Cael* III 7, where Aristotle criticises the treatment of generation as a re-combination of actual constituents, in the course of which things come to be by separation (ἔκκρισις) from each other.[29] Simplicius in his commentary adds Anaxagoras to the group, and identifies him as a specific target of Aristotle's third objection (305b20-6),[30] which is parallel to our argument, namely that the process of generation by ἔκκρισις must come to a stop, unless it is assumed that a finite body can contain the infinity of finite magnitudes. For, on the assumption that evaporation is ἔκκρισις, i.e., happens without any transformation of water, when some air is extracted, some water remains. Thus, every stage in the process of decomposition will have to result in two components: a container and a mass of released air. Since there are no constraints on the matter of air contained within the remaining water qua potential magnitude, there is no reason to assume that we'll ever come to a stage where the residue of water does not contain any matter of that kind. So, if the process is allowed to go on indefinitely, this will involve an impossible result of an infinite's being contained within the finite. If the process does come to a stop, then the principle of ἔκκρισις is not universally applicable. For if there is a stage in the process at which air (by assumption 'latently' present in water) ceases to come to be from water, there must be some

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28 I take γάρ at 320b10 to pick up συμβήσεται πολλὰ καὶ ἀδύνατα, the whole clause λέγω δ' ... τὴν ὕλην αὐτοῦ as explicative of the second apodosis of the preceding sentence (κεχωρισμένον οὕτως ὥστε ... τι εἶναι). Cf. *Cael* III 7, where the 'merely apparent' character of change is first stated as an implausible conclusion on its own (see next note), and then granted for the sake of argument (305b6) and shown impossible on other grounds.

29 *Cael* III 7, 305b2: οἱ μὲν οὖν περὶ Ἐμπεδοκλέα καὶ Δημόκριτον λανθάνουσιν αὐτοὶ αὐτοὺς οὐ γένεσιν ἐξ ἀλλήλων ποιοῦντες ἀλλὰ φαινομένην γένεσιν· ἐνυπάρχον γὰρ ἕκαστον ἐκκρίνεσθαί φασιν, ὥσπερ ἐξ ἀγγείου τῆς γενέσεως οὔσης ἀλλ' οὐκ ἔκ τινος ὕλης, οὐδὲ γίγνεσθαι μεταβάλλοντος.

30 *in Cael* 632, 2-11.13-16; 635, 4-29 Heiberg

reason for this cessation, and this will probably involve a stronger causal link between air and water than the one that is provided by the concept of matter as 'potential body'.[31]

In *GC* I 5, Aristotle takes up the same argument, assuming that the process of change is real and so does not terminate while the stuffs are present.[32] Since by assumption, as he interprets it, water is not supposed to contribute any of its own stuff in the evaporation, but only release some of its content, it will follow that it will always persist, and will always have some matter ready for the process of separation. Hence, it will contain an infinite amount of 'matters' of air, which can all be actualised (they can all be actualised, presumably, because the process does not have to stop).[33] This will follow if the matter of growth is posited as separate from the growing thing.

We may notice that the logic of regress here is very similar to that of Zeno's 'paradox of place', which Aristotle reports in *Physics* IV 3, 210b22 (= DK 29A24): 'if there is a place it will be in something'.[34] With this *reductio* Aristotle wants to say that the theories of change in recent cosmologies do not solve the problems raised by the Eleatic critique. What is needed in order to solve these problems is not just a plausible description of the mechanism of change, but a different, analytical concept of a thing which is a subject of change — of the kind he himself gives in *Physics* I 7.

This is not a place to discuss whether Aristotle does justice to the theories he attacks. He is interested in spelling out the implications of a

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31 The condition of ἔκκρισις was that any, however small, amount of water will decompose into some air and some water; therefore as long as any water remains the process does not come to a halt. If no water remains, that means that the process was not that of ἔκκρισις after all. Thanks to Jim Hankinson for querying this point.

32 In *GC* I 5 no attribution of the criticised theories is made, but the coincidence of the two main objections, as well as the references to the κενόν at the beginning and in the summary of the argument, (otherwise never explicitly discussed), suggest that we are dealing with the restatement of the same argument. (cf. *Cael* III 7, 305b8-20).

33 So my reading of the passage is close to that of Zabarella and Joachim, who treat ἄπειροι ὕλαι as quantitatively infinite. The suggestion of Averroes, revived by Verdenius and Waszink, that ἄπειροι ὕλαι means 'indefinite in quality' rather than 'in quantity', by no means implausible, arguably makes a stronger and a far more specific claim, which still implies, *a fortiori*, quantitative infinity.

34 ὁ δὲ Ζήνων ἠπόρει, ὅτι εἰ ὁ τόπος ἐστί τι, ἔν τινι ἔσται, λύειν οὐ χαλεπόν κτλ.

certain way of thinking which he presents as being in a stark contrast with his own theory of change.[35]

Aristotle says in conclusion: 'It is better then to make matter inseparable in every case, so that it should be one and the same in number, but not one in account' (320b12-14). The scope of this argument and its conclusion is broader than is needed for the case of growth.[36] It shows that the matter of change cannot be construed as a separate (causally dissociated) property of a thing that undergoes change. But of course, what is true of a more general case has to be true of a more special case of growth.

Aristotle says that the view according to which the matter of a body would be 'either a point or a line' is not acceptable either. The more exact target of this remark has been a matter of debate,[37] but it is clear that Aristotle's objection is intended to be against the derivation of corporeal magnitude from something that lacks such magnitude. Although points and lines, unlike the void, are not fictitious posits within a body, they still cannot qualify as the matter of growth. Matter, rather, is that of which these are limits, but it can in no way exist without an affection (πάθος) or structure (μορφή).[38]

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35 For a considerably less sanguine appraisal of this feature of Aristotle's method in the discussion of the topic, see, e.g., Cherniss 1935, 119-20. Cf. C.C.W. Taylor's note on this passage in Taylor 1999, 85 n 78. For the attribution of this explanation of growth to the atomists, see *GC* I 8, 325a36-b4, and Joachim's note ad loc. Cf. Andersen 1978, esp. at 43.

36 This is perhaps acknowledged by the remark immediately following the refutation (320b11: ἔτι δ' οὐδ' οὕτω φαίνεται γιγνόμενος ἀὴρ ἐξ ὕδατος, οἷον ἐξιὼν ὑπομενόντος).

37 Alexander *ap Philop* 81, 22-31 Vitelli, suggested that 'lines' stand for the 'planes' of Plato's *Timaeus*; a suggestion was criticized by Philoponus as insufficiently grounded by the text (which says 'lines', not 'planes'). In a parallel way in our own time, Joachim has suggested Pythagoreans and Plato's *Timaeus* as Aristotle's targets, and was criticized by Verdenius and Waszink who have collected interesting evidence with which to argue that Aristotle might be thinking of Pythagoreans and *Speusippus* rather than Plato.

38 Aristotle in several places criticises the attempts to raise the analytical derivation of solid bodies from their geometrical constituents to the rank of a cosmological theory. Examples of arguments are *Metaph* B 2, 997b34-a19; M 2, 1076a38; 1077a31; 8, 1083b13, 1085a31-b4. *Cael* III 1, 299a2-300a19. *Ph* VI 1, 231a17-b18. The closest discussion to our passage is the proof of infinite divisibility in *GC* I 2, 316a25-b16, where Aristotle gives a number of reasons why a body cannot be made up by sizeless

Aristotle concludes the discussion with the following methodological statement:

> (i) For in the unqualified sense one thing comes to be from another, as it has been defined elsewhere, and by something that exists in actuality and is the same either (a) in genus, or (b) in species (like fire by fire, and man by man), or (c) by the actuality (for the hard is not generated by the hard). (ii) But if something is a matter of a corporeal substance, that is to say of a body which is already of some definite kind (for there is no "common" body), it is also the matter of the affection and magnitude, separable conceptually (λόγῳ), but not separable spatially (τόπῳ), since the affections, too, are not separable. (320b17-25).

In (i), Aristotle gives a classification of efficient causes which operate in the coming to be broadly construed (including not just the coming to be of substances, but also of properties). The common feature of all three types of causal mechanism is that each presupposes a transfer of a property from the actual causal agent to the object of generation.[39] This feature of coming to be cannot be adequately captured by 'mathematical' models of matter. (ii) says that the matter of a growing thing, i.e., the subject of quantitative change, must share in qualitative characteristics that are relevant to a given mechanism of causation. This is a general and preliminary statement: Aristotle has not yet described the causal mechanism of growth; but an implication seems to be that the matter of growth

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points. The reference at 320b16 to 'the same causes' (διὰ τὰς αὐτὰς αἰτίας) was found difficult by commentators (see Joachim *ad loc*). Philoponus takes it to mean that the causes valid in the case of the στιγμαί are valid in the same way in case of the γραμμαί; in other words, as pertaining to γραμμαί only. This may be correct, particularly if we assume that Aristotle here refers to the abovementioned argument in GC I 2, where the causes effective in case of the στιγμαί are related in detail.

39 'Property' has to be broadly understood as well: in generation of natural substances (b) this can refer to the whole set of essential properties of a species (the complexity of the set will depend on the species: it will be less complex for fire, but more complex for human being), in other cases it can be an opposite quality (as in case [a]), or a property completely devoid of any structural similarity with the cause as a result of multiple transformations in the corresponding process of change (as in [c]). For the interpretation of this passage, see Appendix 2, pp. 152-4 below.

in the growing thing has to be the same as the matter of a thing qua sensible substance.[40]

The gist of Aristotle's objection to the models of growth he criticises is that in all of them the effect of increase is ascribed by him to a factor ontologically separate from the matter of the growing thing. This has to be the case in a universe made up of ultimately non-mixable, separate entities, be they the atoms of Democritus or the 'roots' of Empedocles, or analogous entities in other systems. An attempt to account for growth or generation in such a universe will lead to paradoxes. In order to get rid of the paradoxes, a different analysis of matter is needed, whereby the matter of growth will form a real unity with a sensible substance, being separable from it only 'in the account'. Having this established, Aristotle makes a fresh start.

3 The Process of Growth: Methodological Postulates

There are several conditions, or specific principles, which our thinking about growth should respect. Two of them are introduced at the beginning of the chapter as accepted facts: it does appear, says Aristotle, that in growth, any given part is undergoing growth, and in decrease any given part becomes smaller; there also has to be some 'addition' or some 'subtraction'.[41]

This set of conditions seems to be open to the following difficulty: growth has to happen either by means of something incorporeal or a body. Both possibilities are logical dead ends: if the 'addition' made is incorporeal, this will lead us to postulating a separate void, as has been

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40 Aristotle uses this principle in the argument for the unity of nutritive and generative powers of a living body in *GA* IV 2, 740b35: ἡ γὰρ αὐτὴ ἐστιν ὕλη ᾗ αὐξάνεται καὶ ἐξ ἧς συνίσταται τὸ πρῶτον, ὥστε καὶ ἡ ποιοῦσα δύναμις ταὐτὸ τῷ ἐξ ἀρχῆς κτλ. The principle of unity of the matter of growth and constitutive matter invoked here is the object of the proof we have just considered. For some problems involved in this proof, see de Haas 1997, 138–47.

41 *GC* I 5, 321a2–5: φαίνεται δὴ τοῦ αὐξανομένου ὁτιοῦν μέρος ηὐξῆσθαι, ὁμοίως δὲ καὶ ἐν τῷ φθίνειν ἔλαττον γεγονέναι, ἔτι δὲ προσιόντος τινὸς αὐξάνεσθαι καὶ ἀπιόντος φθίνειν. Note that φαίνεται constructs with the infinitive, which conveys reference to belief, either common or expert, rather than something self-evident. I am grateful to Jim Hankinson for this observation.

shown in the course of the discussion of 'potential magnitude'. If it is corporeal, then it appears that two bodies will be occupying the same place simultaneously.[42]

Aristotle indicates that it will not do to try to solve this dilemma by re-describing growth as an instance of a complete transformation, whereby one body just turns into another without a residue. Growth is not like evaporation, for it is a non-substantial change *sui generis*, while evaporation is an instance of a substantial change. The crucial point of difference is that in the case of evaporation, which is an instance of coming-to-be rather than accidental change, there is no thing that can be said to have increased as a result of the process of change. Air does occupy a greater volume than an equal mass of water, but it has not existed prior to the process of change, so it cannot be said to have gained volume. In the same way, the water ceases to exist, so it cannot be said to have diminished in the proper sense — it is just extinguished.

There is one interesting possibility of rescuing the continuant for the case of simple generation, to which Aristotle gives brief consideration here. It might be, he suggests, that what persists in the case of generation, and thus can be taken to be the subject of change, is 'body' taken without further qualifications. After all, both air and water are of bodily nature, so why could not this nature itself play the part of the continuant? Suppose,

> there is something common to both a thing coming to be and the one that passes away, such as body. For water has not grown, and neither has air, but rather the former has perished and the latter has come to be. But the body, if anything, has grown. (321a15-17)

The fact that Aristotle discusses this suggestion is noteworthy. The idea that body qua body can play the role of the continuant in different kinds of transformations was found attractive by a number of Aristotelian

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42 321a5-7: ἀναγκαῖον δὴ ἢ ἀσωμάτῳ αὐξάνεσθαι ἢ σώματι. Εἰ μὲν οὖν ἀσωμάτῳ, ἔσται χωριστὸν κενόν — ἀδύνατον δὲ μεγέθους ὕλην εἶναι χωριστὴν, ὥσπερ εἴρηται πρότερον· εἰ δὲ σώματι, δύο ἐν τῷ αὐτῷ σώματα τόπῳ ἔσται, τό τε αὐξανόμενον καὶ τὸ αὖξον, ἔστι δὲ καὶ τοῦτο ἀδύνατον. This dilemma has the structure of a doxographical *topos*; as such it was used by later commentators and doxographers. Cf. Alexander *Mixt* XVI, 234,23 Bruns; Philop 90, 8 Vitelli. For the place of this division in the tradition concerning the nature of the soul, see references and analysis in Mansfeld 1990a, 3065-85.

commentators in Late Antiquity and the Middle Ages.[43] It is therefore particularly interesting that Aristotle here explicitly rejects it, at least for the case of growth. The ground for this rejection is that the notion of 'unqualified body' does not satisfy the methodological conditions of the account of growth.

A sound account of growth has to preserve some characteristic facts about growing things,[44] namely:

(i) any given part (ὁτιοῦν μόριον) of a growing magnitude must become bigger in size;

(ii) growth happens when some addition is being made (viz. to a growing thing);

(iii) a growing thing must be preserved and persist through the process of growth.

Condition (ii), the necessity of external input, can be regarded as a consequence of the argument against 'potential magnitude'. The reasons for (iii), the postulate of a continuant, have just been discussed. Simple generation, construed as the process which has an unqualified body as its continuant, does not satisfy these two conditions. First, it happens without any external addition, and secondly, there is no subject that persists in the process from the beginning to the end (321a17-29).[45]

Condition (i) deserves a little more consideration. It is introduced without an explicitly stated argument, as a commonly recognised fact. And yet we have relatively little evidence as to its precise content and source in Aristotle's thinking.

Two points in the preliminary discussion might be of relevance here. In the discussion of the 'manner' of growth, Aristotle's selection of types of motion for comparison might suggest that he was thinking about the kinetic pattern which involves a proportionate increase of bodily mass, equal in all directions. But in that discussion nothing is said about how the mechanism of such increase works on the level of bodily structure.

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43 Cf. B, pp. 149-52 below.

44 321a17-18: δεῖ γὰρ σώζειν τῷ λόγῳ τὰ ὑπάρχοντα τῷ αὐξανομένῳ καὶ φθίνοντι.

45 Whether Aristotle here implies that an unqualified body is a continuant in the case of substantial generation, cannot, I think, be established on the basis of this passage.

The expression 'any part' (ὁτιοῦν μόριον) is quite vague, too. But one page down, Aristotle reformulates the thesis using a more precise expression 'perceptible point' (σημεῖον αἰσθητόν, 321b14). This must imply that he thinks of the proportionate increase of volume throughout the whole of a bodily structure, in such a way that no part could be left out of the process. By way of analogy, we could say that the material structure of a growing thing should be isotropic in respect of growth.[46]

We have seen, further, that the conclusion of the *aporia* of potential magnitude was that the matter of a sensible substance is not separable from its accidents, such as affection and magnitude. One particular consequence of this claim was that material components of a sensible substance cannot remain unaffected by the processes of change.

The same idea of a special character of motion imparted to a living body by the faculty of growth recurs in *de Anima* II 4, where Aristotle makes a well-known polemical remark against Empedocles' view of growth. According to Aristotle, Empedocles thought that growth of different parts of a body is directed by the natural tendencies of the dominant elements.[47] This passage is more often quoted because of its conclusion, where Aristotle says that there must be something to hold together fire and earth, lest a plant be torn apart.[48] But the standpoint from which Aristotle criticises Empedocles seems to be the same as the one expounded in *de Anima* II 2, where the omnidirectionality of the movement of growth is regarded as one of the signs of life.[49] The context

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46 Joachim's note *ad* 321b14: '*Every perceptible particle*: for a body does not consist of points' seems to suggest a polemical overtone against the proponents of the idea that a body does consist of points. Whether the isotropy condition itself was a part of any of the doctrines of 'geometrical' genesis, is difficult to say, but the question seems well worth looking into. Cf. also interesting reference material on the 'geometrical' genesis collected by Verdenius and Waszink, *ad loc.*

47 415b30: 'Εμπεδοκλῆς δ' οὐ καλῶς εἴρηκε τοῦτο, προστιθεὶς τὴν αὔξησιν συμβαίνειν τοῖς φυτοῖς κάτω μὲν συρριζουμένοις διὰ τὸ τὴν γῆν οὕτω φέρεσθαι κατὰ φύσιν, ἄνω δὲ διὰ τὸ πῦρ ὡσαύτως.

48 416a6-9: πρὸς δὲ τούτοις τί τὸ συνέχον εἰς τἀναντία φερόμενα τὸ πῦρ καὶ τὴν γῆν; διασπασθήσεται γάρ, εἰ μή τι ἔσται τὸ κωλῦσον.

49 413a26: διὸ καὶ τὰ φυόμενα πάντα δοκεῖ ζῆν· φαίνεται γὰρ ἐν αὐτοῖς ἔχοντα δύναμιν καὶ ἀρχὴν τοιαύτην, δι' ἧς αὔξησίν τε καὶ φθίσιν λαμβάνουσι κατὰ τοὺς ἐναντίους τόπους· οὐ γὰρ ἄνω μὲν αὔξεται, κάτω δ' οὔ, ἀλλ' ὁμοίως ἐπ' ἄμφω καὶ πάντοσε καὶ τρέφεται καὶ ζῇ διὰ τέλους, ἕως ἂν δύνηται λαμβάνειν τροφήν.

of the remark (the difference between the ensouled and soulless), as well as the contrast with the upward and downward movements, indicates that Aristotle probably has Empedocles in mind. The alternative to Empedocles proposed by Aristotle involves not only the notion of the teleological dependence of the geometry of natural place, but also the idea of a special kinetic pattern characterising natural motion within this geometry.[50]

An important part of the methodological proœmium (320b34-1b10) is the question of the nature of the continuant (321a29-32). What is the subject of growth: is it a growing thing, i.e., the one that was there before the process has started, or the part that has been added, i.e., the nourishment? It is fairly obvious that it is the growing thing that continues. If someone's shin is growing, then the shin gets bigger, but not that 'by' which it grows, i.e., nourishment. But the shin, as it grows, incorporates some of the nourishment. How can we draw a line between the two? Probably the shin grows because it does preserve its substance (οὐσία), says Aristotle, whereas the nourishment does not (321a34).

The criterion by which to judge whether the substance has been preserved is the persistence of its core functions. In the case of organic growth, when nourishment is converted into the matter of the organs, it is not the food, but the organs that are said to grow, because they retain all their functions, while those of the food are destroyed. In the same way when water is poured into wine, it is said that wine, not water, increases in volume, because the mixture retains the functions of the wine, not of the water.[51] Thus, the moving cause of growth is within a growing thing because its functions are preserved.

Aristotle cites alteration (ἀλλοίωσις) as an illustration of the same principle. If flesh remains flesh and 'what it is', and there comes about

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50 The Greek Aristotelian commentators understand this passage from *de An* II 4 the way I suggest. Alexander of Aphrodisias, *De Anima*, 9, 1-4 Bruns: τὰ μέν γε [scil. ἁπλᾶ] μιᾶς καὶ ἁπλῆς κινήσεως ἀρχὴν ἔχει, τούτων δὲ ἕκαστον ἐν αὑτῷ καὶ τοῦ τρέφεσθαι τὴν ἀρχὴν ἔχει καὶ τῆς ἐπὶ πάσας τὰς διαστάσεις κατὰ τὴν αὔξησιν κινήσεως. Cf. Themistius, *In An*, 44, 13-18 Heinze.

51 321b1: ποιεῖ γὰρ τὸ τοῦ οἴνου ἔργον ἀλλ' οὐ τὸ τοῦ ὕδατος τὸ σύνολον μῖγμα. Aristotle here has in mind not an extreme case of a thought experiment, when a drip of wine is dissolved in ten thousand pitchers of water (*GC* I 10, 328a27), but more likely a usual way of serving wine mixed with water: no one would doubt that the mixture being served is wine, because it has wine's inebriating powers.

an affection or property (πάθος) which was not there before, flesh gets altered. As for that *by which* it is altered (τὸ ᾧ ἠλλοίωται), it sometimes does not get affected, and sometimes does. The principle of alteration in this case, as in the case of growth, is within an altered thing, says Aristotle:

> That which exercises the alteration (τὸ ἀλλοιοῦν) and the principle of movement is in that which grows and that which is altered (for that which moves is in these). Even though occasionally both the incoming [nourishment] and the body that consumes it get bigger, as when the incoming [nourishment] has become breath (πνεῦμα), — still precisely in being so affected it is destroyed, and that which moves (τὸ κινοῦν) is not in it. (321b6-10).

This analysis of alteration presents an exegetical problem that was perceived already by the ancient commentators.[52]

The notion that the moving cause of alteration is within the subject of alteration, apparently squares ill with Aristotle's restriction on self-motion. As opposed to the cases of growth and animal locomotion, alteration, by and large, is not regarded by Aristotle even as a potential exception to the general rule.[53] As Philoponus reasonably points out, when we get warmed by fire or chilled by snow, we attribute the efficient causes of these changes to fire and snow, respectively.[54] It is not exactly clear what should correspond to the role of active power in case of alteration, or what kind of self-induced alterations Aristotle might have in mind. The only example Aristotle actually gives at this point has to do with growth rather than alteration: even though nourishment turns

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52 Cf. Philoponus *in GC* 98, 19-21 Vitelli.

53 Philoponus considers it to be a standard view that in the cases of alteration and generation, the principle of movement and the efficient cause are external, while in the cases of locomotion and growth they are internal; and writes up an explanation of this fact (99, 6-100, 24 Vitelli). Cf. Furley 1994 (=1978), 10 and n 8.

54 96, 31-7 Vitelli: μάχεται δὲ τῷ λόγῳ καὶ ἡ τῶν πραγμάτων ἐνάργεια. Θερμαινόμεθα γὰρ ὑπὸ πυρὸς καὶ ψυχόμεθα ὑπὸ χιόνος, καὶ οὐδεὶς ἂν αἰσθήσει χρώμενος τὸ ποιητικὸν τῆς θέρμης ἢ τῆς ψύξεως αἴτιον ἐν τῷ σώματι ἡμῶν τῷ ἀλλοιουμένῳ εἶναι λέξειε, καὶ οὐκ ἐν τῷ πυρὶ καὶ τῇ χιόνι· καὶ ὁ κηρὸς δὲ ἀλλοιοῦται ἐκ κύβου φέρε σφαῖρα γινόμενος, καὶ παντὶ δῆλον ὡς ἡ ἀλλοιωτικὴ δύναμις οὐκ ἐν τῷ κηρῷ ἐστιν, ἀλλ' ἐν τῷ διαπλάσαντι.

into the internal breath and in this way increases its volume, thus causing the increase of the bodily bulk, it is still the body, not the nourishment, that is the seat of the moving cause for this increase.

Alexander, trying to salvage the standard analysis, suggests that τὸ ἀλλοιοῦν καὶ ἡ ἀρχὴ κινήσεως must be understood not as referring to the efficient cause in the strong sense, but to the cause of 'being altered', which in a certain way is the cause for the agent to bring about the alteration.[55] This interpretation may seem strained, because according to it, τὸ ᾧ ἠλλοίωται will correspond to the active cause of alteration, while τὸ ἀλλοιοῦν καὶ ἡ ἀρχὴ κινήσεως will designate not the efficient, but formal cause conducive to change. Alexander may have in mind Aristotle's distinction between the active and passive principle of motion and change;[56] but an even closer source of this suggestion is likely the interpretation of Aristotle's theory of agency in later Peripatetic tradition, attested for Andronicus, who describes the internal nature of a thing in this way:

> ἡ δὲ φύσις καὶ προδιατιθεμένη διατίθεσι τὸ ὑποκείμενον ἔνδοθεν καθ' ἕκαστον κινήσεως εἶδος, ὡς καὶ ὁ Ἀνδρόνικος ἔλεγε. κἂν γὰρ θερμαίνηται ὑπὸ πυρὸς τὸ ὕδωρ, ἀλλ' ἡ ἐν τῷ ὕδατι φύσις πρώτη θερμὴ γινομένη, οὕτως θερμαίνει ἢ συνθερμαίνει τὸ ὑποκείμενον.
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> Nature, while being itself predisposed, disposes the substrate from within, in accordance with each kind of change, as Andronicus also said. For although it is by fire that water is heated, however, the nature in the water first becomes hot, and then heats or co-heats the substrate. (450, 16-20 Diels)

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55 *ap Philop* 98, 1-6 Vitelli: πρὸς τοῦτο τοίνυν ἐνιστάμενός φησιν ὁ Ἀλέξανδρος, ὅτι οὐ περὶ τοῦ ποιητικοῦ αἰτίου ἐστὶν αὐτῷ ὁ λόγος. Οὐδὲ γὰρ τοῦ ἀλλοιοῦν τὴν ἀρχὴν καὶ τὴν δύναμίν φησιν εἶναι ἐν τῷ ἀλλοιουμένῳ, ἀλλὰ τοῦ ἀλλοιοῦσθαι, ἥτις τρόπον τινὰ αἰτία γίνεται τῷ ποιοῦντι τοῦ ἀλλοιοῦν· οὐ γὰρ ἀλλοιοῖ τὰ ποιοῦντα, εἰ μὴ μόνα τὰ ἔχοντα τὴν δύναμιν τοῦ ἀλλοιοῦσθαι.

56 *Ph* VIII 4, 255b28-30: ὅτι μὲν τοίνυν οὐδὲν τούτων αὐτὸ κινεῖ ἑαυτό, δῆλον· ἀλλὰ κινήσεως ἀρχὴν ἔχει, οὐ τοῦ κινεῖν οὐδὲ τοῦ ποιεῖν, ἀλλὰ τοῦ πάσχειν. *Metaph* Θ 1, 1046a11-5: ἡ μὲν γὰρ τοῦ παθεῖν ἐστὶ δύναμις, ἡ ἐν αὐτῷ τῷ πάσχοντι ἀρχὴ μεταβολῆς παθητικῆς ὑπ' ἄλλου ἢ ᾗ ἄλλο· ἡ δ' ἕξις ἀπαθείας τῆς ἐπὶ τὸ χεῖρον καὶ φθορᾶς τῆς ὑπ' ἄλλου ἢ ᾗ ἄλλο ὑπ' ἀρχῆς μεταβλητικῆς. Aristotle's examples of passive powers are dispositional properties: the oily substances burn well, and the soft are fragile. For discussions, see Furley 1978; Gill 1994, 17-24, Cohen 1996, 152-4.

This theory according to which the nature of a thing undergoing change is an immanent cause of change may go back to the Hellenistic Peripatos.[57]

Immediately after Alexander's suggestion, Philoponus' commentary contains a discussion of an anonymous alternative suggestion that in some cases the *active* principle of alteration still might be in a thing that is being altered. Thus, some medicinal drugs have the power of heating (or cooling), which they can only exercise when they are inside the animal bodies, but not otherwise. So it seems that animate bodies do have an active internal principle of alteration.[58] The reply to this stated by Philoponus is that the animate body in question does not contain the principle of change within itself, but can trigger the heating (or cooling) power of medicines: the medicine needs to enter an animal body in order to have its curative power activated by the elements of this body. But once it has been activated it works as an agent, and so the Aristotelian principle according to which the agent and the patient must be distinct is preserved.[59] The question of a direct source of this discussion is most tantalising.[60] A similar theory of ἀντιθέρμανσις is developed by

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57 Cf. 440, 12-7; for discussion see Gottschalk 1987, 1112-3; cf. Moraux 1973, 113-6.

58 The discussion is presented as a reaction to Alexander's proposal of 'passive powers': 'So in this way Alexander maintains that the phrase "the origin of change" should not be understood as a reference to the efficient cause. But in some cases of alteration it is possible to find the origin of change, the efficient cause as it were, existing in a thing that is being altered — as in the case, for example, of the alterations which take place in connection with the bodies of animals owing to drugs not actually in possession of observable coldness or heat, but potentially warming or cooling. All things of this sort, pepper, pellitory, hemlock and the like, when applied to inanimate bodies evince no power and do not alter them, but when they approach the bodies of animals, these they do alter by being changed in turn by the nature and life that is in the body, and when they are changed give proof of their own power. So in all such cases the origin of change is plausibly said to exist in the body that is altered' (98, 6-18 Vitelli, trans. C.J.F. Williams).

59 'But perhaps this <solution> too may be rejected by someone. For it is not true, in the cases of alteration we have been considering, that the origin of change is in the thing that is altered. Rather, the power that is in the drugs is brought into actuality by our bodies, and once it is brought into actuality it eventually reacts in this way on our bodies and alters them' (98, 21-6 Vitelli, trans. C.J.F. Williams).

60 On the use of medical doctrines by Philoponus and other philosophers of Alexandrian school, see Todd 1977, Todd 1984.

Galen.[61] It is worth pointing out that in Galen we find *both* the idea that the medicines that have their curative power only potentially, but not actually, are brought to action by the animal organism;[62] *and* that the role of the animal organism consists in only initiating the small-scale action which 'triggers' the activity of the power inherent in a medicine.[63] The triggering mechanism in many cases is physical: in order to have the latent medicinal powers actualised, the drugs may have to be ground, slightly warmed up, moistened, etc. — these functions are performed by the animal organism. The 'reply' in Philoponus rewrites both ideas in a Peripatetic key: rejecting the suggestion of self-motion and analysing the 'triggering' movement as distinct from the 'triggered' one.

In the case of growth, the contribution of the 'immanent' factor of a thing undergoing change to the process of alteration is more substantial, in that here the qualities of the newly growing structure must be fully defined by the nature of the continuant; nonetheless, the efficient causal role of external input must not be played down. In order to see whether and how this works, we shall now have to turn to Aristotle's analysis of the elements and mechanism of the process of growth.

4 Solution Outlined: Form and Matter in the Process of Growth

The account, we remember, must take care of the three main principles — omnidirectionality; input; continuant, — while observing the methodological restrictions according to which 'neither the body should be void, nor should two magnitudes be in one place, nor should there be growth by the incorporeal' (321b15-16). Aristotle's approach to the solution involves two points, based, respectively, on two important distinctions. The first point is that the non-uniform parts of a living body grow in the growing of their uniform parts.[64] The distinction between uniform

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61 *Temp* III 1-2, 89, 15-95, 25 Helmreich; cf. *simpl medic temp* XI, 400-3 K.

62 *Temp* III 1, 89, 15-90, 21 Helmreich

63 *Temp* III 1, 94, 3-95, 25 Helmreich

64 321b16-19: ἔν μὲν ὅτι τὰ ἀνομοιομερῆ αὐξάνεται τῷ τὰ ὁμοιομερῆ αὐξάνεσθαι (σύγκειται γὰρ ἐκ τούτων ἕκαστον).

and non-uniform is standard in Aristotle's natural philosophy. In *PA* II 1, 646a13-25, he distinguishes three types of natural composition: elemental, based on the elemental powers; homoeomerous, or uniform; and anomoiomerous, or non-uniform. The uniform parts are the ones where a part is isomorphic with the whole,[65] such as flesh, bone, and blood in living bodies; gold, bronze, stone in the inanimate. Any particle of gold still counts as gold; and so does any particle of flesh. The non-uniform parts are functionally different from each other and from the whole that they make up. Therefore they cannot be isomorphic with their wholes. In a living body these are all the organs which have structure: beaks, paws, claws, necks, etc. Aristotle calls them ὀργανικά, i.e., 'instrumental'. In the inanimate world these are artifacts: levers, knives, wheels, pumps, etc.

Aristotle's first point is that growth is a type of change whose proper subject is to be sought on the level of the uniform parts of the body. This is the level of composition mediating between the elemental and the instrumental. The elemental level is the level at which the primordial elemental qualities interact, tempering and moderating each other. Elemental composition is common to all parts and organs of a body, and does not define any structure in particular. The 'free' subsistence of the elements in sublunary world would be a constant process of transformation. Within the natural bodies, this process is bound and slowed down by the overriding structures, but it is still there. This is why Aristotle says that it is better to say that the first level of composition is made up by 'powers'.[66] The non-uniform level of composition is 'instrumental': non-

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65 Note the use of the term συνώνυμα to describe the relation between the wholes and parts of the homoiomers in *PA* II 9, 655b6, cf. *GC* I 1, 314a20; cf. ὁμώνυμα in *PA* II 2, 647b17 (on this usage, cf. Bonitz's remarks, *Index* 514a25-b18). On the use of the terms in the biological treatises, see Peck's introductory note in *GA*, xlviii-ix; on the role of homoiomers in Aristotle's system, see Kullmann 1982.

66 *PA* II 1, 646a14-21: ἔτι δὲ βέλτιον ἴσως ἐκ τῶν δυνάμεων λέγειν, καὶ τούτων οὐκ ἐξ ἁπασῶν, ἀλλ' ὥσπερ ἐν ἑτέροις εἴρηται καὶ πρότερον· ὑγρὸν γὰρ καὶ ξηρὸν καὶ θερμὸν καὶ ψυχρὸν ὕλη τῶν συνθέτων σωμάτων ἐστίν κτλ. The reference must be to the *GC* II 4 where the primordial qualities are defined. We may compare this description of the elements with the manner of presence of the simple bodies in Plato's ὑποδοχή (*Ti* 47e-51b).

The precise status of the elemental level within the hylomorphic constitution of a living organism has been the subject of a lively discussion for about a decade. For a conceptual analysis of the function of elements in the hylomorphic constitution, see Gill 1989; Bogen 1994; Fine 1994; Freudenthal 1995; King 2001. For a useful

uniform parts, or organs, may have as their components organs distinct in their functions from themselves and from each other. Uniform parts are in between the elements and the non-uniform parts: in contrast with the elements, they do have specific bodily composition; in contrast with the non-uniform parts, they are not themselves composed of functionally distinct parts, and for this reason they should be more suitable than the non-uniform parts for satisfying the isotropy condition.

The second distinction that Aristotle draws is between the form and matter of the uniform parts of a body. In the 'instrumental' parts, such as a hand, it is easy to see the difference between form and matter, the structure and the 'stuff'. In the uniform parts, such as flesh, this difference is less ostensible. But it must be there, otherwise we would slip down from the level of things to the level of unguided elemental processes. Furthermore, the different uniform parts still differ in their functions, viz. forms.[67] So there must be a way of drawing this distinction theoretically. Aristotle says that

> flesh, and bone, and each of such parts is double, as also each of other things which have form in matter. For both the matter and the form are called flesh and bone. (321b19-21)[68]

This distinction between form and matter in the uniform parts is the second point in Aristotle's solution to the problem. Aristotle says that the omnidirectionality of growth can be preserved only by form, but not matter. He explains this with the following analogy:

> For it should be understood as if someone were measuring water with the same measure; for what comes to be is always different. In this way the matter of flesh grows, so that it does not increase in each and every part, but rather something flows out, while something comes in; how-

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analytical survey of the texts in the biological corpus dealing with relation between the elements and the homeoemerous parts in the constitution of the living organisms, see Althoff 1992, 25-7.

67 I owe this point to Jim Hankinson.

68 321b19-21: ὅτι σὰρξ καὶ ὀστοῦν καὶ ἕκαστον τῶν τοιούτων μορίων ἐστὶ διττόν, ὥσπερ καὶ τῶν ἄλλων τῶν ἐν ὕλῃ εἶδος ἐχόντων· καὶ γὰρ ἡ ὕλη λέγεται καὶ τὸ εἶδος σὰρξ καὶ ὀστοῦν.

> ever, [it does increase] to each and every part of the shape and form. (321b25-28)[69]

The commentators agree that water stands for matter and measuring unit for form, but there is somewhat less clarity on the actual content of the illustration. Which operation in water-measuring is parallel to the process of growth? In Philoponus' commentary there is a suggestion that the analogy is not really intended to illustrate growth, but only to show 'what persists and what flows'.[70] This way of looking at the passage has proved so far most rewarding, philosophically.[71] As far as growth is concerned, this analogy should be taken as clarifying the nature of the problem and the general direction of the solution, without specifying yet the exact nature of the mechanism of increase.[72]

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69 321b24-5: δεῖ γὰρ νοῆσαι ὥσπερ εἴ τις μετροίη τῷ αὐτῷ μέτρῳ ὕδωρ· ἀεὶ γὰρ ἄλλο καὶ ἄλλο τὸ γινόμενον. οὕτω δ' αὐξάνεται ἡ ὕλη τῆς σαρκός, καὶ οὐχ ὁτῳοῦν παντὶ προσγίνεται, ἀλλὰ τὸ μὲν ὑπεκρεῖ, τὸ δὲ προσέρχεται, τοῦ δὲ σχήματος καὶ τοῦ εἴδους ὁτῳοῦν μορίῳ.

70 112, 31-113, 1 Vitelli: οὐ πρὸς τὴν αὔξησιν δὲ ἔλαβε τὸ ὑπόδειγμα, ἀλλ' ὑπὲρ τοῦ δεῖξαι τί μέν ἐστι τὸ μένον, τί δὲ τὸ ῥέον.

71 One example of the metaphysical benefits of such reading is G.E.M. Anscombe's use of this passage in her analysis of the problem of individuation (Anscombe 1981, 64-5).

72 Modern commentators attempted to interpret the simile as a direct illustration of the metaphysical principle. According to Joachim, a 'water-measure' is a vessel made of elastic material, which can extend and contract following the increase and decrease of its contents, yet preserve its original shape. The 'form' of a hylomorphic compound is taken to refer to the 'combining formula' (λόγος τῆς μίξεως) of the bodily mixture (Joachim, 130). ἀεὶ γὰρ ἄλλο καὶ ἄλλο τὸ γινόμενον and καὶ οὐχ ὁτῳοῦν παντὶ προσγίνεται, ἀλλὰ τὸ μὲν ὑπεκρεῖ, τὸ δὲ προσέρχεται refer, according to him, respectively, to the flow of matter through the same form, and to the successive filling and emptying of the water-measure. 'The increase in every part of form' means in this case the overall increase of the quantity of stuff which has this combining formula (say, H_2O). The meaning of 'a part of form' on this reading is 'a part of a whole insofar as it has this form'.

Verdenius and Waszink disagree with Joachim's suggestion that the water measure in question has a flexible size. According to them, the sameness of form is paralleled by the sameness of the size of the bucket. They think, further, that both expressions, ἀεὶ γὰρ ἄλλο καὶ ἄλλο τὸ γινόμενον ανδ καὶ οὐχ ὁτῳοῦν παντὶ προσγίνεται, ἀλλὰ τὸ μὲν ὑπεκρεῖ, τὸ δὲ προσέρχεται, refer to the fact that the parts of the flux, of water in one case, and of matter in another, are being added in discrete units of

In growth that takes place in the uniform parts, form and matter must be related in the same way as they are in the proportionate growth of the non-uniform parts. Although life-functions are less clearly visible in flesh and bones, they are no less real than in hands and feet.[73] Aristotle says that in some sense every part of flesh grows, and in some sense not: as regards the form, the addition is made to every part, but not as regards the matter. However, the whole thing does grow. The mechanism of growth involves the addition of nourishment. The incoming nourishment has a sensible form made up by qualities opposite to those making up the form of a growing thing, and then it gets transformed into the form of this latter, as, e.g., when moist is added to dry (or solid) and is transformed into solid.[74] 'Form' is illustrated here by an example of simple qualities (moist and dry)

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the same size. The reason why matter does not grow equally in all parts is that its parts are discrete, lacking physical continuity. The same amount of water can be replenished by discrete units of the same volume. However, as regards the portions themselves, even if they could be traced in the volume of a vessel into which they are poured, they cannot be said to increase equally with every new influx (cf. Verdenius, Waszink, 26-7).

Aristotle's text, in my view, gives no clear indication either (a) that the measuring unit refers to the unit of addition, or (b) that it is elastic, as Joachim suggests. (a) In the first clause, the presence of ἀεί, in the absence of any additional locative markers, suggests that the γινόμενον refers to the contents of a water measure referred to in the previous clause. Thus a 'temporal' interpretation of ἄλλο καὶ ἄλλο is convincing. The case is similar with τὸ μὲν ... τὸ δὲ of the second clause, where there are again no locatives indicating any external application. The verb ὑπεκρεῖ also suggests that the reference is to flux rather than 'uneven' distribution of water in the vessel. (b) In Alexander's analysis from which Joachim takes his cue elasticity is a property of a living body, not of the reservoir of Aristotle's example. Thus Philoponus (or his source) seems to be right in that in this example Aristotle shows how a dynamic entity can have a stable structure without showing how exactly the 'extra' influx becomes a part of growing structure.

73 321b28-32: ἐπὶ τῶν ἀνομοιομερῶν δὲ τοῦτο μᾶλλον δῆλον, οἷον χειρός, ὅτι ἀνάλογον ηὔξηται — ἡ γὰρ ὕλη ἑτέρα οὖσα δήλη μᾶλλον τοῦ εἴδους ἐνταῦθα ἢ ἐπὶ σαρκὸς καὶ τῶν ὁμοιομερῶν, διὸ καὶ τεθνεώτος μᾶλλον ἂν δόξειεν εἶναι ἔτι σὰρξ καὶ ὀστοῦν ἢ χεὶρ καὶ βραχίων.

74 321b35-2a4. I agree with Verdenius and Waszink that at 322a1 the ἐναντίου of EJ is a better reading than ἐνάντιον printed by Joachim.

which are actually at work in Aristotle's physiological account of growth, as will be seen shortly.[75]

The proposed solution is, then, this. A thing can be said to grow, without violating the 'persistence' condition, despite the fact that it has lost some of its material components, as long as these components have been replaced by a larger quantity of new ones, which possess the same qualitative structure, i.e., the same sensible form, as the old ones did. In this form, the solution still begs at least two questions. First, it is open to the 'Theseus ship' paradox. If it is just the sensible qualities that are decisive for the persistence of the subject of growth, then the patched 'Theseus ship' can still count as the original vessel.[76] The difficulty is formulated by the later Aristotelian commentators not as a general problem of identity, but rather as a problem of ontological status of (sublunary) animals, with the help of the principles of replacement of matter and persistence of form. If all the matter of an animal can be replaced over and over again, why cannot this animal be immortal?[77]

Secondly, even if it is granted that sensible form so understood can account for the persistence of the subject of growth, it has to be shown that it can also satisfy the condition of omnidirectionality.

That Aristotle is most probably aware of both problems becomes clear from his discussion of the mechanism of assimilation of nourishment. In this discussion he indicates, by means of analogies, the constraints on the mechanism of replacement, and sketches an idea of the underlying dynamics of the process of physical expansion in the case of growth. His solution is not designed to cover all kinds of aggregates, but only living aggregates, i.e., the ones that have a natural monitoring system based on the 'modules' of nutrition, growth and reproduction. All three 'modules' are designed to reproduce a thing's qualitative structure. It is worth

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75 εἶδος. Cf. C.J.F. Williams who translates it as 'form' but remarks that 'in this context "kind" would have been more natural'.

76 For a discussion of this thought-experiment with respect to the general problem of defining substance, see Frede 1985.

77 Philoponus: ἀλλ' οὐδὲ τὴν ὕλην νομιστέον ὅλην καθ' ὅλην αὐτὴν τῷ χρόνῳ ἀμείβεσθαι, κατὰ μέρος ὑπεκρέουσαν, ὥστε μηδὲν εἶναι σῶμα ἐν ἡμῖν γηράσασι τοῦ ἐξ ἀρχῆς ἐκ τῆς πρώτης συμπήξεως ὑποκειμένου ἐν ἡμῖν. εἰ γὰρ τοῦτο ἦν, δυνατὸν ἦν καὶ ἀθάνατα εἶναι τὰ ζῷα, ἀεὶ τῆς ὕλης ἀκμαζούσης (107, 3-7 Vitelli). The arguments that follow in Philoponus' commentary are attributed to Alexander in Ibn Rushd's Middle Commentary, 50, 15 'Alâwî, discussion in Kupreeva 2004b, Eichner 2005.

pointing out that Aristotle here is not so much interested in physiological detail, the issues discussed in due course in the biological treatises, as in the principal ontological mechanism at work (i.e., factors accounting for identity, persistence, causal transmission, etc.). Hence the 'inorganic' examples of wine and fire:

> τί οὖν παθὸν ὑπὸ τούτου ηὐξήθη; ἢ μιχθέν, ὥσπερ οἴνῳ[78] εἴ τις ἐπιχέοι ὕδωρ, ὁ δὲ δύναιτο οἶνον ποιεῖν τὸ μιχθέν; καὶ ὥσπερ τὸ πῦρ ἁψάμενον τοῦ καυστοῦ, οὕτως ἐν τῷ αὐξανομένῳ καὶ τῷ ὄντι ἐντελεχείᾳ σαρκὶ τὸ ἐνὸν αὐξητικὸν προσελθόντος δυνάμει σαρκὸς ἐποίησεν ἐντελεχείᾳ σάρκα. οὐκοῦν ἅμα ὄντος· εἰ γὰρ χωρίς, γένεσις. ἔστι μὲν γὰρ οὕτω πῦρ ποιῆσαι ἐπὶ τὸ ὑπάρχον ἐπιθέντα ξύλα. ἀλλ' οὕτω μὲν αὔξησις, ὅταν δὲ αὐτὰ τὰ ξύλα ἀφθῇ, γένεσις.
>
> What kind of action does it undergo from that, by virtue of which it has grown? Is it, perhaps, mixed, as when someone mixes water into wine, which in turn could make the admixed stuff into wine?
>
> And as fire, when it has ignited the combustible, so in a thing which is growing and which is actually flesh, the inherent [power] that promotes growth (τὸ ἐνὸν αὐξητικόν), when that which is potentially flesh arrives, makes the actual flesh. That is, when it [the potential flesh] is in contact (ἅμα) [with the actual]; for if it is separate, it is generation. For in this way one can make fire by putting wood on top of the existing fire; but in this case it is growth, whereas when the wood itself is set on fire, it is generation (322a8-16).[79]

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78 For a defence of the reading ὑγρῷ ἢ οἴνῳ see Rashed 2001, 341.

79 Joachim excises ηὐξήθη in the first sentence and translates: 'In what way, then, has food been modified by the growing thing so as to be transformed into flesh?' He argues that 'the subject of παθόν at a8 is not τὸ αὐξανόμενον, but τὸ ᾧ αὐξάνεται, i.e., the food: for (i) it is more natural to suggest that the food is 'mixed' with the tissue than vice versa; (ii) the whole problem concerns the food (cf. a4-5 ἀπορήσειε ... αὐξάνεται), and (iii) ὑπὸ τούτου (a8-9) ought to mean 'by the agency of this, i.e., the growing thing', and not simply 'by this', i.e., 'by the food' as τὸ ᾧ αὐξάνεται'. I take the subject to be τὸ αὐξανόμενον, as is suggested by the syntax of the phrase. (i) Since the subject of discussion now is the material mechanism of growth, there is nothing wrong in saying that a growing thing is mixed with the food. (ii) seems to me to be too general a consideration to be decisive here. Making a growing thing into a subject is not inconsistent with the general topic. (iii) seems to be at the root of Joachim's decision: he thinks that because the cause of growth is internal, the

Aristotle invokes 'mixture' here not in a specific sense of combination of stuffs, but to illustrate a more likely physical mechanism by which the incoming nourishment could acquire the relevant properties of the growing tissue and become its functional part.

The example of fire should not be taken to have the same force as that of mixture;[80] rather, it limits the force of mixture example in a specific way, illustrating not the physical mechanism of adhesion, but the ontological mechanism of transmission of qualitative structure. Mixing wine with water is ontologically ambivalent, as it can stand not only for growth but also for diminution (as it does at 322a31-2). Combustion in this sense is unambiguous.[81]

Fire is a particularly good illustration of an 'entity' which possesses only intensity, getting its extension and division into parts from a thing it burns. The unity between the assimilated food (blood) and the growing thing is preserved by something that by itself cannot be divided into parts or added by parts of a similar kind. All the attempts to think of such an entity as existing on its own have been firmly ruled out of court, under any disguise, in the first part of Aristotle's discussion.

Just as the increase of fire involves the increase of intensity, so biological growth is the increase primarily not in bulk but in a special kind of intensity, biological, which preserves the dynamic and functional unity of a living thing as living. Aristotle does not say this much in our passage, but we can conjecture that it has to do with form. We shall now turn to

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growing thing cannot be regarded as a 'patient'. We have already discussed the nature of agency in the tripartite scheme used by Aristotle. Food cannot be the first efficient cause of change, but it can be the 'last' cause producing the immediate action of increase, when it has been assimilated to a growing body. Cf. *GC* I 7, 324a26-b3. (Joachim is followed by Mugler, Migliori, Williams, Verdenius and Waszink are silent; Kuhl is on my side.) Note that Philop 117, 12 is mistakenly cited by Joachim as a parallel: the subject of ηὔξησε is τὸ ὕδωρ, not τὸ ποσὸν τοῦ οἴνου as Joachim assumes. Cf. the translation by C.J.F. Williams: 'The water, when mixed and turned by the power of the wine into its own substance, increases the quantity of the wine and changes it into a larger mass'.

80 Cf. Rashed 2001, 319, who argues for a deletion of καί at 22a10, in part, on doctrinal grounds.

81 But here Aristotle is anxious to point out the difference between the continued burning and the newly-started process: the first corresponds to growth, the second to generation. The limited character of 'fire' analogy is pointed out in *de An* II 4, 416a14. Cf. also Williams 1982 *ad loc.*

the analysis of the mechanism of growth as it is presented in the last part of Aristotle's chapter.

5 The Mechanism of Growth: Bloody Ducts and Skeletons on the Walls Revisited

Aristotle points out that the quantity that comes to be in growth cannot be 'universal', because there is no such thing, just as there is no animal which is neither a man nor any other particular animal. We normally talk rather about the coming to be of flesh, bone, hand — all taken as uniform bodies — in a certain quantity.[82] A certain quantity of flesh comes to be when a certain quantity is added — not of flesh, but of something else (for the process of growth involves the assimilation of a dissimilar food).

Aristotle draws a distinction between the process of nourishment, which underlies subsistence, on the one hand, and growth, which underlies proportionate increase, on the other. He says that insofar as the added material is flesh potentially, the process is that of nourishment. Insofar as it is 'a certain quantity of that which is flesh potentially', the process will be that of growth. The distinction is not straightforwardly clear: one would think that anything that is potentially flesh (δυνάμει σάρξ), must come in a certain quantity, so must also be potentially a certain quantity of flesh (δυνάμει ποσὴ σάρξ). It is best understood from the viewpoint of the general theory of change as developed in *Physics* I 7, according to which ποσὴ σάρξ designates the acquired qualification (εἶδος) in the case of growth (σάρξ without a modifier corresponds to the case of simple generation, as Aristotle never fails to point out).

The final simile, which is supposed to illustrate the distinction, is difficult both textually and conceptually. Aristotle says (in the text as emended by Joachim):

> And this form is, like a *duct* (αὐλός), a certain power in matter. So that if some matter arrives, which is potentially a *duct* and has potentially a certain quantity, these *ducts* will be bigger. But if it cannot make anything more, but as water being more and more admixed to wine

82 322a19: σὰρξ δὲ ἡ ὀστοῦν ἢ χεὶρ καὶ τούτων τὰ ὁμοιομερῆ. I agree with Verdenius and Waszink that Joachim's insertion of ἢ βραχίων after χείρ is unnecessary.

> finally makes it watery and water, then it produces diminution of the quantity. But the form persists. (322a29-33)[83]

Ancient commentators read ἄϋλος in all three occurrences.[84] The correct reading is owed to Joachim's emendation, prompted, as he points out, by the translation of Vatablus (*tibia* and *tibiae*) and by the word αὐλός used by Philoponus on 321b10 (109, 29-32 Vit).[85] Other grounds for his reading cited by Joachim include Aristotle's use of the word αὐλός 'for various kinds of "ducts" or "channels" in an animal's body: cf. Bonitz, *Ind* 122a26ff.'[86], as well as the 'water-measuring' analogy at 321b24.[87] Joachim's correction is accepted by most commentators,[88] although further explanations are usually avoided.[89] Common agreement seems to be due to the fact that αὐλός is most certainly a *lectio difficilior*.

It is possible that we do have indirect evidence for this reading from the earlier tradition, before Philoponus. In Alexander's discussion of

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83 322a28-33: τοῦτο δὲ τὸ εἶδος [ἄνευ ὕλης], οἷον αὐλός, δύναμίς τις ἐν ὕλῃ ἐστίν. ἐὰν δή τις προσίῃ ὕλη, οὖσα δυνάμει αὐλός, ἔχουσα καὶ τὸ ποσὸν δυνάμει, οὗτοι ἔσονται μείζους αὐλοί. ἐὰν δὲ μηκέτι ποιεῖν δύνηται, ἀλλ' οἷον ὕδωρ οἴνῳ ἀεὶ πλεῖον μιγνύμενον τέλος ὑδαρῆ ποιεῖ καὶ ὕδωρ, τότε φθίσιν ποιήσει τοῦ ποσοῦ· τὸ δ' εἶδος μένει. I follow Joachim's text, also in excising [ἄνευ ὕλης], although not without a minor reservation: I think it would not be impossible to take it provisionally as adverbial, contrasting with ἐὰν δή τις προσίῃ ὕλη, at least until some more positive evidence of interpolation turns up. As will be seen shortly, Aristotle does treat blood as 'matter' of the flesh, so it is not altogether impossible to think of a runnel as a 'form without matter'.

84 Philop 121, 25-122, 8 Vitelli. Alexander does not report any different readings, nor does he question the received one (ἄϋλος as well as ἔνυλος being a part of his own active vocabulary). But his explanation of this passage recorded by Philoponus shows that he wants to stave off the unlikely metaphysical connotations of the expression at this point: ἤ, ὡς ὁ Ἀλέξανδρός φησι, τὸ τοῦτο δὲ τὸ εἶδος ἄνευ ὕλης, ἴσον ἐστὶ τῷ 'ἡ τροφή, ὅταν τρέφῃ μέν, μὴ αὔξῃ δέ, τὸ εἶδος τηρεῖ ἄνευ προσθήκης ὑλικῆς' (122, 4-6 Vitelli).

85 In Philoponus' discussion the word refers to a wax tube.

86 Cf. also n 117 below.

87 Or rather, perhaps, Alexander's discussion of growth which Joachim takes to be applying this analogy.

88 Migliori is one notable exception. See a review by Sharples 1979, at 214-5.

89 So Verdenius and Waszink, Kuhl, and Williams 1982.

growth, both in his treatise *De Mixtione* and in the fragments of his commentary quoted by Philoponus, we find an image of a pipe made of elastic material, such as skin, in the explanation of omnidirectional growth. A 'pipe' analogy is supposed to illustrate proportionate growth in the non-uniform parts.

> Each of them [viz. non-uniform parts] grows as a whole by this proportion, while they preserve the body that they are in, and we must understand that the case of bodies that grow through nutriment by the agency of nature and the nutritive faculty is like conceiving wine moving along a pipe which maintains the same shape, but because of its elasticity and pliancy is compressed and maintains its shape in a smaller volume when the liquid moving along it is less than its volume, but when it is greater it expands in every direction and assumes a larger volume. As with such a pipe the water is not what grows, as it does not remain at all stable, but assumes varying volumes, but the shape containing the liquid is what is stable and what assumes expansion and contraction — so too must the process involved in natural growth be understood: that while the matter to which the growing form belongs must vary at different times on account of its continual evacuation, the form, on the other hand, that persists in the flowing matter, analogously to the shape of a pipe, diminishes when the matter decreases, but grows when the absorption of matter increases, maintaining all along the body's proper shape. (237, 25-238, 10 Todd trans, lightly modified)

This explanation is found also in Philoponus' commentary, where we get more details concerning the analogy itself (the pipe is said to be leathern, ὁ σωλὴν δερμάτινος), and the physiological processes it is supposed to illustrate.[90] Philoponus most likely took this over from Alexander's commentary.[91] We do not know how Alexander arrived at this image in his interpretation of Aristotle's analogies. It is very likely that he is not aware of the reading αὐλός; otherwise this reading would have surfaced in one of our sources. Still the possibility should not be

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90 105, 22-3; 107, 28, 31; 108, 13; 117, 26 Vitelli. Cf. also 105, 18-19: ὥσπερ γὰρ εἰ θύλακός τις εἴη, which is probably Philoponus' gloss.

91 On relation between Philoponus' and Alexander's commentaries, see Todd 1977, Gannagé 1998, Kupreeva 2004b and 2005.

ruled out that his commentary builds on an earlier tradition which reflects a correct reading: the words σωλήν and αὐλός are often used as synonyms in the medical tradition.[92]

Modern commentators differ in their interpretation of the whole passage. Joachim thinks that τοῦτο τὸ εἶδος refers to the part of the soul which is the efficient cause of growth, and makes it also the subject of the last sentence.[93] He notes that on this reading, the parallel with water and wine does not work very well, but does not consider the possibility of a different construal.[94] Verdenius and Waszink argue, on the contrary, that τοῦτο τὸ εἶδος has to refer to τὸ προσιόν back at line 26.[95] Unlike Joachim, they think that Aristotle's comparison with wine-mixing is

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92 E.g., Galen, *de plenitudine* X (VII 563, 6 K). τὸ γὰρ ἐπὶ τῇ τῶν στερεῶν σωμάτων εὐτροφίᾳ νομίζειν ποτὲ δύνασθαι κίνησιν ἀτονωτέραν ἀπεργασθῆναι μὴ γινοσκόντων ἐστὶν ἀνθρώπων ὡς δι' ὅλων τῶν στερεῶν σωμάτων αἱ δυνάμεις διήκουσιν, ἀλλ' ὥσπερ αὐλοὺς ἢ σωλῆνας πνευματι τὰς ἀρτηρίας καὶ τὰ νεῦρα παρασκευαζόντων. Cf. *de usu part* XVI (IV 320, 11 K): φαίνεται τοίνυν ἡ φύσις αὖ τοῖς μεγίστοις τῶν ἀγγείων ὁμοίως τοῖς ἀγωγοῖς τῶν ὑδάτων χρωμένη, καθ' ἕκαστον δὲ τῶν χωρίων ὧν διεξέρχεται ταῦτα τοῖς πλησίον ἅπασιν οἷον ὀχέτους τινας ἢ σωλῆνας ἐπιπέμπουσα διαφόρους τῷ μεγέθει κατὰ τὴν ἀξίαν τε καὶ χρείαν τῶν ληψομένων, ἅπαντας γοῦν ἐκ βραχυτάτου διαστήματος ἐπάγουσα.

93 'The 'form' is the embodied ψυχὴ αὐξητική, the δύναμις αὐξητική which is essentially immersed in matter. cf. *21b25-28. As the animal grows old, this 'power' ... becomes weaker, i.e., unable to assimilate sufficient food to balance the waster of the tissues (cf. *22a24). Aristotle compares this enfeeblement of the αὐξητικόν to the weakening of the wine, when more and more water is mixed with it. But the parallel is not exact: for the 'form' of the tissue remains (a33), whereas the wine is ultimately converted into water (a32).' In this Joachim is followed most recently by King 2001, 160, n 125. C.J.F. Williams obelizes the whole passage in his translation and resigns from the explanation.

94 'Aristotle's meaning is clear: but the illustration (a31-2 ἀλλ' ... καὶ ὕδωρ) is rather loosely attached to the main sentence. *What has to be illustrated* is the decay of the power embodied in the tissue: but *what is expressed in the illustration* is the action of the water in weakening the wine.'

95 Verdenius, Waszink, 29: 'Aristotle calls the food which causes the growth of the flesh (1) τὸ προσιόν (a26) and (2) δυνάμει ποσὴ σάρξ (a26-27). Similarly he says: ἐὰν δή τις προσίῃ ὕλη, οὖσα δυνάμει αὐλός, ἔχουσα καὶ τὸ ποσὸν δυνάμει (a29-30). Hence, the 'potential duct' is conceived as a kind of food. Since the εἶδος is defined as δύναμίς τις ἐν ὕλῃ, the conclusion is obvious that this 'form' denotes the acceding matter. The words τοῦτο τὸ εἶδος refer to the preceding τὸ προσιόν, and the two sentences are closely connected.'

appropriate.[96] They also argue, on the basis of Aristotle's general theory of mixture, that the last clause τὸ δ' εἶδος μένει refers to the power of food to become flesh, and the power of water to become wine.[97]

I would like first to clarify the phrase τοῦτο ... τὸ εἶδος ... οἷον αὐλός, starting with εἶδος. At 322a20-4, Aristotle draws a distinction between that which is δυνάμει σάρξ and that which is δυνάμει ποσὴ σάρξ. The incoming matter of growth is described at 322a29 as οὖσα δυνάμει αὐλός, ἔχουσα καὶ τὸ ποσὸν δυνάμει. Obviously, the analysis of αὐλός — whatever that means — is supposed to be parallel to the analysis of σάρξ: δυνάμει ποσὸς αὐλός is parallel to δυνάμει ποσὴ σάρξ. It is logical to suppose that αὐλός should then correspond to σάρξ taken without a quantitative modifier (ποσή). Taking a cue from this parallel, we can conjecture that the first sentence of our passage, τοῦτο δὲ τὸ εἶδος [ἄνευ ὕλης], οἷον αὐλός, δύναμίς τις ἐν ὕλῃ ἐστίν (322a28-9), explains what σάρξ is as the subject of growth: it is some form, such as duct, which is a certain power in matter. The description of form, and more specifically, 'duct', as a δύναμις can be understood in the light of Aristotle's description of the function of the uniform parts in the process of growth.[98] The following sentence then should describe what happens when the incoming matter is potentially a duct with a quantity. Aristotle says that in this

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96 Verdenius, Waszink, 30: 'We think the illustration to be correct and the subject of the sentence to have the same function as the water it is compared to. Since the water is added to wine, the subject must be τὸ προσιόν. Accordingly, the term ποιεῖν does not refer to the assimilating power of the growing thing, but to the producing power of the matter which is added to it. The water which is added to the wine in a steadily increasing amount at last produces a mixture which we are no longer justified in calling wine; similarly, an excessive amount of food may cause illness and a diminution of flesh.'

97 'Yet the water, which in this case, owing to its overwhelming amount, has not been able to produce wine, does not lose its power to increase the quantity of wine. For the constituents of a mixture remain potentially what they were before the mixing took place (327b24-26 ἐνεργείᾳ μὲν ἑτέρου ὄντος τοῦ γεγόνοτος ἐξ αὐτῶν, δυνάμει δ' ἔτι ἑκατέρου ἅπερ ἦσαν πρὶν μιχθῆναι). So the water retains its εἶδος (322a33), i.e., remains δυνάμει ποσὸς οἶνος, just as the food is always δυνάμει ποσὴ σάρξ.'

98 It may be noteworthy that in his discussion of the composition of living bodies in *PA* II 1, Aristotle points it out as a difference between the uniform and non-uniform parts that the former always instantiate one kind of *power* each, while each of the non-uniform parts has several 'powers' in combination. See the discussion below, 142 and n 106.

case 'these ducts become bigger'. What ducts? Most probably the ones that have been in the matter of a growing thing before the new arrival of matter. So, ducts are within the matter of a growing thing, and the incoming matter has to be a duct potentially. This agrees with the suggestion that 'this form' should be taken as referring to the functionally relevant qualitative structure of a growing thing, which a thing 'by which' growth happens (food) must possess potentially.

The last sentence of the passage in question, ἐὰν δὲ μηκέτι ποιεῖν δύνηται, ἀλλ' οἷον ὕδωρ οἴνῳ ἀεὶ πλεῖον μιγνύμενον τέλος ὑδαρῆ ποιεῖ καὶ ὕδωρ, τότε φθίσιν ποιήσει τοῦ ποσοῦ· τὸ δ' εἶδος μένει (322a31-3), should deal with the case where the incoming matter is δυνάμει σάρξ, without a quantity which could produce growth 'on top' of nourishment. According to the reading which I have proposed, μηκέτι ποιεῖν δύνηται must refer to the difference between the two cases, described in terms of a different capacity of the incoming matter. This is illustrated by the example of water and wine. The sense of the analogy in this sentence is difficult. Joachim's inclination to construe the predicate, on doctrinal grounds, with δύναμις αὐξητική (grammatically and thematically absent from the passage) is very understandable. But the grammatical intuition of Verdenius and Waszink at this point (taking τὸ προσιόν as the subject, nn 95-6 above) seems to be correct. Additionally, φθίσιν ποιήσει τοῦ ποσοῦ would be expected to be functionally parallel to the subject of ὑδαρῆ ποιεῖ καὶ ὕδωρ, i.e., ὕδωρ. This need not mean a departure from the doctrinal point about the immanent cause of growth. The verb ποιεῖν does not have to refer only to the first efficient cause of change. In *GC* I 7 Aristotle discusses different types of moving and efficient causes, distinguishing between the 'first' and the 'last' causes in the causal chain. On this view, although the first principle of growth is within the growing thing, some relevant power is in the food, too, and the food can be said to 'produce' growth or nourishment, as long as the meaning of this has been made clear. Aristotle does in fact cite 'bread' as an example of the last productive cause which undergoes an action while producing an effect.[99] This usage is also in agreement with a non-theoretical way of speaking: we can say that food 'cannot produce growth', as we say that

99 *GC* I 7: 324a34-b4: ὅσα γὰρ μὴ ἔχει τὴν αὐτὴν ὕλην, ποιεῖ ἀπαθῆ ὄντα (οἷον ἡ ἰατρική, αὐτὴ γὰρ ποιοῦσα ὑγίειαν οὐδὲν πάσχει ὑπὸ τοῦ ὑγιαζομένου), τὸ δὲ σιτίον ποιοῦν καὶ αὐτὸ πάσχει τι ἢ γὰρ θερμαίνεται ἢ ψύχεται ἢ ἄλλο τι πάσχει ἅμα ποιοῦν. ἔστι δὲ ἡ μὲν ἰατρικὴ ὡς ἀρχή, τό δὲ σιτίον τὸ ὡς ἔσχατον καὶ ἀπτόμενον.

food, or medicines, can no longer help under the circumstances, meaning not any lack of inherent power in food or drugs, but rather their inadequacy in the situation in question.

τὸ δ' εἶδος μένει refers to the form which resides in the matter of a growing thing.[100] The food which does not have enough quantity to produce growth, can produce diminution of the quantity; but the form itself persists.

In order to explain this last point, it is necessary, finally, to deal with the exact meaning of αὐλός. I have assumed so far that the whole passage explains the last point of Aristotle's discussion of the difference between growth and nourishment, which begins at 322a20. I would like to suggest taking the word αὐλός as referring to the basic type of structure characteristic of flesh as a uniform part of a living body. In this I merely follow the idea of Joachim who says *ad loc*: 'The duct, as that which limits and measures the tissue, may be regarded as its "figure" or "form".' But Joachim seems to identify form with a non-uniform structure, whereas my suggestion is to follow through the distinction between form and matter in the uniform parts, and explore the possibility of taking the 'duct' to be the form of a uniform part.

That a blood vessel is an essential structural unit of flesh, appears to be Aristotle's standard view in the biological treatises. In *PA* III 5, having shown that there has to be one central organ in the animal organism, Aristotle goes on to explain why blood is dispersed from the central organ all over the body. According to him, this is because blood is the matter of the whole body, and, being liquid, it is in need of a vessel.[101] He explains the idea using the two 'craft' analogies:

> The system of blood-vessels in the body may be compared to those water-courses which are constructed in gardens: they start from one

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100 In this I agree with Joachim, against Verdenius and Waszink.

101 668a4: τοῦ δ' εἰς τὸ πᾶν διαδεδόσθαι τὸ σῶμα τὰς φλέβας αἴτιον τὸ παντὸς εἶναι τοῦ σώματος ὕλην τὸ αἷμα, τοῖς δ' ἀναίμοις τὸ ἀνάλογον, ταῦτα δ' ἐν φλεβὶ καὶ τῷ ἀνάλογον κεῖσθαι. I agree with I. Düring and P. Louis, against A.L. Peck, that there is no need to seclude the passage 668a9-14: Συνισταμένων δὲ τῶν μορίων ἐκ τοῦ αἵματος, καθάπερ εἴπομεν, εὐλόγως ἡ τῶν φλεβῶν ῥύσις διὰ παντὸς τοῦ σώματος πέφυκεν· δεῖ γὰρ καὶ τὸ αἷμα διὰ παντὸς καὶ παρὰ πᾶν εἶναι, εἴπερ τῶν μορίων ἕκαστον ἐκ τούτου συνέστηκεν. On blood as matter of the body, cf. also *PA* II 4, 651a14.

> source, or spring, and branch off into numerous channels, and then into still more, and so on progressively, so as to carry a supply to every part of the garden. And again, when a house is being built, supplies of stones are placed all alongside the lines of the foundations. These things are done because (a) water is the material out of which the plants in the garden grow, and (b) stones are the material out of which the foundations are built. In the same way, Nature has provided for the irrigation of the whole body with blood, because blood is the material out of which it is all made. (668a14-22, trans. Peck)[102]

Both analogies have a good pedigree in the Greek philosophical literature of the classical period. The imagery of irrigation is used for the description of physiological functions in Plato's *Timaeus* 77c5-79a4, where the analogy of water-courses is put in the context of the purposeful activity of the constructive cosmic powers.

> Now when our superiors have planted all those natures to be food for us who are of the weaker stock, they cut various channels through a body as through a garden, that it might be watered as from a running stream.[103]

Plato uses the terminology of ὑδραγωγία in order to describe the complex mechanism of repletion in what he regards as a single system of vessels serving the functions of respiration, nutrition and basic sensation, at the

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102 668a14-22: ἔοικε δ' ὥσπερ ἐν τοῖς κήποις αἱ ὑδραγωγίαι κατασκευάζονται ἀπὸ μιᾶς ἀρχῆς καὶ πηγῆς εἰς πολλοὺς ὀχετοὺς καὶ ἄλλους ἀεὶ πρὸς τὸ πάντῃ μεταδιδόναι, καὶ ἐν ταῖς οἰκοδομίαις παρὰ πᾶσαν τὴν τῶν θεμελίων ὑπογραφὴν λίθοι παραβέβληνται, διὰ τὸ τὰ μὲν κηπευόμενα φύεσθαι ἐκ τοῦ ὕδατος, τοὺς δὲ θεμελίους ἐκ τῶν λίθων οἰκοδομεῖσθαι, τὸν αὐτὸν τρόπον καὶ ἡ φύσις τὸ αἷμα διὰ παντὸς ὠχέτευκε τοῦ σώματος, ἐπειδὴ παντὸς ὕλη πέφυκε τοῦτο.

103 77c5-8: ταῦτα δὴ τὰ γένη πάντα φυτευσάντες οἱ κρείττους τοῖς ἥττοσιν ἡμῖν τροφήν, τὸ σῶμα αὐτὸ ἡμῶν διωχέτευσαν τέμνοντες οἷον ἐν κήποις ὀχετούς, ἵνα ὥσπερ ἐκ νάματος ἐπιόντος ἄρδοιτο. On the link between respiration and nutrition: 78e5-79b4: ὁπόταν γὰρ εἴσω καὶ ἔξω τῆς ἀναπνοῆς ἰούσης τὸ πῦρ ἐντὸς συνημμένον ἕπηται, διαιρούμενον δὲ ἀεὶ διὰ τῆς κοιλίας εἰσελθὸν τὰ σιτία καὶ ποτὰ λάβῃ, τήκει δή, καὶ κατὰ σμικρὰ διαιροῦν, διὰ τῶν ἐξόδων ἧπερ πορεύεται διάγον, οἷον ἐκ κρήνης ἐπ' ὀχετοὺς ἐπὶ τὰς φλέβας ἀντλοῦν αὐτά, ῥεῖν ὥσπερ αὐλώνος διὰ τοῦ σώματος τὰ τῶν φλεβῶν ποιεῖ ῥεύματα. Note αὐλών, 'aquaeduct' (Cornford), which is here an analogy for the body taken as a mass: this is not far from Aristotle's imagery in the GC I 5 passage.

same time.[104] Aristotle's debt to Plato's locus is clear from the language and cross-references, as well as from the emphasis on the teleological import of the analogy common (although differently expressed) in both authors.

Aristotle's 'watering' analogy in this case has a more specific theoretical target than the one used by Plato. Its main point is to explain the status of blood in terms of functional distinction between unstructured matter and the principle of structure. To that end, this analogy is 'backed up', as it were, by a parallel analogy of house-building, one of Aristotle's favourite paradigms used to illustrate a number of different theoretical points. In our passage, its main point is that the blood-vessels of a living body are like the lines of an architect's plan on a construction site. They provide the guidelines to the process of construction because they determine the structure of a building, in one case, and of a living being in the other.

Moreover, this formal structure is not merely provisional; not like the scaffolding or the ladder which can be thrown away once the goal of its use has been achieved. It is something that makes a real part of a thing, and whose destruction is only possible at a price of the destruction of a thing itself. When a thing is present, in however diminished condition, the system of blood vessels has to be present, too. Aristotle says that

> <t>his becomes evident in cases of severe emaciation, when nothing is to be seen but the blood-vessels: just as the leaves of vines and fig-trees and similar plants, when they wither, leave behind nothing but veins. The explanation of this is that the blood (or its counterpart) is, potentially, the body (that is, flesh — or its counterpart). Thus, just as in the irrigation system the biggest channels persist whereas the smallest ones quickly get obliterated by the mud, though when the mud abates they reappear; so in the body the largest blood-vessels persist, while the smallest ones become flesh in actuality, though potentially they are blood-vessels as much as ever before.[105] (668a22-33, trans. Peck)

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104 For the explanation of the theory of physiological functions, see Cornford 1937 *ad loc.* On the dependence of the *Timaeus* physiology on the medical theories of the fifth and fourth centuries, see Harris 1973, 117-21.

105 668a22-33: γίνεται δὲ κατάδηλον ἐν τοῖς μάλιστα καταλελεπτυσμένοις· οὐδὲν γὰρ ἄλλο φαίνεται παρὰ τὰς φλέβας, καθάπερ ἐπὶ τῶν ἀμπελίνων τε καὶ συκίνων φύλλων καὶ ὅσ' ἄλλα τοιαῦτα· καὶ γὰρ τούτων αὐαινομένων φλέβες λείπονται μόνον. τούτων δ' αἴτιον

The description of flesh as 'this form, a kind of power in matter, like a duct' is consistent with Aristotle's account of organic tissues in the biological corpus. Introducing the distinction between the uniform and non-uniform parts in *PA* II 1, he says that every given uniform part can have natural powers (i.e., physical qualities, such as hard/soft, moist/dry, viscous/brittle) only 'in part', i.e., in each homoiomer there will be present at most one part of each tangible contrariety.[106] It is reasonable to suppose that there must be some basic structure underlying each of these 'powers'. In the case of flesh, this structure involves a system of blood-vessels.

Aristotle describes the internal organs of a living body as non-uniform parts which are each composed of a single uniform tissue.[107] All of them have a common formative mechanism, which Aristotle consistently likens to the process of sedimentation. All the viscera, except the heart, are formed on the blood vessels, like the mud or silt deposited by running streams:

> They are all composed of the same matter, as they all have a sanguineous character, and this is because they are situated upon the channels of the blood-vessels and on the points of ramification. All these viscera (excluding the heart) may be compared to the mud which a running

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ὅτι τὸ αἷμα καὶ τὸ ἀνάλογον τούτῳ δυνάμει σῶμα καὶ σὰρξ ἢ τὸ ἀνάλογόν ἐστιν· καθάπερ οὖν ἐν ταῖς ὀχετείαις αἱ μέγισται τῶν τάφρων διαμένουσιν, αἱ δ' ἐλάχισται πρῶται καὶ ταχέως ὑπὸ τῆς ἰλύος ἀφανίζονται, πάλιν δ' ἐκλειπούσης φανεραὶ γίνονται, τὸν αὐτὸν τρόπον καὶ τῶν φλεβῶν αἱ μὲν μέγισται διαμένουσιν, αἱ δ' ἐλάχισται γίνονται σάρκες ἐνεργείᾳ, δυνάμει δ' εἰσὶν οὐδὲν ἧσσον φλέβες.

106 Non-uniform parts, on the other hand, can have the combinations of different 'powers' that include contraries. *PA* II 1, 646b20-27: τὰ μὲν οὖν ὁμοιομερῆ κατὰ μέρος διείληφε τὰς δυνάμεις τὰς τοιαύτας (τὸ μὲν γὰρ αὐτῶν ἐστι μαλακὸν τὸ δὲ σκληρόν, καὶ τὸ μὲν ὑγρὸν τὸ δὲ ξηρόν, καὶ τὸ μὲν γλίσχρον τὸ δὲ κραῦρον), τὰ δ' ἀνομοιομερῆ κατὰ πολλὰς καὶ συγκειμένας ἀλλήλαις· ἑτέρα γὰρ πρὸς τὸ πιέσαι τῇ χειρὶ χρήσιμος δύναμις καὶ πρὸς τὸ λαβεῖν. διόπερ ἐξ ὀστῶν καὶ νεύρων καὶ σαρκὸς καὶ τῶν ἄλλων τῶν τοιούτων συνεστήκασι τὰ ὀργανικὰ τῶν μορίων, ἀλλ' οὐκ ἐκεῖνα ἐκ τούτων. From the previous context it is clear that δύναμις here refers not to a single inherent quality but in a special kind of qualitative structure where all parts are functionally identical.

107 646b31: τὰ μὲν γὰρ ἀνομοιομερῆ ἐκ τῶν ὁμοιομερῶν ἐνδέχεται συνεστάναι, καὶ ἐκ πλειόνων καὶ ἑνός, οἷον ἔνια τῶν σπλάγχνων· πολύμορφα γὰρ τοῖς σχήμασιν, ἐξ ὁμοιομεροῦς ὄντα σώματος ὡς εἰπεῖν ἁπλῶς.

> stream deposits; they are as it were the silt deposits left by the current of blood in the blood-vessels.[108] (647a35 trans .Peck, lightly modified)

When there is enough right nourishment, blood in the narrowest vessels can convert into flesh. When the vessels are filled they still retain their power of 'ducts', if only potentially. To explain this, Aristotle again invokes the analogy of drowned and clogged channels in the irrigation system: the furrows are still there although they are not clearly seen under water and mud. It is for this reason, he says,

> that as long as the flesh is in a sound condition, wherever it is cut, blood will flow; and although no blood-vessels are visible, they must be there (because we cannot have blood without blood-vessels) — just as the irrigating channels are there right enough, but are not visible until they are cleared of mud. (668a33 trans. Peck)[109]

When the incoming food which is potentially flesh (i.e., blood) is not in a right quantity to ensure growth, it can eventually 'clear' the vessels, destroying the quantity of flesh. However the 'form', i.e., the vessel itself, will still persist while the animal is alive. This can be seen in cases of emaciation. This is what the last clause of *GC* I 5 refers to.

The image of clogged blood-vessels is fairly persistent in the description of the structure of flesh.[110] So is the 'architectonic' image of a functional blueprint of a living body. We have seen above how the idea of the architectonics of a living body embedded in the fluctuating irrigation system is underscored by the 'construction site' analogy. In *HA* III

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108 647a35: ἐκ τῆς αὐτῆς γὰρ ὕλης συνεστᾶσιν· αἱματικὴ γὰρ ἡ φύσις πάντων αὐτῶν διὰ τὸ τὴν θέσιν ἔχειν ἐπὶ πόροις φλεβικοῖς καὶ διαλήψεσιν. καθάπερ οὖν ῥέοντος ὕδατος ἰλύς, τἆλλα σπλάγχνα τῆς διὰ τῶν φλεβῶν ῥύσεως τοῦ αἵματος οἷον προχεύματα ἐστιν.

109 668a33: διὸ καὶ σωζομένων τῶν σαρκῶν καθ' ὁτιοῦν αἷμα ῥεῖ διαιρουμένων· καίτοι ἄνευ μὲν φλεβὸς οὐκ ἔστιν αἷμα, φλέβιον δ' οὐδὲν δῆλον, ὥσπερ οὐδ' ἐν τοῖς ὀχετοῖς αἱ τάφροι πρὶν ἢ τὴν ἰλὺν ἐξαιρεθῆναι.

110 *HA* III 4: 'In little animals and those scantily supplied with blood, either from natural and inherent causes or from a prevalence of fat in the body, thorough accuracy in investigation is not equally attainable; for in the latter of these creatures the passages get clogged, like water-channels choked with slush (τῶν μὲν γὰρ οἱ πόροι συνκεχυμένοι καθάπερ ὀχετοί τινες ὑπὸ πολλῆς ἰλύος εἰσίν); and the others have a few minute fibres to serve instead of veins. But in all cases the big vein is plainly discernible, even in creatures of insignificant size' (515a22-6, trans D'Arcy Thompson).

5, Aristotle draws a contrast between the vascular system and the system of sinews with the help of a further 'craft' analogy:

> For the veins have the shape of the entire body, as in a sketch; in such a way that in very attenuated organisms the whole mass seems to be full of small veins; for the same place, when they are thin, is small blood-vessels, when they get thick, is flesh). Sinews, on the other hand, are divided from each other being located on the joints and flexures of the bones.[111] (trans. D'Arcy Thompson, modified)

The same image is used again in the introduction of the non-uniform parts in *GA* II 6:

> Beginning at the heart, the blood-vessels extend all over the body. They may be compared to the sketches of [human or animal] figures drawn on the walls of buildings. For the parts are situated around the blood-vessels, because they are formed out of them.[112]

The word for 'sketch', κάναβος, extremely rare in this spelling, gave much trouble to students of the text. The only cue to the meaning that Aristotle himself gives us, apart from the blood-vessels analogy, is the indication that these κάναβοι were drawn on the walls. The lexicographers, on the other hand, say that the term refers to a sculptor's device.[113] The point of the analogy is that the blood-vessels, running from the heart, form as it were a blueprint of a living body. In the process of nourishment these vessels can partly convert into flesh, and when nourishment is not sufficient they can re-convert back to the basic structure. This basic structure plays the role of form of a body in all its different transforma-

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111 515a33-b5: αἱ μὲν γὰρ φλέβες, ὥσπερ ἐν τοῖς γραφομένοις κανάβοις, τὸ τοῦ σώματος ἔχουσι σχῆμα παντὸς οὕτως ὥστ' ἐν τοῖς σφόδρα λελεπτυσμένοις πάντα τὸν ὄγκον φαίνεσθαι πλήρη φλεβίων (γίνεται γὰρ ὁ αὐτὸς τόπος λεπτῶν μὲν ὄντων φλέβια, παχυνθέντων δὲ σάρκες), τὰ δὲ νεῦρα διεσπασμένα περὶ τὰ ἄρθρα καὶ τὰς τῶν ὀστῶν ἐστι κάμψεις.

112 743a1-4: ἐκ δὲ τῆς καρδίας αἱ φλέβες διατεταμέναι καθάπερ οἱ τοὺς κανάβους γράφοντες ἐν τοῖς τοίχοις· τὰ γὰρ μέρη περὶ ταύτας ἐστίν, ἅτε γινόμενα ἐκ τούτων. Peck's emendation διατέτανται seems unnecessary if we assume an omitted verb in the first clause.

113 See Appendix 3, pp. 154-6 below.

tions. It is particularly interesting to note that the same bodily texture can now be flesh, and at another time a blood-vessel, or vessels.[114] The border between the actual and the potential within a living tissue seems to be open, although restrictedly so, the restrictions being laid down by the specific form of the whole of a living thing. Thus, the analogy of 'ducts' used by Aristotle at the end of the growth chapter appears to support the hylomorphic analysis of uniform parts as outlined by him in the middle of his discussion.

A problem may arise for the suggested reading that has to do more specifically with Aristotle's views on the physiology of growth. It appears from *GC* I 5 that flesh grows because the ducts in matter become bigger when suitable matter arrives in the right quantity. But the description of the mechanism of sedimentation in the biological treatises implies that flesh is formed at the expense of the vessels, and vice versa: in the process of growth of flesh the vessels in which flesh is formed as sediment should get clogged and effectively 'obliterated' instead of becoming bigger. As M.P. Duminil has pointed out, in the texts of the Hippocratic corpus contemporary or near-contemporary with Aristotle, we find a parallel view, according to which flesh grows at the expense of the vessels.[115] Is this consistent with the idea stated in *GC*, namely that the vessels become bigger?

I think there need not be an inconsistency between the two accounts, if we draw a distinction between a more specific physiological account found in the biological treatises, where flesh is contrasted with the corresponding system of vessels, and the less specific one, in which flesh is treated as a uniform part together with the corresponding vascular system. The ground for such a distinction is provided by Aristotle's clarification of the analogies of sedimentation and house-building: the deposits of blood are compared to the proximate matter of house-building, ready to be used in the construction: this function of blood as a material out of which vessels are constructed is not cancelled by the fact

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114 Cf. also *HA* III 15, 519b32: λεπτυνομένων μὲν οὖν τῶν ζῴων ἀφανίζονται (scil. σάρκες), καὶ γίνονται φλέβια καὶ ἶνες· εὐβοσίᾳ δὲ πλείονι χρωμένων πιμελὴ ἀντὶ σαρκῶν. Εἰσὶ δὲ τοῖς μὲν ἔχουσι τὰς σάρκας πολλὰς αἱ φλέβες ἐλάττους καὶ τὸ αἷμα ἐρυθρότερον καὶ τὰ σπλάγχνα καὶ τὰ κοιλία μικρά· τοῖς δὲ τάς φλέβας ἔχουσι μεγάλας καὶ τὸ αἷμα μελάντερον καὶ σπλάγχνα μεγάλα καὶ κοιλία μεγάλη, αἱ δὲ σάρκες ἐλάττους.

115 *Epid* II 1, 8 (V 80, 6 Littré), VI 4, 19 (V 312, 7 L), *de diaeta salubri* c 7 (VI 84, 1L), discussion in Duminil 1983, 16-21.

that the 'fleshy' part increases at the expense of the vascular part. Both are constitutive of a single continuous activity of a living tissue.[116] If the word αὐλός is taken as a description of this functionally inclusive structure of flesh, not in the exclusive sense of an empty vessel as opposed to the mass of sediment,[117] we can take the passage as describing the growth of flesh in the uniform parts. This will preserve the consistency of Aristotle's position. The question of the precise physiological mechanism of growth of vessels themselves is, on this reading, unanswered. Moreover, no answer to this question is found in the rest of the extant Aristotelian corpus. Many different answers supplied by followers and commentators, from Erasistratus to Ibn-Rushd, show the absence of a 'canonical' doctrine on this issue.

* * * *

The goal of this paper was to analyse the argument, explaining difficulties and trying to track down the logic of the concepts 'form' and 'matter' in the account of growth. We have seen that the argument makes a number of significant metaphysical claims. In the first part of his discussion, Aristotle considers growth in its most general meaning of 'increase', and shows that there are no separate powers of increase which could produce an increase without any contribution of actually existing things. The notion of matter of growth has to be very special. It cannot be construed as 'another thing', or even a property of 'another thing', triggering the emergence of a new quantity, as it were 'extrinsically'. It

116 Note Aristotle's remark in *HA* III 2, 511b14, that in a dead body vessels disappear; discussion in Duminil 1983, 16-17.

117 The word αὐλός, in the meaning of 'tube' or 'channel' (as opposed to 'flute') occurs in the Aristotelian works ca. 30 times. It is used technically in several zoological contexts, denoting the blowhole of the cetaceans and dolphins through which they discharge water (*HA* 489b3-4; 524a10; 537b1; 589b2-19; *PA* 659b16; 697a17-24, *Resp* 476b16-28), the funnel of cephalopods (*PA* 679a2: καλούμενος αὐλός; *GA* 720b32), the branchial artery in fishes (*Resp* 478b8). He also uses this term to designate a tube as a hypothetical device, in the explanation of vision (*GA* 780b19-81a9). I think the use of this word in our passage is similar to this latter case: it does not illustrate the idea by reference to any particular bodily part, but explains the principle. So the word refers to an internal hollow structure within a non-uniform part of a living body. Given the range of meanings of this term, such a use does not seem beyond the norm.

has to be one and the same with the matter of a growing thing itself, yet separable in account.

In the second part of his discussion, Aristotle considers growth as a specific process, with several distinct structural and phenomenological characteristics (omnidirectionality, dependence on external input, continuance). Here Aristotle arrives at the notion of form as an internal sensible structure of a living thing which is the proper recipient of growth. I have tried to show that this concept is well entrenched both in his theory of change and in his views on the structure of living matter formulated in the biological treatises. Perhaps the most interesting consequence of the suggested analysis is that the form of a uniform part is not just a formula of an elemental combination, as is often assumed by scholars, but also a sensible qualitative structure which has a specific ontological status of its own. This lower-order form depends upon the form of the whole living being, but possesses its own phenomenological regularity which allows it to act as a continuant and contribute to the functional unity of the whole thing in the process of growth. This concept of form can, I think, give some additional support to a realist reading of the argument in the *Metaphysics* Z according to which form is to be regarded as substance *par excellence*.

Appendix 1: *GC* I 5, 320a34-b3

χωριστὴ μὲν γὰρ οὖσα ἢ οὐδένα καθέξει τόπον ἢ οἷον στιγμὴ τις, ἢ κενὸν ἔσται καὶ σῶμα οὐκ αἰσθητόν· τούτων δὲ τὸ μὲν οὐκ ἐνδέχεται, τὸ δὲ ἀναγκαῖον ἔν τινι εἶναι.

A. Text

Philoponus thought the second ἢ to be a confusing insertion, and suggested understanding its force as adversative (= ἀλλά). He also reported the omission of ἢ in some of the manuscript readings. But Philoponus' text obviously had ἢ instead of καὶ (73, 5 Vitelli, not recorded by Joachim), together with L, and F^2 (which has ἢ καὶ, ἢ inserted by a correcting hand), against the other MSS. So Philoponus treated both the 'point' and the 'void' as illustrating the first alternative (matter occupies no place); and took the second alternative to be that of an imperceptible body. He takes the 'imperceptible body' to refer to an unqualified body, such as the three-dimensional (ἄποιον σῶμα, ὑποῖόν ἐστι τὸ τριχῇ διαστατόν 73, 19 Vitelli, see discussion in de Haas 1997). Some of this material

must go back to Alexander of Aphrodisias. In Averroes' Middle Commentary, clearly dependent on Alexander, the text is construed in the same way. M. Migliori accepts Philoponus' reading in his translation of the text without an argument, which might be in place, given a highly idiosyncratic character of Philoponus' interpretation of the 'imperceptible body'.

Joachim bracketed the second ἢ following Philoponus and Averroes, but took the sense of the sentence differently. According to him, 'The first alternative way (a) is that the matter "occupies no place", and Aristotle suggests "the point" as an illustration. ... The second alternative way (b) is that matter is a "void".' (Joachim *ad loc*) Joachim explains his emendation by doctrinal considerations: 'though the point "possesses position" (θέσιν ἔχει), it cannot be said to "occupy place" (τόπον κατέχειν), since nothing can "occupy place" except κινητὸν σῶμα' (*ibid.*), according to the doctrine expounded in *Physics* IV. C.J.F. Williams and Ch. Mugler follow Joachim without discussion. I think Joachim's explanation of σῶμα οὐκ αἰσθητόν as epexegetic of κενόν is correct, although I take it in a weaker sense as in the preceding chapter (*GC* I 4, 319b18-21), rather than as in *Physics* IV 6, 213a27-8 cited by Joachim.

But I do not find convincing Joachim's reasons for bracketing the second ἢ. Joachim thinks that 'point' illustrates a more general case of 'matter not occupying place'. As Verdenius and Waszink rightly point out, this ill agrees with the fact that Aristotle does discuss the case of 'points' at line 14. Their own suggestion is to retain the second ἢ but take its meaning to be concessive within the first term of disjunction: 'it either does not occupy place (unless like a point), or it is void, etc.' This makes fairly good general sense, but it remains not entirely clear where this point belongs in Aristotle's refutation. So I read the sentence as it stands in the MSS., taking ἢ in all cases as an iterated disjunction, but ἔσται as a common predicate of both στιγμή and κενόν. The main 'wedge' of the disjunction, corresponding to the division of μὲν ... δέ of the next clause, will then be at the second occurrence of ἢ. This reading is consistent with the fact that Aristotle discusses points and lines right after the discussion of the void at 320b14 (the fact difficult to explain on any other hypothesis). Cf. also the respective positions of 'points' and 'nothing' in a similar division in the dilemma of divisibility in *GC* I 2: 316a25: ἀλλὰ μὴν εἰ μηδὲν ἔσται σῶμα μηδὲ μέγεθος, διαίρεσις δ' ἔσται, ἢ ἐκ στιγμῶν ἔσται, καὶ ἀμεγέθη ἐξ ὧν σύγκειται, ἢ οὐδὲν παντάπασιν. Here the two impossible assumptions to be refuted are that the residue of the infinite division should be nothing at all, or 'points' which do not have size. Each is refuted in a separate argument, the refutation strategy resembling the

one of 'our' argument. The main 'wedge' is, again, *between* the 'nothing' and the 'points'.

B. Aristotelian commentators on 'imperceptible body' and 'common body'

320b2. σῶμα οὐκ αἰσθητόν. This passage is discussed in Philoponus' commentary twice, first in a summary exposition which looks like a *theōria* for this section, secondly in the discussion of the *lexis*. In the *theōria* (73, 18-74,4),[118] 'imperceptible body' is taken to be an equivalent of 'unqualified' (ἄποιον) body which is equated with the 'three-dimensional'. 'Imperceptible' or 'unqualified' body is said to be always in a place insofar as any body is in a place by virtue of being dimensioned, or quantified; while being in a certain place, viz., one of the 'natural places' is connected with qualities.

In the *lexis*, there are two different construals of the argument at 320b2-3. The first one refers οὐκ ἐνδέχεται to the 'point' and 'void', and ἀνάγκη ἐν τόπῳ εἶναι to the imperceptible body, this latter being now glossed as δυνάμει σῶμα καὶ ὕλη ἀνείδεος (76, 29-30). The argument according to which 'a place-occupier must come to be from a place-occupier' (320b3-5) is taken to show that imperceptible body must occupy place (similarly to the way it is elaborated in the *theōria*). This construal is criticised, because the latter argument provides a demonstration not just for the imperceptible body, but for a quite general case of coming to be. The second interpretation expounded by Alexander of Aphrodisias is said to be better. On it, the οὐκ ἐνδέχεται, the predicate of τὸ μέν, covers all three sections of division above (points, void, and the imperceptible body); while the necessity of being in place (and τὸ δέ, its subject) is said to pertain to the matter of growth in general. The imperceptible body, on this second construal, is glossed as a 'mathematical body', and the reason why it *cannot* be in place is that it exists only in thought.[119]

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118 Analysed in detail in de Haas 1997, 138-47.

119 77, 14-15: ἀλλ' οὐδὲ τὸ οὐκ αἰσθητὸν σῶμα, εἴπερ τὸ οὐκ αἰσθητὸν σῶμα τὸ μαθηματικὸν λέγομεν· τοῦτο γὰρ ἐν ἐπινοίᾳ μόνον ἐστιν.

We cannot rule out the possibility that Alexander is the source of Philoponus (and Ammonius) for both interpretations (*pace* de Haas 1997, 141 n 24). A version of the first interpretation is apparently adopted by Averroes who does have some access to Alexander's commentary.

> With regard to the point and the existent void being the matter for the body, it has been explained in the preceding. As to the imperceptible body [being such matter], this body, insofar as it generates something that has magnitude (*min jihatin mâ minhu kawnu l-'iẓâmi*), must be in a place, for everything, from which there comes to be something, must be in a place, either *per se* (*bi-ḏâtihi*) or as an accident, the way we said about the prime matter; for there is no difference in terms of necessity between that from which a body comes to be in an unqualified sense (*'alâ l-iṭlâqi*) and that out of which a body grows, since the coming to be is in respect of the whole, and growth is the coming to be in respect of a part. (43, 18-44,6 'Alawî)

> And it is best then for us to assume that the matter (*mâdda*) of the body and of its growth is the prime matter (*al-hayûlâ al-ûlâ*), which, as we said, is one in number and many in potentiality, not that the [prime] matter (*al-hayûlâ*) is a body which exists in actuality from body, and not that it is again points and lines and planes, for these necessarily must not be in a place, either *per se* or accidentally, whereas that from which a magnitude comes to be must be in a place, as we said, either *per se* or accidentally, but the [prime] matter (*al-hayûlâ*) is that of which lines and planes are terminations and limits, and therefore it is never found separate from the accidents and forms, since the terminations cannot be separated from that of which they are terminations. (45, 1-9 'Alawî)

In Philoponus' *theōria*, the three-dimensional as a candidate for the matter of growth is not described as 'formless matter', but the logic of the argument is similar to the first interpretation of the *lexis*, and to the interpretation adopted by Averroes: 'imperceptible body' so understood must be 'in a place' accidentally. With regard to the question of authorship it may be worth noting that Philoponus' commentary follows Ammonius' lectures, and both Ammonius and Philoponus seem to have had access to Alexander's commentary;[120] while it has been argued that

120 Gannagé 1998, Kupreeva 2005

Averroes does not know Philoponus' commentary.[121] A more precise source for the interpretation of 'imperceptible body' as 'formless matter' is not clear, but in several works of Alexander's circle there is a distinction between 'body *qua* body' (stripped of all qualities, which sometimes gets a Stoic definition 'three-dimensional with resistance') and 'some (qualified) body'.[122] On the possible link of this interpretation with Aristotle's *Metaph* Z 3, cf. de Haas, 143 n 30.

320b23. σώματος δ' ἤδη τοιουδί· σῶμα γὰρ κοινὸν οὐδέν ἐστιν, At this point Alexander's commentary seems to be overwritten by Philoponus (Ammonius):

> (i) Since, he says, the coming to be is of particular bodies, and of this something (τοῦδε τινος). (ii) For of the common, predicated of others, there is neither coming to be in unqualified sense, nor subsistence (ὑπόστασις). (iii) For the universal subsists only in the creative rational principles. (iv) And so the matter is of some body, but not of a common body; for if it were of a common body, then it would not have been subsistent as matter in actuality, since the common does not subsist in actuality. (v) So, just as the universal body is inherent in the creative rational principles, so too should one think of the universal matter; for nothing can be universal in subsistence, neither body, not the matter of body. (85, 9-17)

(i) and (ii) can be compared with Alexander *de Anima* 6, 13-20. (iii) is the Neoplatonic realist assumption used throughout the commentary. (iv) seems to be spelling out the idea that the matter which can be identified as such in actuality (viz., proximate matter) is of some body, and so is distinct in definition from the prime matter (which never exists in actuality). (v) The conclusion, according to which both the universal body and the universal (viz., prime) matter have their subsistence as such only on the level of rational creative principles may be Ammonius' appropriation, in a modified form, of Proclus' thesis of the eternity of matter. On Philoponus' later rejection of this thesis in connection with

121 Eichner 2005

122 Cf. *mantissa* 3, 116, 18-37; 6, ; 7, 125, 139-19 Bruns.

his own concept of prime matter as three-dimensional, see de Haas 1997, 1-45.

Appendix 2: Efficient causes, *GC* I 5, 320b17-21

> γίγνεται μὲν οὖν ἁπλῶς ἕτερον ἐξ ἑτέρου, ὥσπερ καὶ ἐν ἄλλοις διώρισται, καὶ ὑπό τινος δὲ ἐντελεχείᾳ ὄντος (a) ἢ ὁμογενοῦς (b) ἢ ὁμοειδοῦς (οἷον πῦρ ὑπὸ πυρὸς ἢ ἄνθρωπος ὑπ' ἀνθρώπου) (c) ἢ ὑπ' ἐντελεχείας (σκληρὸν γὰρ οὐχ ὑπὸ σκληροῦ γίνεται). (translated under (i) on p. 116 above)

The trichotomy of the types of generation has caused many different interpretations. Joachim suggested re-positioning the second bracketed phrase ('not hard by hard') after ὁμογενοῦς.

Philoponus explains that ὑπ' ἐντελεχείας clarifies ὁμογενοῦς, because 'efficient cause, whatever it is, always is in actuality' (84, 8 Vitelli). On this interpretation, being of the same genus is explained by being in actuality, so that in fact there is no trichotomy, but the claim is rather that any efficient cause is always of the same genus with its effect, by virtue of its existence in actuality, and sameness in species is a special case of the sameness of genus, when there is a structural similarity between cause and effect. (Vitelli in the lemma prints ὁμοειδοῦς ἢ ὁμογενοῦς, without noting any discrepancies among his MSS with respect to the order. In the text, 83,28, the order is reverse.)

Kuhl 1959, 41-2, has argued that the order ὁμοειδοῦς ἢ ὁμογενοῦς (found in the MSS of family a, EMWL Arabic [following the nomenclature of Rashed 2001]) suits Aristotle's logic better than the reverse order (found in family b, JPVFHN, and printed by Joachim), because he takes 'fire by fire' to illustrate the case ὑπὸ ὁμοειδοῦς (on the basis of *Cael* 276b5-6) and 'man by man' the case ὑπὸ ὁμογενοῦς (on the basis of *GA* 746a29: γίνεται δὲ ὁ συνδύασμὸς τοῖς ζῴοις κατὰ φύσιν μὲν τοῖς ὁμογένεσιν). This argument is taken over by Rashed 2001, 341. I don't think the *GA* passage provides a support needed for our case, as here ὁμογενῆ is not contrasted with ὁμοειδῆ: on the contrary, from context it seems clear that Aristotle means the animals of the same species, subsequently making allowance for those 'whose nature is near akin'; this latter class would be covered by ὁμογενῆ is a strict logical sense; cf. ROT translation: 'copulation takes place naturally between animals of the same kind'). The terms γενός and εἰδός are used somewhat loosely in the biological corpus.

The following fragment of Theophrastus' lost *Physics* (ap Simpl *in Phys* 1236, 1-9 Diels = fr. 176 FHSG) may shed some additional light on the classification:[123]

> Διαιρεῖ δὲ ὁ Θεόφραστος ἐν τρίτῳ τῶν φυσικῶν ἢ περὶ οὐρανοῦ τὰ γινόμενα οὕτως· (a′) ἢ γὰρ ὑπὸ ὁμοίου γίνεται, φησίν, ὡς ἄνθρωπος ὑπὸ ἀνθρώπου καὶ θερμόν ὑπὸ θερμοῦ, (b′) ἢ ὑπὸ ἐναντίου, ὡς ὁρῶμεν τοὺς κεραυνοὺς καὶ τὰς ἀστραπάς· ὑπὸ γὰρ ψυχρότητος ἡ τούτου τοῦ πυρός ἐν τῷ ἀέρι γένεσις ἀθροίζοντος εἰς ἕν τὸ ἐν αὐτοῖς θερμὸν καὶ ἐκπυροῦντος. (c′) ἢ τρίτον ὑπὸ ἐντελεχείᾳ ὅλως ὄντως, ὡς καὶ ὁ μώλωψ· ὑπὸ γὰρ ἐντελεχείᾳ οὔσης τῆς μάστιγος γίνεται, οὔτε δὲ ὁμοίας ἔτι οὔτε ἐναντίας τῷ γινομένῳ. καὶ τὰ ὑπὸ τοῦ ἡλίου δὲ, φησι, γινόμενα ὑπὸ ἐντελεχείας γίνεται. καὶ γὰρ αὐτὸς οὔτε ὅμοιος οὔτε ἐναντίος τοῖς γινομένοις ὑπ' αὐτοῦ.
>
> Theophrastus, in the third (book) of the *Physics*, or *On Heaven*, divides things that come to be as follows. "(a′) Either they are produced by something which is similar," he says, "as a man (is produced) by a man and heat (is produced) by heat; (b′) or by the opposite, as we see with thunderbolts and lightnings. For it is by cold that this fire is produced in the air, when it gathers the heat in them into a single place and turns it to fire. (c′) Or, thirdly, (things are produced) by what is in actuality, quite generally, as with a weal; for it is produced by the whip, which is in actuality, but neither similar to what is produced nor opposite to it. And the things that are produced by the sun", he says, "are produced by an actuality; for it itself is neither similar nor opposite to the things that are produced by it." (trans. Sharples)

Here we have the trichotomy of causes slightly different from Aristotle's; where Aristotle has 'sameness in genus but not in species', Theophrastus supplies 'contrariety'. But this seems to agree with *GC* I 6 (323b29-4a9, especially 24a5-7: ἐπεὶ δὲ τὸ πάσχον καὶ τὸ ποιοῦν τῷ μὲν γένει ταὐτὰ καὶ ὅμοια τῷ δ' εἰδει ἀνόμοια, τοιαῦτα δὲ τἀναντία, κτλ.); so it is possible that we are dealing here with a common school classification. Aristotle's examples in the first brackets seem to correspond to Theophrastus' examples under (a′), with 'fire' replaced by 'heat'. Theophrastus' example (b′) of contrary cause of the same genus is the production of the heat by the agency of the cold in the formation of lightning: the mechanism

123 I am grateful to Bob Sharples for drawing my attention to this fragment.

of *antiperistasis* described by Aristotle in *Mete* IV and developed further by Theophrastus (cf. Solmsen 1961, 136-7, 413-17; Steinmetz 1964, 123-6). His example of (c') includes, on the one hand, the production of a weal by a whip, and on the other the role of the sun as a remote efficient cause in the processes of coming to be and perishing.

Aristotle's 'hardening' in the second brackets illustrates his (c): the resulting property displays no structural similarity with the causal factor. But since hardening also involves the interaction of hot and cold (*antiperistasis*), it could possibly also be an example of (b), thus serving as a shorthand illustration of both (b) and (c).

Simplicius also reports Alexander's criticism of this trichotomy based on the same idea of actuality being common to all three types of coming to be that we have seen in Philoponus' commentary (see further Sharples' commentary in Sharples 1998, 125-6 [Aristotle's passage is not discussed]).

Appendix 3: κάναβος

The oldest evidence from literary sources, after Aristotle, comes from Pollux, the lexicographer of the mid-second century AD, who gives an explanation of the term in two different places:

> 7.164: περὶ ὃ δὲ οἱ τοὺς πηλίνους πλάττοντες τὸν πηλὸν περιθέντες πλάττουσι, τοῦτο τὸ ξυλήφιον κάναβος καλεῖται ... (Bethe)
>
> 10.189: τὸ μὲν δὴ ξύλον ᾧ περιπλάττουσι τὸν πηλὸν οἱ κοροπλάθοι, κάναβυς καλεῖται· ὅθεν καὶ Στράττις ἐν τῇ Κινησίᾳ (I p 716,20 Ko.) τὸν Σαννυρίωνα διὰ τὴν ἰσχνότητα κάναβον καλεῖ (Bethe)

The second passage contains a citation of Strattis, a poet of the New Comedy, whose dates are considered to be ca. 409-375 BC. Both Hesych. Lexic., K, No. 629, 1-2 and Photius, Lexic., K, 139, 15 may be drawing on Pollux. Hesychius: κάναβοι, τὰ ξύλα, περὶ ἃ τὸ πρῶτον οἱ πλάσται τὸν κηρὸν τιθέασιν. ὅθεν καὶ οἱ λεπτοὶ καὶ ἄσαρκοι κάναβοι λέγονται. Photius: τὸ πρῶτον ξύλον ὑπὸ τῶν πλαστῶν, περὶ ὃ τὸν πηλὸν τιθέντες πλάσσουσιν. Stephanus, *Thesaurus Linguae Graecae*, s.v., cites as parallel Pliny the Elder's use of πρόπλασμα, *HN* 35. 155. Jahn 1854 adds Tertullian, *apol* 12 (*crucibus et stipitibus inponitis Christianos; quid simulacrum non prius argilla deformat cruci et stipiti superstructa?*) and *ad natt* 1, 12 (*plasta lignum cruces in primo statuit, quoniam ipsi quoque corpori nostro tacita et secreta linea cruces*

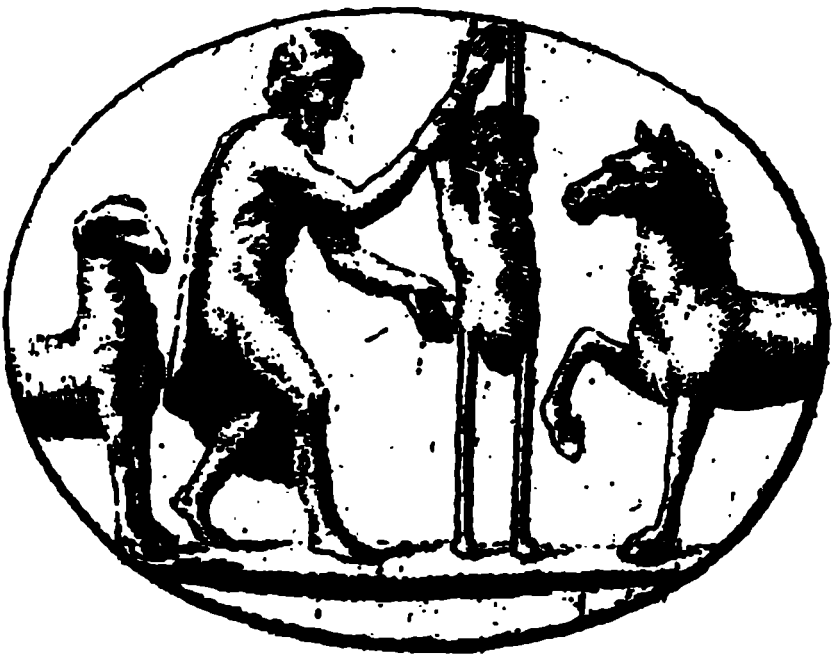

Figure 1. *Prometheus is making the first man with the help of a* κάναβος (?)

situs est. huic igitur exordio et uelut statumini argilla desuper intexta paulatim membra complet et corpus struit et habitum quem placuit positae intus cruci ingerit), and refers to the image of a κάναβος in Ficoroni, *gemmae antiquae litteratae*, Taf IV, 5, where Prometheus is making a man using this auxiliary structure (see Figure 1).[124]

124 Reproduction courtesy of Duke Humphrey's Library and Reprographic Services of Bodleian Library. For a more comprehensive discussion of related iconography see Gisler 1991; cf. Furtwängler 1900 III 241 and pl 21, 61=86(x) Gisler. Sir John Boardman, to whom I am very grateful for his most helpful discussion of iconographical material, tells me that the original of Ficoroni drawing is in Alnwick Castle in Northumberland (catalogued in Knight 1921, No.188, Pl. VI). The description of the sculptor as Prometheus goes back at least to Winckelmann 1760 who cites Horace *Od* I 16, 13-16.

While the general meaning of the term and its relevance in the context is clear, the exact reference made by Aristotle is not. It is hardly likely that the reference in *GA* II 6 is, as Platt suggests, 'to drawings on the walls of a lecture-room, showing the course of blood-vessels'.

Peck's translation of the *GA* passage ('skeleton models which are traced on the walls of the buildings'), would need some further explanation, given his rejection of 'sketch' as a meaning for the term. Peck says that in *PA* II 9, Aristotle makes the same point as in the *HA* and *GA* passages, without using the word: περὶ δὲ τὰ ὀστᾶ αἱ σάρκες περιπεφύκασι, προσειλημμέναι λεπτοῖς καὶ ἰνώδεσι δεσμοῖς· ὧν ἕνεκεν τὸ τῶν ὀστῶν ἐστι γένος. ὥσπερ γὰρ οἱ πλάττοντες ἐκ πηλοῦ ζῷον ἤ τινος ἄλλης ὑγρᾶς συστάσεως ὑφιστᾶσι τῶν στερεῶν τι σωμάτων, εἶθ' οὕτω περιπλάττουσι, τὸν αὐτὸν τρόπον ἡ φύσις δεδημιούργηκεν ἐκ τῶν σαρκῶν τὸ ζῷον. τοῖς μὲν οὖν ἄλλοις ὕπεστιν ὀστᾶ τοῖς σαρκώδεσι μορίοις κτλ (654b27-34). Lippold, on the other hand, regards the absence of the term in this description as an indication that Aristotle might *not* be using it for a sculptor's device (*RE*, s.v.), but this presupposes the degree of terminological consistency which is hard to expect from Aristotle. But perhaps the two meanings can be reconciled on the hypothesis that the term was transferred from sculpture to painting to refer to rough sketches of human bodies (Jahn 1854, 42-4, cf. D'Arcy Thompson *ad loc*).

Later commentators seem to have lost the meaning entirely. [Philoponus] *in GA*, 109, 27-33 Hayduck:

> κάναβος δὲ ἐστιν ἡ δεξαμένη, ἣν κινστέρναν ἡ Ῥωμαίων οἶδε γλῶσσα καλεῖν. ὥσπερ γὰρ οἱ ζωγράφοι ἐν τοῖς τοίχοις ζῷα παντοδαπὰ γράφουσιν, οὕτω καὶ κανάβους καὶ ὕδατα, τὸ μὲν δῆθεν ἐξερχόμενον ἐκ τοῦ μέρους τοῦδε τοῦ κανάβου, τὸ δὲ ἐξ ἄλλου. ὡς οὖν τὰ πολλὰ ταῦτα γεγραμμένα ὕδατα ἀρχὴν μίαν ἔχει τὸν γεγραμμένον κάναβον, οὕτω, φησί, καὶ αἱ φλέβες πᾶσαι τὴν καρδίαν· τὰ γὰρ μέρη, ἤτοι αἱ φλέβες, περὶ ταύτας ἤτοι τὰς καρδίας εἰσίν.

Department of Philosophy
University of Edinburgh
David Hume Tower
George Square
Edinburgh EH8 9JX
Scotland
inna.kupreeva@kcl.ac.uk

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