THE STRUCTURE OF TELEOLOGICAL EXPLANATIONS IN ARISTOTLE: THEORY AND PRACTICE

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In the *Posterior Analytics* Aristotle discusses demonstrative knowledge. Despite the long tradition of Aristotelian scholarship on this treatise, many details concerning the nature of demonstration and its relation to explanation remain enigmatic, and are the subject of much controversy.[1] This paper aims to shed light on Aristotle's pivotal discussion of the relation of demonstration, explanation, and scientific knowledge in *Post. An.* 2. 11, and specifically on the structure of teleological explanations as presented in this chapter. In the first part (Sections 1–3) I shall clarify the examples Aristotle provides to illustrate his theoretical remarks about causal explanation. In particular, I hope to make sense of the teleological example of walking after dinner for the sake of health. In Section 4 I shall focus on the structure of the actual teleological explanations provided in Aristotle's *De partibus animalium*. This will show that Aristotle's

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[1] For present purposes, I leave aside the question whether the *Posterior Analytics* presents a theory of scientific methodology and investigation or a theory of the organization and presentation of the finished scientific system. On this matter, see among others J. Barnes, *Aristotle:* Posterior Analytics [*Posterior*] (Oxford, 1993), xi–xix.

theory and practice of teleological explanation are in agreement with each other.

1. Causes, explanations, and middle terms

1.1. *The problem: the middle terms of the examples in* Post. An. *2. 11 do not pick out all four causes*

In *Post. An.* 1. 2 Aristotle introduces demonstrations as being syllogistic in form and causal in content. Demonstrations are thus deductive arguments that produce scientific knowledge (*Post. An.* 1. 2, 71^{b}17–19). For Aristotle, scientific knowledge consists ultimately in knowledge of the explanation of why things are the case (*Post. An.* 1. 2, 71^{b}9–13):

ἐπίστασθαι δὲ οἰόμεθ' ἕκαστον ἁπλῶς, ἀλλὰ μὴ τὸν σοφιστικὸν τρόπον τὸν κατὰ συμβεβηκός, ὅταν τήν τ' αἰτίαν οἰώμεθα γινώσκειν δι' ἣν τὸ πρᾶγμά ἐστιν, ὅτι ἐκείνου αἰτία ἐστί, καὶ μὴ ἐνδέχεσθαι τοῦτ' ἄλλως ἔχειν. δῆλον τοίνυν ὅτι τοιοῦτόν τι τὸ ἐπίστασθαί ἐστι.

We think we have [scientific] knowledge of each thing without qualification (and not in the sophistic way, incidentally) when we think we know of the explanation because of which the state of affairs is the case, that it is its explanation, and also that it is not possible for this [state of affairs] to be otherwise. It is clear that something of this kind is what it is to have [scientific] knowledge.[2]

At the beginning of *Post. An.* 2. 11 Aristotle specifies—and, from our perspective, complicates—this assertion by introducing a 'doctrine' of four *aitiai*, which, he claims, are all to be demonstrated through the middle term (*Post. An.* 2. 11, 94^{a}20–7):

ἐπεὶ δὲ ἐπίστασθαι οἰόμεθα ὅταν εἰδῶμεν τὴν αἰτίαν, αἰτίαι δὲ τέτταρες, μία μὲν τὸ τί ἦν εἶναι, μία δὲ τὸ τίνων ὄντων ἀνάγκη τοῦτ' εἶναι, ἑτέρα δὲ ἡ τί πρῶτον ἐκίνησε, τετάρτη δὲ τὸ τίνος ἕνεκα, πᾶσαι αὗται διὰ τοῦ μέσου δείκνυνται.

Since we think we have [scientific] knowledge when we know the explanation, and there are four types of explanation—one, what it is to be a thing, and another, given what things being the case it is necessary for that to hold;[3] another, what first initiated the motion; and fourth, the for the sake of what—all of them are brought out through the middle term.[4]

[2] All translations are mine, unless indicated otherwise.

[3] The expression used here to refer to material causation is puzzling; I believe Aristotle to imply that material causes for the most part necessitate their results, or

[*See opposite for n. 3 cont. and n. 4*

After this short introduction to the topic of this chapter, Aristotle moves on to give syllogistic examples of how each of the four explanations (*aitiai*) is indeed brought out through the middle term.

In contrast to the apparent clarity of structure and argument in this chapter, its content has raised many interpretative problems for modern scholars, most of which pertain to the general purpose of the chapter and to the nature of the syllogistic examples. The sentence stating that 'all the *aitiai* are brought out through the middle term' has traditionally been interpreted as meaning that all four Aristotelian causes can or even must be picked out by the middle term in scientific demonstrations.[5] However, under this interpretation the syllogistic examples Aristotle gives to illustrate his introductory sentence present us with two major difficulties. In the first place, contrary to the expectations of many interpreters the syllogisms posited in no way constitute typical Barbara demonstrations (the required mood for science) where the predicates hold universally and necessarily of the subjects.[6] In the second place, it is not immediately clear how the middle terms in the given examples refer to the causes in question. In particular the section that shows how final causes are brought out

that they at least do so when picked out in demonstrations. For present purposes, I shall treat the expression and the example discussed below as a 'canonical' example of material explanation, taken in the broad sense as an explanation stating 'that out of which'. For the problems involved (which do not affect the interpretation presented here), see Barnes, *Posterior*, 226–7; W. Detel, *Aristoteles: Analytica Posteriora* [*Analytica*] (Berlin, 1993), 685, 690–4; and W. D. Ross, *Aristotle's* Prior *and* Posterior Analytics*: A Revised Text with Introduction and Commentary* [*Revised*] (Oxford, 1949), 638–42.

[4] See the Appendix below for a complete translation of *Post. An.* 2. 11, $94^{a}20$–$94^{b}26$.

[5] This interpretation ultimately goes back to Philoponus, who criticizes this chapter in his commentary on the *Posterior Analytics* (*In An. Post.* 376. 12–14, 16–18, 31–2; 377. 21–2, 26–7 Wallies). He thinks that the examples are wrong and rebukes Aristotle for having set out the syllogisms in a confused way (*In An. Post.* 378. 16–19; 379. 4–9; 379. 33–380. 3 Wallies). In order to correct Aristotle, Philoponus rearranges the examples and thereby manœuvres the causes into the preferred position of the middle term (*In An. Post.* 378. 19–22; 379. 33–380. 3; 381. 35–6 Wallies). On these issues, see my 'Ancient Comments on *APo.* II. 11: Aristotle and Philoponus on Final Causes in Demonstrations', in F. A. J. De Haas and Mariska E. M. P. J. Leunissen, *Interpreting Aristotle's* Posterior Analytics *in Late Antiquity and the Byzantine Period* (forthcoming).

[6] Cf. Barnes, *Posterior*, xvi ('In chapters *B* 11–12 the syllogism is, alas, a positive embarrassment and a bar to understanding'), 228; and Ross, *Revised*, 647.

through the middle term is notorious,[7] because the final cause is not picked out by the middle term, but rather by the major or predicate term.[8] Some scholars have taken up Aristotle's own suggestion that things will become clearer if we 'change the *logoi*' (94^b21–2: *μεταλαμβάνειν τοὺς λόγους*), taking it to mean that we as readers are supposed to rearrange the syllogism so that the middle term picks out the final cause after all.[9] However, it is not an easy undertaking to construct such a syllogism, let alone to do so while remaining close to the Aristotelian original. On the whole, the verdict of interpreters on this chapter has been very negative.[10]

1.2. *The hypothesis: the causality of the explanation and of the explanatory middle term can be different*

The hypothesis that I put forward in order to solve the problem outlined above is a fairly simple one. I submit that it is not the examples that are wrong, but rather our interpretation of what Aristotle means by saying that 'all the *aitiai* are brought out through

[7] For the difficulties modern commentators encounter in this section, see Ross, *Revised*, 642; Barnes, *Posterior*, 225, 229; Detel, *Analytica*, 695, 707.

[8] See Barnes, *Posterior*, 229 ff.; Detel, *Analytica*, 707 ff.; and Ross, *Revised*, 642–3. W. Detel, 'Why All Animals Have a Stomach: Demonstration and Axiomatization in Aristotle's *Parts of Animals*' ['Stomach'], in W. Kullmann and S. Föllinger (eds.), *Aristotelische Biologie: Intentionen, Methoden, Ergebnisse* (Stuttgart, 1997), 63–84 at 65–6, expresses the problem most emphatically: 'The syllogistic reconstruction of the first of these [two teleological] examples Aristotle seems to offer in the subsequent passage (94b12–20) turns out to be, at first sight, extremely problematic, though, since he represents the aim of being healthy, not by the middle term, B, but by the major term, A. This is *clearly incompatible* with his general claim, expressed in 94a20–24, that the aim too must be proved through the middle term' (emphasis added).

[9] See in particular Detel, *Analytica*, 684–716, and 'Stomach', 65–7. Most recently, Johnson has argued that 'changing the terms' should be read as entailing that 'health' and 'good digestion' are convertible in this explanation: see M. R. Johnson, *Aristotle on Teleology* (Oxford, 2005), 52–5. This, however, would be possible only if the terms were coextensive, which seems unlikely in this case. R. Bolton, 'The Material Cause: Matter and Explanation in Aristotle's Natural Science' ['Material'], in Kullmann and Föllinger (eds.), *Aristotelische Biologie*, 97–124 at 115, saves the example, but suggests that ultimately what is picked out by the major term (the final cause) is 'in its primitive definition' equal to what is picked out by the middle term (the material cause).

[10] This might explain why the chapter has largely been ignored by some recent studies on the *Posterior Analytics* (e.g. O. Goldin, *Explaining an Eclipse: Aristotle's* Posterior Analytics *2. 1–10* (Ann Arbor, 1996), and R. McKirahan, *Principles and Proofs: Aristotle's Theory of Demonstrative Science* (Princeton, 1992)).

the middle term'. What is crucial for the understanding of this chapter is that within an Aristotelian demonstration there can be a difference between the type of causality expressed in the *explanation* of a state of affairs (i.e. the causality expressed by the whole demonstrative syllogism) and the type of causality expressed in the middle term that picks out the *explanans* of this state of affairs. In the case of teleological explanations, I shall even argue for the stronger case that the type of causality expressed by the middle term *must be* different from that expressed in the explanation. The upshot of this distinction for Aristotle's theory of demonstration is that all four types of explanation will be brought out through the middle term (because it is through the middle term that a demonstrative syllogism is construed), but that the middle term itself will not have to refer to the corresponding cause in all four cases.

I shall give an example to illustrate this distinction. Consider the *dia ti* ('Why?') question of what is ice. Aristotle takes this question (as presented in *Post. An.* 2. 12, 95[a]16–21) to be about the essence of ice—about what ice *is*. An adequate explanation thus needs to be a formal one. By assuming (the nominal definition) that ice is solidified water Aristotle makes a first move towards such a formal-cause explanation. However, this preliminary answer does not qualify as a demonstration yet, because we do not know why it is that 'solidified' belongs *per se* to 'water', or why there is ice. This is where the explanatory middle term comes in: the middle term picks out the *explanans* of why solidified belongs to water. The explanatory middle term that Aristotle proposes for this particular example is a complete cessation (ἔκλειψις) of heat: ice comes about when there is a complete cessation of heat. The middle term, which picks out the efficient cause[11] of the solidification of water, reveals the essence of ice: ice is solidified water resulting from a complete cessation of heat in water. While the explanation is a formal-cause explanation, the middle term bringing out this explanation picks out an efficient cause.

In sum, Aristotle's claim that 'all the *aitiai* are brought out through the middle term' means under this scheme that all four types of explanations are brought out through the middle term, but

[11] I here follow D. Charles, 'Aristotle on Substance, Essence and Biological Kinds' ['Substance'], in L. P. Gerson (ed.), *Aristotle: Critical Assessments* (London and New York, 1999), 227–55 at 233–5, who identifies ἔκλειψις as a process (the suffix -σις indicates a *nomen actionis*) and an efficient cause.

that these demonstrations may proceed through middle terms that pick out causes of a different type.

1.3. *The semantic distinction between* hē aitia *and* to aition

Within the context of the *Posterior Analytics* this philosophical distinction is supported by a semantic distinction between the terms *hē aitia* (fem.; pl. *aitiai*) and the term *to aition* (neut.; pl. *aitia*). Frede has argued that the two terms were used differently in the original legal context in which they arose: *to aition*, from the adjective *aitios* 'responsible', designated the agent responsible for a state of affairs, while *hē aitia* designated the accusation.[12] This distinction between *aition* as cause and *aitia* as causal account or explanation seems to be preserved in Plato's *Phaedo*,[13] and perhaps also in Chrysippus[14] and Diocles.[15]

Outside the *Posterior Analytics*, there is little or no evidence that Aristotle also endorsed this distinction,[16] but within the *Posterior Analytics* I believe there is. The semantic distinction is not crucial for the philosophical distinction, but a short sketch of the semantic distinction might help us to obtain a clearer view of the theory Aristotle is setting out in *Post. An.* 2. 11.

First *to aition*: usually, *to aition* is characterized as a condition for knowledge.[17] More specifically, in 'demonstrations of the reason why' the middle term must always refer to an *aition*.[18] This is

[12] M. Frede, 'The Original Notion of Cause' ['Cause'], in M. Schofield, M. Burnyeat, and J. Barnes (eds.), *Doubt and Dogmatism* (Oxford, 1980), 217–49 at 222–3.

[13] Frede, 'Cause', 223; J. G. Lennox, *Aristotle's Philosophy of Biology: Studies in the Origin of Life Science* [*Biology*] (Cambridge, 2001), 282–3; D. Sedley, 'Platonic Causes', *Phronesis*, 43 (1998), 114–32 at 115 and 115 n. 1.

[14] Frede, 'Cause', 222.

[15] Diocles, fr. 176 van der Eijk.

[16] In other treatises the distinction may be preserved only in 'technical discussions' of demonstrations such as *DA* 2. 2, 413^{a}11–21; this, however, requires further research. Interpreters of the *Posterior Analytics* usually take the terms to be semantically equivalent, and translate them more or less randomly as cause, reason, or explanation. See e.g. Barnes, *Posterior*, 89–90: 'I . . . resolved to adhere to a single translation for all occurrences of the word [i.e. *aitia* and its cognates]; and I opted for "explanation".'

[17] Knowing why is to know *by means* of *to aition* (75^{a}35); this knowledge proceeds *from aitia* (76^{a}19–20) that are primitive (78^{a}25–6). See also 93^{a}4–8, ^{b}19, 21–6; 95^{a}10–12, 22–5, ^{b}14.

[18] The middle term in demonstrations of the reason why always picks out the *aition* that is immediate and primitive (89^{b}15; 90^{a}7–9; 93^{a}4–8; 95^{a}10–12, 17; *passim* in 98^{b}17–99^{b}13). If the deduction does *not* proceed through the *aition* but through

what Aristotle points out at the end of the following passage (*Post. An.* 2. 2, 89[b]37–90[a]9):

> *ζητοῦμεν δέ, ὅταν μὲν ζητῶμεν τὸ ὅτι ἢ τὸ εἰ ἔστιν ἁπλῶς, ἆρ' ἔστι μέσον αὐτοῦ ἢ οὐκ ἔστιν· ὅταν δὲ γνόντες ἢ τὸ ὅτι ἢ εἰ ἔστιν, ἢ τὸ ἐπὶ μέρους ἢ τὸ ἁπλῶς, πάλιν τὸ διὰ τί ζητῶμεν ἢ τὸ τί ἐστι, τότε ζητοῦμεν τί τὸ μέσον. . . . συμβαίνει ἄρα ἐν ἁπάσαις ταῖς ζητήσεσι ζητεῖν ἢ εἰ ἔστι μέσον ἢ τί ἐστι τὸ μέσον. τὸ μὲν γὰρ αἴτιον τὸ μέσον, ἐν ἅπασι δὲ τοῦτο ζητεῖται.*
>
> When we seek the fact or if something is without qualification, we are seeking whether or not there is a middle term for it. And when, having come to know either the fact or if it is—either partially or without qualification—we again seek the reason why or what it is, we are then seeking what the middle term is. . . . Thus it results that in all our searches we seek either whether there is a middle term or what the middle term is. For the middle term is the *aition*, and in all cases it is this which is being sought.

The middle term must pick out whatever is responsible for the connection between the two terms it mediates. In this way, the middle term clarifies the causal relation between the two terms by providing the real cause (and not merely the epistemic reason) of why the one extreme term holds of the other. I therefore translate the noun *to aition* as cause.[19]

The term *hē aitia* is used less frequently in the *Posterior Analytics*, and is usually part of the definition of scientific knowledge. Scientific knowledge is always knowledge of *hai aitiai*.[20] For instance, in *Post. An.* 1. 2, 71[b]20–33, Aristotle first picks up on his definition of scientific knowledge as being knowledge of *hē aitia* of something, and then continues by stating that this knowledge can be reached through things that are, among other things, *aitios* of the conclusion:

> *εἰ τοίνυν ἐστὶ τὸ ἐπίστασθαι οἷον ἔθεμεν, ἀνάγκη καὶ τὴν ἀποδεικτικὴν ἐπιστήμην ἐξ ἀληθῶν τ' εἶναι καὶ πρώτων καὶ ἀμέσων καὶ γνωριμωτέρων καὶ προτέρων καὶ αἰτίων τοῦ συμπεράσματος· . . . αἰτιά τε καὶ γνωριμώτερα δεῖ εἶναι καὶ πρότερα, αἴτια μὲν ὅτι τότε ἐπιστάμεθα ὅταν τὴν αἰτίαν εἰδῶμεν.*
>
> If, then, to have [scientific] knowledge of something is what we have posited it to be, then demonstrative knowledge in particular must proceed from [items which are] true and primitive and immediate and more familiar

the more familiar of the (non-explanatory) converting terms, that is, when the middle term does not pick out the relevant cause, then the demonstration that follows is not a demonstration of the reason why, but of the fact (78[a]27–9, [b]4, 12, 15, 24; 79[a]4).

[19] See e.g. 78[b]17; 85[b]22; 94[b]8, 18; 95[b]20, 28; 98[a]35–[b]3; *passim* in 98[b]17–99[b]13.

[20] See 71[b]9–13, 30–1; 87[b]40; 94[a]21–4.

than and prior to and *aitios* of the conclusions. . . . They [the items that are constitutive of demonstrative understanding] must be *aitios* and more familiar and prior—*aitios* because we understand something only when we have knowledge of *hē aitia* . . .

Other passages (especially $78^{b}28$–31) indicate that Aristotle conceives of these *aitiai* as being larger linguistic or syllogistic formulae that state the reason why in answer to the question 'why' (*to dioti* or *to dia ti*).[21] At least within the *Posterior Analytics* it is thus implied that *hē aitia* itself is a kind of *syllogismos* containing an explanatory middle term, where *to aition* is a subordinated element of *hē aitia*.[22] I therefore translate *hē aitia* with such terms as 'causal account' or 'explanation', and the adjective *aitios* as either 'causative' or 'explanatory' depending on the context.

Assuming that this semantic distinction between *aition* and *hē aitia* illustrates a philosophical distinction between the type of causality that is revealed through the middle term and the type of causality picked out by the middle term, I shall now present a new reading of *Post. An.* 2. 11.

2. Towards a new reading of *Posterior Analytics* 2. 11

2.1. *Making sense of the opening statement and the examples in* Post. An. *2. 11*

In his opening statement of the chapter, Aristotle first recapitulates his definition of scientific knowledge. That is, we know something when we know its explanation, which is the syllogistic formula stating the *aition* of the state of affairs to be explained. He then specifies four kinds of explanation, which are formulated as four different questions as to the reason why (formal explanation is an explanation of *what* it is to be a thing; material explanation is an explanation

[21] These are explanations of the reason why, picking out *to aition* through the middle term (cf. $78^{b}12$–34; $85^{b}23$–7, 35–6). In $93^{b}33$ *hē aitia* indicates a non-syllogistic causal account.

[22] One might object that in $85^{b}24$–7 Aristotle uses the expressions 'of the *aitia* and of the *dia ti*' and 'of the *aition* and of the *dia ti*' interchangably. However, the first expression applies to the nature of the demonstrative syllogism (what is demonstrated is the explanation and the reason why), while the second applies to the nature of the universal premiss, which is more explanatory in the sense that it shows the *aition* more clearly (cf. $88^{a}5$–6).

of *given what* things being the case it is necessary for that to hold; efficient explanation is an explanation of *what* initiated the movement; and teleological explanation is an explanation of the for the sake of *what*). As the 'since' (*ἐπεὶ δέ*) indicates, this should all be common knowledge.

The new information is that all of these explanations are brought out through the middle term. This is the process of demonstration: the explanations of the reason why are demonstrated through middle terms that explain why the predicate holds of the subject in the conclusion. The middle term thus reveals a causal connection underlying the *per se* relation between these two terms.[23] The point is that it is only by setting out the whole syllogism and thereby expressing explicitly the cause of why the predicate holds of the subject term that we come to reach true understanding of a phenomenon.

Aristotle then works out three examples of explanations (material, efficient, and final) that are brought out through the middle term. He gives no separate example of formal explanation, supposedly because that 'has already been proven' (*Post. An.* 2. 11, $94^{a}35$–6) in earlier chapters.[24] For the sake of completeness, I shall supply a formal-cause explanation from an earlier chapter in my discussion below.

My reconstruction of the four examples and their formalizations into syllogisms is as follows:

Example 1. Material explanation (*Post. An.* 2. 11, $94^{a}27$–35; cf. Eucl. *El.* 3. 31)

Explanandum:

(i) [Why [*dia ti*] is there a right angle?] [Why A?]
(ii) Why [*dia ti*] is the angle in a semicircle a right angle? [Why A of C?]

A = right
B = half of two rights (*aition* = *material cause*)
C = angle in a semicircle

AaC because of B: right holds of the angle in a semicircle because of being half of two rights.

[23] In $73^{a}10$–17 Aristotle explicates the *per se* relation in terms of causation, i.e. as something holding because of itself (*δι' αὑτό*).

[24] I take Aristotle to refer to chapter 2. 8, which is part of his larger investigation into the relation of definition and causal explanations in chapters 2. 8–10.

Example 2. Formal explanation (*Post. An.* 2. 8, $93^{b}8$–13; 2. 11, 94^{b} 34–6)

Explanandum:

(i) What is thunder? [What is A?]
(ii) Why [*dia ti*] is there noise in the clouds? [Why A of C?]

A = thunder (a sort of noise)
B = extinction of fire (*aition* = *efficient cause*)
C = cloud

AaC because of B: thunder is noise in the clouds because of fire being extinguished.

Example 3. Efficient explanation (*Post. An.* 2. 11, $94^{a}36$–$^{b}8$)

Explanandum:

(i) [Why [*dia ti*] is there a Persian war?] [Why A?]
(ii) Why [*dia ti*] did the Persian war come upon the Athenians? [Why A of C?]

A = war
B = being the first to attack (*aition* = *efficient cause*)
C = Athenians

AaC because of B: being warred upon holds of the Athenians because of being the first to attack.

Example 4. Teleological explanation (*Post. An.* 2. 11, $94^{b}8$–26)

Explanandum

(i) Why [*dia ti*] does he walk? [Why C?]

A = being healthy
B = food not floating (*aition* = *material cause*)
C = walking after dinner

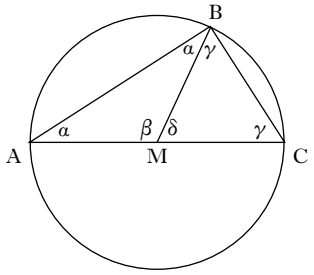
AaC because of B: being healthy holds of walking after dinner because of the food not floating.

Before turning to an analysis of these examples, let me state from the outset that contrary to the traditional interpretation I see no decisive indications in the text as to why Aristotle should be concerned only with syllogisms in the Barbara mood. I submit that the introduction of the four types of explanation in *Post. An.* 2. 11 rather shows that he is concerned with laying out a general syllogistic structure into which *every* causal relation can be fitted. If we read the chapter in this way, the contingency and singularity of

the examples noted by critics of Aristotle need no longer constitute a lingering problem. They can be accounted for within the larger framework of causal relations that Aristotle is interested in, and so can the other examples he mentions in the remainder of the chapter (*Post. An.* 2. 11, 94[b]27–34).[25]

2.2. *The example of material explanation*

The first example of material explanation is developed in the context of a discussion of the necessary nature of demonstrative syllogisms (*Post. An.* 2. 11, 94[a]24–27).[26] The example can be analysed as follows (for the proof see Figure 1). The *dia ti* question Aristotle poses is 'Because of what is the angle in a semicircle a right angle?' An adequate explanation should thus state the geometrical proof showing 'that out of which' it follows that the angle in a semicircle is right. This example of material explanation is in fact reflected in a theorem from Euclid (*El.* 3. 31), and the proof might be as well.



Demonstration: ∠ABC = 90°
∠MAB = ∠MBA (α)
∠MCB = ∠MBC (γ)
(i) $\beta+\delta=180°$.
(ii) $2\alpha+\beta=180°$; $2\gamma+\delta=180°$.
(iii) $2(\alpha+\gamma)+\beta+\delta=360°$.
(iv) $2(\alpha+\gamma)=180°$.
(v) $\alpha+\gamma$ ('the angle in a semicircle') = 180° ('two rights') divided by 2 ('half') = 90° ('right').

FIG. 1. Material explanation

Here Aristotle introduces the search for the middle term by rephrasing the question explicitly in terms of material necessity: 'Given what being the case is it a right angle?' What we are looking for is a condition that necessitates the rightness of the angle in a semicircle—a condition, incidentally, that will be immediately

[25] These latter examples are rather more fanciful than serious, such as the Pythagorean belief that it thunders in order to frighten the inhabitants of Tartarus, or else they report scientific views that Aristotle rejects elsewhere, such as the explanation of thunder as being the extinction of fire in the clouds (this explanation is explicitly rejected at *Meteor* 2. 9, 369[b]12–24).

[26] Here Aristotle states that, given a middle term shared by two propositions, it is necessary for the conclusion of the syllogism to hold. The middle term, or the two premisses taken as one, literally bring about the conclusion, and are therefore in a sense the material causes of the conclusion (cf. *Phys.* 2. 3, 195[a]18–19).

evident once the right mathematical figure has been discovered (cf. *Metaph*. *Θ* 9, 1051[a]21–9). Aristotle then formalizes the explanation, while introducing 'half of two rights' as the middle term (B) that explains why 'right' (A) holds of 'angle in a semicircle' (C).

The rationale Aristotle offers in this section is somewhat obscure, but is not too problematic once we presuppose the familiarity of Aristotle's readership with the relevant mathematical figure and the proof of the proposition as we know it from Euclidean geometry (Aristotle hints at both of them in the above-mentioned passage in *Metaph*. *Θ* 9). Important in this proof is that the geometrical relations between 'right angle' and 'angle in a semicircle' are discovered by *division*.[27] It is this division that Aristotle refers to when claiming that '[the term B] is equal to A, and C to B, because it [C] is of two rights—half.'[28] It is this 'being half' that necessitates the angle in a semicircle being a right angle. In sum, the angle in a semicircle is a right angle because it is half of two rights; 'being half of two rights' is the material cause of 'right' holding of 'the angle in a semicircle.' The angle in a semicircle is by necessity a right angle *given that it is two rights—divided in half*.

In this case, both the causation expressed by the explanation and the explanatory middle term that brings out this explanation are of the material type.

2.3. *The example of formal explanation*

The second example of formal explanation (taken from *Post*. *An*. 2. 8, 93[b]8–13) can be analysed as follows. The *dia ti* question Aristotle poses is why there is thunder. This is a reformulation of the question 'What is thunder?', which is a request for the definition of thunder (Aristotle answers the 'what is' question by stating that it is the extinction of fire in cloud, which is not a demonstration of the essence of thunder yet). For Aristotle, the question why there is thunder is equivalent to the question what thunder is, except that the first is a request for a demonstration and the latter for a definition (cf. *Post*. *An*. 2. 10, 94[a]1–8). An adequate explanation of why there is thun-

[27] Cf. *Metaph*. *Θ* 9, 1051[a]22–3: 'Mathematical figures, too, are discovered by actualization; for they find them by dividing [the figures] [*διαιροῦντες*].'

[28] Note the word order in the Greek: while B is defined as $\frac{1}{2}$-2R (94[a]29: *ἡμίσεια δυοῖν ὀρθαῖν*; 94[a]32–33: *ὄντος ἡμίσεος δύο ὀρθῶν*), C is explained as 2R—$\frac{1}{2}$ (94[a]32: *δύο γὰρ ὀρθῶν ἡμίσεια*).

der thus needs to be a formal explanation expressing the essence of thunder through a middle term that brings out this essence.

However, as Aristotle indicates in another text where he discusses the same example (*Metaph. Z* 17, 1041^{a}24–32),[29] the only way to get a demonstration is by converting the *explanandum* into a predicative relation.[30] This can be done, first, by taking the nominal definition of thunder (as being 'a sort of noise in the cloud': *Post. An.* 2. 8, 93^{a}22–3). Secondly, one can do this by turning the request for a definition into a *dia ti* request for a demonstration, in which the object of enquiry is 'a something of something else' (i.e. why is there thunder in the clouds). Because the explanation in this case is already known (i.e. thunder comes about through the extinction of fire in the cloud), Aristotle sets out immediately to formalize the example: the subject term (C) is 'cloud'; the middle term (B) is 'extinction of fire'; and the predicate term (A) is 'thunder'. Now, B holds of C, because the extinction of fire takes place *in* the cloud (the cloud is the locus in which the phenomenon typically resides), and A—'thunder' (i.e. a sort of noise)—holds of B, because B is a definition of A.

In this case, the explanatory middle term picks out an efficient cause of why there is thunder or noise in the clouds: the origin of motion of the noise lies in the extinction of fire. It is through this efficient cause that the essence of thunder and thereby the formal explanation of why there is thunder are revealed: thunder is noise in the clouds caused by fire being extinguished.[31]

2.4. *The example of efficient explanation*

The third example of efficient explanation (*Post. An.* 2. 11, 94^{a}36–^{b}8) is fairly straightforward. Here Aristotle picks a historical example in asking why it is that the Persian war came upon the Athenians, rephrased as what the explanation is for the Athenians being warred upon. It is not clear from the outset which type of explanation will be demonstrated; a similar example at *Phys.* 2. 7, 198^{a}18–19, shows that this question has different answers.

[29] For the thunder examples in the *Posterior Analytics* and *Metaphysics*, see Charles 'Substance', 233–5, 238–9.

[30] J. G. Lennox, 'Getting a Science Going: Aristotle on Entry Level Kinds', in G. Wolters (ed.), *Homo Sapiens und Homo Faber: Festschrift Mittelstrass* (Berlin, 2004), 87–100 at 90 n. 2.

[31] Charles, 'Substance', 239; J. G. Lennox, 'Aristotle on the Unity and Disunity of Science', *International Studies in the Philosophy of Science*, 15 (2001), 133–44 at 141.

However, the short explanation Aristotle offers first ('because the Athenians attacked Sardis with the Eretrians') shows that he is looking for some state of affairs that initiated the movement, which is an efficient cause (and not for that for the sake of which, such as the desire of the Persians to gain an empire). Aristotle then formalizes the example in the following way: 'War, A; being the first to attack, B; Athenians C.' It is significant that Aristotle here adds the notion of 'first' to the attack: it is being the *first* to do wrong that is explanatory for being wronged, and this is the origin of motion.

In this case, the middle term picks out the efficient cause of why war came upon the Athenians: for 'people make war on those who first began', which is why being warred upon holds of those who first began. The Athenians were the ones who first began (they fall under this formal description), and this explains the origin of the Persian war.[32]

2.5. *The example of teleological explanation*

Aristotle introduces the section on teleological explanation (*Post. An.* 2. 11, 94^{b}8–26) with a somewhat puzzling clause: *ὅσων δ' αἴτιον τὸ ἕνεκά τινος*. From what follows it is clear that the explanations that are at stake are teleological ones: Aristotle gives two parallel examples ('For what reason does he walk? In order to be healthy. For what reason is there a house? In order to protect possessions'), and identifies the final cause or the purpose in each example ('In the one case it is in order to be healthy, in the other in order to protect'). He also explains that in these cases there is no difference between a 'because of what' question and a 'for the sake of what' question. However, it is not immediately clear whether or not Aristotle means that the final cause has to be picked out by the middle term.

The introductory clause (*Post. An.* 2. 11, 94^{b}8) has often been read as implying just that (i.e. that in these cases the cause is that for the sake of which),[33] but it does not have to be read in this way. The Greek has *τὸ ἕνεκά τινος*, which means something different from *τὸ*

[32] Note that in all three examples the primary *explanandum* is the occurrence of a certain phenomenon (i.e. 'rightness', 'thunder', and 'war') that can be expressed in a predicative relation with a subject in which the phenomenon typically and for the most part inheres (i.e. 'angle in a semicircle', 'cloud', and 'Athenians'). In the demonstration that follows what is revealed is that there is always some aspect of this subject that explains the holding of its attributes.

[33] See e.g. H. G. Apostle, *Aristotle's* Posterior Analytics*: Translated with Commentaries and Glossary* (Grinnell, 1981), 59: 'Lastly, there is a final cause [or, that

οὗ ἕνεκα. The latter is the more common expression and is used more or less as a stock phrase designating the end (literally, 'that for the sake of which', in which *οὗ* is a relative pronoun).[34] *τὸ ἕνεκά τινος/του* designates rather the teleological relation of something being for the sake of something else (literally, 'that which is for the sake of something', where *τινος* is an indefinite pronoun). In this expression, the *τό* is not used as a definite article to substantivize the prepositional phrase, but to identify whatever is for the sake of something, or the relation as such.[35]

Under this interpretation, the point Aristotle makes here is not that the explanatory middle term in this case is the final cause, but that the causal relation involved is teleological, and that the middle term must pick out something that explains how something is for the sake of something. The teleological explanation is brought out through a middle term that need not itself be a final cause, but that rather shows how an end can hold of something. This causal relation is then illustrated by the two examples: walking is for the sake of health, and a house is for the sake of protection. The middle term that we are looking for needs to pick out a state of affairs that shows why this teleological relation between walking and being healthy obtains.

In a simplified version of the demonstrative syllogism, the predicate term (A) is being healthy, the middle term (B) is the food not floating, and the subject term (C) is walking after dinner. In this case, the middle term picks out the material cause of why being healthy holds of walking after dinner, because it identifies the physiological condition that is healthy—a condition that itself is initiated by walking that brings about health as an efficient cause.[36] For the identification of 'the food not floating' as a material cause, compare Aristotle's qualification of the boiling of the blood surrounding the heart as a material cause of anger at *DA* 1. 1, $403^{a}25$–$^{b}1$.

for the sake of which]'; Barnes, *Posterior*, 60: 'suppose it is the purpose which is explanatory'.

[34] Cf. *Phys*. 2. 2, $194^{a}27$–30: 'Further, that for the sake of which [*τὸ οὗ ἕνεκα*], or the end, as well as whatever is for the sake of these [*ὅσα τούτων ἕνεκα*], belongs to the same study. But nature is an end and a that for the sake of which [*οὗ ἕνεκα*].' *De caelo* 2. 12, $292^{b}6$–7: 'For action always consists in two factors, when there is that for the sake of which [*οὗ ἕνεκα*] and that which is for the sake of something [*τὸ τούτου ἕνεκα*].'

[35] Cf. *Phys*. $196^{b}17$, 20–2; *DA* $434^{a}32$; *GA* $715^{a}4$, $778^{b}13$; *MA* $700^{b}26$–7; *Metaph*. $1065^{a}31$.

[36] As Bolton, 'Material', 113–15, suggested.

In all four examples the different explanations that are at stake are revealed through the middle term, which picks out a cause for the holding by the predicate term of the subject term. However, in my analysis of the example of teleological explanation I have left two important questions unanswered. First, if Aristotle did not intend the final cause to be picked out by the middle term, what does he mean by 'changing the *logoi*'? Secondly, one might wonder what it is about this example—or about teleological explanations in general—that makes it so hard to rewrite the demonstrations in such a way that the final cause is actually picked out by the middle term. The following sections address these questions.

3. Teleological explanations and what it means to 'change the *logoi*'

3.1. *Why walking is for the sake of health*

The argument of the section on final causes is fairly long compared with the illustration of the other types of explanation, and it proceeds in a quite complicated way. Here I shall first separate the different steps in the argument and give a detailed interpretation of each; next, I shall propose two possible interpretations of 'changing the *logoi*'. Let me start by introducing the way Aristotle originally formulates the terms of the explanation (Table 1). For the sake of clarity, I also add the alternative formulations of the terms that Aristotle uses during the argument (Table 2).[37]

The argument itself proceeds in roughly the following four steps. First Aristotle asks us to suppose that to make the food not floating (B_2) holds of C, walking after dinner, and that this is healthy (A_2). Note that he changes the formulations of the terms A and B, presumably to show that walking (which is an activity) holds of another activity that produces the condition of the non-floating of food. It is this latter activity that Aristotle calls healthy, for healthy is just that which produces (or is useful to) the condition of being healthy. This is in fact the way Aristotle characterizes 'healthy' in the *Eudemian Ethics* (*EE* 1. 8, 1218^{b}16–22):

[37] I shall retain the numbering in my discussion of the example of teleological explanation; where it is not clear which formulation Aristotle has in mind, the term is not numbered.

TABLE 1. *The original formulations of the terms*

A_1	Being healthy	*τὸ ὑγιαίνειν*	Condition	Final cause
B_1	The food not floating	*τὸ μὴ ἐπιπολάζειν τὰ σίτια*	Condition	*Aition*
C	Walking after dinner	*περίπατος ἀπὸ δείπνου*	Activity	*Explanandum*

TABLE 2. *The alternative formulations of the terms*

A_2	Healthy	*ὑγιεινός*	Productive of condition
B_2	To make the food not floating	*τὸ ποιεῖν μὴ ἐπιπολάζειν τὰ σίτια*	Activity productive of condition

ὅτι δ' αἴτιον τὸ τέλος τοῖς ὑφ' αὑτό, δηλοῖ ἡ διδασκαλία. ὁρισάμενοι γὰρ τὸ τέλος τἆλλα δεικνύουσιν, ὅτι ἕκαστον αὐτῶν ἀγαθόν· αἴτιον γὰρ τὸ οὗ ἕνεκα. οἷον ἐπειδὴ τὸ ὑγιαίνειν τοδί, ἀνάγκη τόδε εἶναι τὸ συμφέρον πρὸς αὐτήν· τὸ δ' ὑγιεινὸν τῆς ὑγιείας αἴτιον ὡς κινῆσαν, καὶ τότε τοῦ εἶναι ἀλλ' οὐ τοῦ ἀγαθὸν εἶναι τὴν ὑγίειαν.

And that the end stands in a causal relation to the means subordinate to it is shown by teaching. For, having defined the end they show, regarding other things, that each of them is a good, because that for the sake of which is explanatory. For example, since 'being healthy' is such-and-such a thing, then necessarily this other thing will be what is useful for it. And *what is healthy will be the efficient cause of health*, though only the cause of its being, but not of health being a good.

By characterizing walking as an activity that is productive of the food not floating, and the latter as being productive of health, Aristotle implies that C is an efficient cause of A_1, being healthy: walking is productive of a healthy condition (cf. *Rhet*. 1. 6, 1362[a]31–4). Walking and health are thus causes of each other: while walking is the efficient cause of health, health is the final cause of walking (cf. *Phys*. 2. 3, 195[a]8–11). Now, if walking is a health-producing activity, it remains for the teleological demonstration to exhibit why it is that walking effects a change that is directed towards health. Accordingly, Aristotle continues the argument (and this is step 2) by explaining that it is thought that B_1, the material condition where the food is not floating on the surface, holds of C, walking, and healthy (A_2) holds of B (B_1). This opinion points towards the explanatory role of B_1.

Indeed, Aristotle now (thirdly) poses the question what the *aition* is that causally connects C, walking, and A, the 'that for the sake of

which'.[38] The answer is B_1, the not floating. Aristotle adds that 'this is like a definition of that' (*Post. An.* 2. 11, 94^b19–20). Probably the first 'this' refers to B_1, the not floating, while 'that' refers to A_1, being healthy, 'for', Aristotle explains, 'in that way the A will be explained'. The not floating of the food is like a definition of being healthy in the sense that it shows how being healthy in this context (i.e. in the context of a person who has just had dinner) is to be understood. Part of what it means to be healthy in this case is to be in a condition where the food is not floating on the surface of the stomach.[39]

Finally, Aristotle turns to an account of the minor premiss: 'For what reason does B hold of C?' He answers that the reason is 'because that is what being healthy is: to be in such a condition.' The formulation of this response suggests that we have touched upon a premiss that is not further analysable but is immediately evident (that is, the premiss is immediate). At this point Aristotle ends his discussion of this particular example of teleological explanation.

3.2. *Two possible interpretations of 'changing the* logoi*'*

The section is completed by the enigmatic statement (Barnes called it the 'Delphic injunction')[40] that one needs to 'change the *logoi*' (*μεταλαμβάνειν τοὺς λόγους*), and that 'in that way each of them will become clearer' (*Post. An.* 2. 11, 94^b21–2). The traditional interpretation reads this sentence in an apologetic way: Aristotle realizes that his example of the final cause is ill-chosen and messy, and that by mistake the middle term does not pick out the final cause. In order to make sense of this example, we should therefore (stipulate that the terms are coextensive and) rearrange the order of the terms or of the premisses in such a way that the middle term will pick out health as the final cause. However, I see two problems with this reading that strongly suggest that we should look for a different interpretation.

First, Aristotle spends quite some time expounding the example of teleological explanation, and it seems not very charitable to assume that this is not the example he actually would have liked to

[38] The apposition 'the for the sake of which' at *Post. An.* 2. 11, 94^b18, belongs to A, not to the *aition*.

[39] Other definitions of health are having one's body in a uniform state (*Metaph. Z* 7, 1032^b6–8), or having fasted for a while (*Phys.* 194^b36).

[40] Barnes, *Posterior*, 229.

present to his readers. In fact, the explanation that walking is for the sake of health is a stock example in the Aristotelian corpus, and the rationale Aristotle provides for health holding of walking in this chapter is perhaps not entirely transparent, but very much in line with other accounts of the example. If my interpretation holds, then we might say that Aristotle succeeds quite well in demonstrating how the middle term, i.e. the food not floating, exhibits the teleological relation between walking and health. There is thus no need to rearrange the example.

Secondly, Aristotle uses the verb *μεταλαμβάνειν* as a technical term in the *Prior Analytics* and *Topics*, where it means without exception 'to substitute for'.[41] This suggests that we should expect *μεταλαμβάνειν τοὺς λόγους* to mean something like 'substituting the *logoi* (for something else)'. In fact, the use of *μεταλαμβάνειν* as some kind of technical procedure of substitution in these texts presents two options for how to interpret the expression in the context of the *Posterior Analytics*, neither of which implies a rearrangement of the example.

One possible interpretation[42] is that the substitution concerns the formulations (*logoi*) of the terms. This reading is based on Aristotle's use of *μεταλαμβάνειν* in chapter 34 of the first book of the *Prior Analytics* (*Pr. An.* 1. 34, $48^{a}1$–27):

πολλάκις δὲ διαψεύδεσθαι συμπεσεῖται παρὰ τὸ μὴ καλῶς ἐκτίθεσθαι τοὺς κατὰ τὴν πρότασιν ὅρους. . . . τούτου δ' αἴτιον τὸ μὴ καλῶς ἐκκεῖσθαι τοὺς ὅρους κατὰ τὴν λέξιν, ἐπεὶ μεταληφθέντων τῶν κατὰ τὰς ἕξεις οὐκ ἔσται συλλογισμός, οἷον ἀντὶ μὲν τῆς ὑγιείας εἰ τεθείη τὸ ὑγιαῦνον, ἀντὶ δὲ τῆς νόσου τὸ νοσοῦν. οὐ γὰρ ἀληθὲς εἰπεῖν ὡς οὐκ ἐνδέχεται τῷ νοσοῦντι τὸ ὑγιαίνειν ὑπάρξαι. τούτου δὲ μὴ ληφθέντος οὐ γίνεται συλλογισμός, εἰ μὴ τοῦ ἐνδέχεσθαι· τοῦτο δ' οὐκ ἀδύνατον· ἐνδέχεται γὰρ μηδενὶ ἀνθρώπῳ ὑπάρχειν ὑγίειαν. . . . φανερὸν οὖν ὅτι ἐν ἅπασι τούτοις ἡ ἀπάτη γίνεται παρὰ τὴν τῶν ὅρων ἔκθεσιν· μεταληφθέντων γὰρ τῶν κατὰ τὰς ἕξεις οὐδὲν γίνεται ψεῦδος. δῆλον οὖν ὅτι κατὰ τὰς τοιαύτας προτάσεις ἀεὶ τὸ κατὰ τὴν ἕξιν ἀντὶ τῆς ἕξεως μεταληπτέον καὶ θετέον ὅρον.

Mistakes frequently will happen because the terms in the premiss have not been well set out. . . . The reason for this is that the terms are not set out well

[41] R. Smith (trans. and comm.), *Aristotle:* Prior Analytics (Indianapolis, 1989), 137, 261. See *Pr. An.* 1. 17, $37^{b}15$; 1. 20, $39^{a}27$; 1. 22, $40^{a}34$–5; 1. 23, $41^{a}39$; 1. 29, $45^{b}12$–20; 1. 34, $48^{a}1$–27; 1. 38, $49^{b}1$–2; 1. 39, $49^{b}3$–6; 2. 4, $56^{b}7$–8; 2. 8, $59^{b}1$–11; *Top.* 2. 2, $110^{a}4$–9; 5. 2, $130^{a}29$–$^{b}10$; 6. 4, $142^{b}3$; 6. 9, $147^{b}12$–14; 6. 11, $148^{b}24$–$149^{a}7$ (*passim*).

[42] Already suggested by W. W. Fortenbaugh, '*Nicomachean Ethics* I, 1096b26–29', *Phronesis*, 11 (1966), 185–94 at 192.

with regard to formulation, since if the terms for being in the conditions are substituted [for the terms for the conditions themselves], there will not be a deduction; for example, if instead of 'health' 'healthy' is posited, and instead of 'disease' 'diseased'. For it is not true to say that being healthy cannot hold of someone diseased. But if this is not assumed, there is no deduction, except in respect of possibility: and that is not impossible. For it is possible that health holds of no man. . . . It is evident, then, that in all these cases the fallacy results from the setting out of the terms; for if the terms for being in the conditions are substituted, there is no fallacy. Thus, it is clear that in such premisses the term for being in the condition always needs to be substituted and posited instead of that of the condition itself.

In this passage Aristotle deals with fallacies that occur when the terms of the syllogisms have not been set out well with regard to formulation (48^{a}9: *κατὰ τὴν λέξιν*).[43] The problem is solved by substituting terms 'for being in the conditions', i.e. adjectives such as 'healthy' (*ὑγιαῖνον*) and 'diseased', instead of the terms for the conditions themselves, i.e. nouns such as 'health' (*ὑγίεια*) and 'disease'. We might postulate that a similar kind of substitution of the formulation of the terms has taken place in *Post. An.* 2. 11: the terms indicating the conditions are replaced by terms indicating what is in the condition, or rather, by terms indicating what is productive of the condition. We have seen that Aristotle substituted 'healthy' (A_2) for 'being healthy' (A_1), and 'to make the food not floating' (B_2) for 'the food not floating' (B_1). Through these substitutions A and B could be predicated of C (a term indicating an activity), and furthermore the causal relations (in this case, both material causal and efficient causal ones) between the three terms would become more evident.

Another possible interpretation[44] is that the substitution concerns the replacement of words by their definitions. This is the stock use of the expression in the context of the *Topics*, and accordingly, we should supply *ἀντὶ τῶν ὀνομάτων* in the passage in *Post. An.* 2. 11. One context in which the expression 'to substitute the definitions for the words' is used in the *Topics* is that of the fallacy of repeating the word that is being defined or predicated in the definition or predication. The failure pertains to not having used the prior or better-known term in the definition or predication. The procedure

[43] For parallels for this method of *μετάληψις* in the ancient grammatical tradition, see I. Sluiter, *Ancient Grammar in Context: Contributions to the Study of Ancient Linguistic Thought* (Amsterdam, 1990), 111 ff.

[44] Suggested by Pieter Sjoerd Hasper in personal correspondence.

of substituting definitions for words is one of the recommended ways to detect the fallacy (*Top*. 6. 9, 147[b]12–14; 6. 4, 142[a]34–[b]6):

ἄλλος, εἰ αὐτῷ κέχρηται τῷ ὁριζομένῳ. λανθάνει δ' ὅταν μὴ αὐτῷ τῷ τοῦ ὁριζομένου ὀνόματι χρήσηται, οἷον εἰ τὸν ἥλιον ἄστρον ἡμεροφανὲς ὡρίσατο· ὁ γὰρ ἡμέρᾳ χρώμενος ἡλίῳ χρῆται. δεῖ δ', ὅπως φωραθῇ τὰ τοιαῦτα, μεταλαμβάνειν ἀντὶ τοῦ ὀνόματος τὸν λόγον, οἷον ὅτι ἡμέρα ἡλίου φορὰ ὑπὲρ γῆς ἐστιν.

Another [failure] is, if one has used the term defined itself. This passes unnoticed when the actual name of the object being defined is not used, e.g. supposing anyone had defined the sun as a star that appears by day. For in bringing in day he brings in the sun. To detect errors of this sort, substitute the definition for the word, e.g. the definition of day as the passage of the sun above the earth.

The expression is also used in the context of examining the correctness of definitions rendered of a complex term. For the definition to be correct, the words of the complex term have to be replaced by the definitions of the words (*Top*. 6. 11, 149[a]1–3). The substitution of definitions of words used in definitions also helps to clear up whether or not the predications hold non-accidentally (*Top*. 2. 2, 110[a]4–9):

λαμβάνειν δὲ καὶ ἀντὶ τῶν ἐν τοῖς λόγοις ὀνομάτων λόγους, καὶ μὴ προαφίστασθαι ἕως ἂν εἴς τι γνώριμον ἔλθῃ· πολλάκις γὰρ ὅλου μὲν τοῦ λόγου ἀποδοθέντος οὔπω δῆλον τὸ ζητούμενον, ἀντὶ δέ τινος τῶν ἐν τῷ λόγῳ ὀνομάτων λόγου ῥηθέντος κατάδηλον γίνεται.

One should substitute definitions also for the words contained in the definitions, and not stop until one comes to something familiar; for often when the definition is given as a whole, the thing looked for is not cleared up, whereas if for one of the words used in the definition a definition be stated, it becomes obvious.

Under this interpretation, we need to replace the words set out in the syllogism—such as 'walking' or 'being healthy'—by their definitions (perhaps just as Aristotle did himself), until we find the more familiar terms, [45] and in that way the predications will become clearer. A striking parallel is provided by Galen, who—plainly fol-

[45] This type of substitution might be connected to the one Charles observes in the *Posterior Analytics* concerning the example of thunder: the predicative term 'thunder' is replaced by its nominal definition 'noise in the clouds', which both gives us more familiar terms and indicates how thunder is to be understood in the relevant syllogism. See Charles, 'Substance', 240.

lowing Aristotle—uses *μεταλαμβάνειν* in precisely this way while discussing scientific demonstrations.[46]

The expression *μεταλαμβάνειν τοὺς λόγους* may be too elliptical to help us decide which of the two possible interpretations we should favour, but this problem need not concern us too much. Both uses seem to be at play in the *Posterior Analytics* context: Aristotle probably meant some technical procedure of substitution that he applied himself in discussing the example, and through which the causal relations between the terms and the predications became clearer.

3.3. *Ends cannot be picked out by middle terms*

If my interpretation is right, then Aristotle has offered us an example of teleological explanation where the middle term picks out a material cause, while the final cause is picked out by the predicate term. This leaves us with the question why he did not simply provide us with an example of teleological explanation where the middle term picks out a final cause.

I believe that Aristotle indirectly addresses this question in the passage where he brings up the order of causation in different types of demonstration (*Post. An.* 2. 11, 94^{b}23–6):

> *αἱ δὲ γενέσεις ἀνάπαλιν ἐνταῦθα καὶ ἐπὶ τῶν κατὰ κίνησιν αἰτίων· ἐκεῖ μὲν γὰρ τὸ μέσον δεῖ γενέσθαι πρῶτον, ἐνταῦθα δὲ τὸ Γ, τὸ ἔσχατον, τελευταῖον δὲ τὸ οὗ ἕνεκα.*
>
> Here the events occur in the opposite order from the cases where the causes are according to motion. For in the latter the middle term must occur first, while here C, the ultimate term, [must occur first], and last the for the sake of which.

In this passage Aristotle contrasts the order of causation in demonstrations of efficient causal explanations with those of teleological explanations. As we saw earlier, the middle term in the example of efficient explanation (i.e. being the first to attack) picked out an event that *later* initiated the war against the Athenians. The explanatory efficient cause thus precedes the *explanandum* in time.

[46] See Galen, *Meth. med.* x. 39. 5–10 Kühn: *καί σοι τὸν ἑξῆς λόγον ἤδη ἅπαντα ποιήσομαι, χρώμενος ταῖς μεθόδοις ἃς ἐν τοῖς περὶ τῆς ἀποδείξεως ὑπομνήμασι κατεστησάμην. ὅτι τε γὰρ ἀρχαὶ πάσης ἀποδείξεώς εἰσι τὰ πρὸς αἴσθησίν τε καὶ νόησιν ἐναργῶς φαινόμενα καὶ ὡς ἐπὶ πάντων τῶν ζητουμένων εἰς λόγον χρὴ μεταλαμβάνεσθαι τοὔνομα* [that with regard to every enquiry one needs to substitute the definition for the word], *δι' ἐκείνων ἀποδέδεικται.* I am grateful to Jim Hankinson for bringing this parallel to my attention.

However, in the example of teleological explanation we saw that the action picked out by the subject term (i.e. walking) occurred first. The final cause, health, came about last. It seems that in teleological explanations the final causes are literally, in a temporal sense, the *telos* or the end (and culmination) of the events to be explained.

In later discussions of the temporal relations between the three terms (*Post. An.* 2. 12 and 16) Aristotle puts forward the requirement that the state of affairs picked out by the middle term must be simultaneous with the state of affairs it explains.[47] However, in the case of events that come about consecutively (*Post. An.* 2. 12, $95^{b}13$: ἐφεξῆς) the middle term must be chronologically prior to the state of affairs it explains. As Aristotle points out (*Post. An.* 2. 12, $95^{b}33$–8), there is no difference in demonstration between the two cases.

The upshot is that, given that demonstrations are to reflect the order of causation in the real world,[48] final causes of events cannot be picked out by the middle term, but must always be part of the conclusion that is demonstrated. Since an efficient cause of an event typically occurs before the event itself, the efficient cause can be picked out through the middle term as being causally prior to what needs to be explained. The final cause of an event—although logically prior—typically occurs in actuality after the event itself has already taken place and the necessary prerequisites have been fulfilled.[49] The demonstration then shows how the events to be explained actually bring about the end that constitutes the final cause. This is exactly what Aristotle has shown us, namely that the action of walking actually leads to health, because walking is what makes the food not floating, and being in a condition of having the food not floating is what being healthy is. On this account, ends are part of the conclusion that needs to be demonstrated, and cannot be picked out by the middle term through which the conclusion is demonstrated.

[47] See mainly *Post. An.* 2. 12, $95^{a}22$: 'that which is causative in this way and that of which it is a cause come to be simultaneously [ἅμα γίνεται]', and *Post. An.* 2. 12, $95^{a}36$–7, where Aristotle argues that the middle term must be ὁμόγονος with the state of affairs it explains.

[48] Cf. D. Charles, *Aristotle on Meaning and Essence* (Oxford, 2000), 198–204, on the dependence of the practice of definition on the order of causation in the *Posterior Analytics*.

[49] This might explain why in the case of the teleological explanation in *Post. An.* 2. 11 the *explanandum* is picked out by the subject term ('why does walking after dinner occur?'), rather than by the predicate term as in the other three types of explanation.

The question I shall focus on below is how this picture of the structure of teleological explanations as described in the *Posterior Analytics* relates to the structure of actual teleological explanations offered by Aristotle in *De partibus animalium*. I shall first turn briefly to his discussion of demonstration in the natural sciences, and then analyse three predominant types of explanation in biology that involve final causality. Without going into too much detail, I shall show that the actual teleological explanations illustrate our findings about the theory of explanation rather well.[50]

4. Teleological explanations in practice: evidence from *De partibus animalium*

4.1. *Demonstration in the natural sciences and conditional necessity*

The first book of *De partibus animalium* sets out the principles and standards for biological investigations. It discusses a great variety of scientific principles and also the causes involved in the study of nature, such that its student will be able to assess the 'manner of the things brought to light' (*τὸν τρόπον τῶν δεικνυμένων*: *PA* 1. 1, 639[a]12–15). Aristotle proceeds mainly through discussing various methodological dilemmas, one of which pertains to the question of demonstration in the natural sciences. He states that the modes of demonstration in the theoretical sciences and in the natural sciences are different, because the modes of necessity are different (*PA* 1. 1, 640[a]3–6):

ἡ γὰρ ἀρχὴ τοῖς μὲν τὸ ὄν, τοῖς δὲ τὸ ἐσόμενον· ἐπεὶ γὰρ τοιόνδε ἐστὶν ἡ ὑγίεια ἢ ὁ ἄνθρωπος, ἀνάγκη τόδ' εἶναι ἢ γενέσθαι, ἀλλ' οὐκ ἐπεὶ τόδ' ἐστὶν ἢ γέγονεν, ἐκεῖνο ἐξ ἀνάγκης ἐστὶν ἢ ἔσται.

For the starting-point is in some [i.e. the theoretical sciences] what is, but in others [i.e. the natural sciences] what will be. For, 'since health or man

[50] This question touches upon the important debate on the relation between the ideal of scientific investigation and demonstration set out in the *Posterior Analytics* (the 'theory') and the methodological reflections and actual explanations Aristotle offers in his treatises on natural science (the 'practice'). Although I cannot defend my position here, I am more sympathetic to the approach defended *passim* in the works of, among others, Lennox and Gotthelf, who hold that Aristotle builds upon and elaborates his scientific standards for the different sciences, than to the approach defended by G. E. R. Lloyd, *Aristotelian Explorations* [*Explorations*] (Cambridge, 1996), who argues that Aristotle is a methodological pluralist, and that theory and practice cannot be reconciled with each other.

is such, it is necessary that this is or comes to be', but not 'since this is or has come about, that from necessity is or will be'.

The mode of necessity operative among natural perishable things is thus identified as conditional necessity, which Aristotle explains as the necessity of certain things being present first, if the end is to come to be.[51] Again, because demonstrations of the reason why have to reflect the true order of causality, the necessity that governs deductions of natural phenomena has to be conditional too. If the end has come to be or is (such and such), then its necessary prerequisites have had to come to be or be present first (or, in other words, its necessary prerequisites cannot not be; cf. *Phys.* 2. 9, 200^{a}19–22). The deduction is not of the consequences of a certain starting-point, but of the antecedents of the end.[52] The demonstration that results is not as strong as the demonstrations of the theoretical sciences, because the material-efficient prerequisites (though all in some sense being conditionally necessary for the end) do not ensure[53] the coming to be of the end. Of course, wherever a teleological relation obtains, the necessary material conditions will—for the most part, and if nothing impedes—bring about the end that constitutes the final cause.

These remarks about the nature and structure of demonstrations in the natural sciences present the following picture of what these demonstrations in practice would look like: first, it needs to be noted that the predominant form of demonstration is teleological demonstration. What needs to be demonstrated in the context of *De partibus animalium* is mainly why certain functions belong to the parts whose presence these final causes explain. The final cause of something is the realization of the form of that thing, and this is something that chronologically comes to be last. At the same time, this final cause is taken as a (heuristic and observational) starting-point, presumably as a part of the conclusion of the demonstration. Next, one has to work one's way back to the conditionally necessary

[51] See *PA* 1. 1, 639^{b}26–30: 'It is necessary that a certain sort of matter be present if there is to be a house or any other end, and this must come to be and be changed first, then that, and so continuously up to the end and that for the sake of which each comes to be and is.'

[52] Lloyd, *Explorations*, 32; as Lloyd rightly points out, the antecedents that are deduced are antecedents of the final cause in a chronological or ontological sense, not in a logical one.

[53] This is because, as Aristotle explains (in *PA* 1. 1, 640^{a}6–9, and *GC* 2. 11), the necessity involved does not convert.

antecedents, which the realization of this end demands. These antecedents will be exhibited by material or efficient causes (or both) that are directed towards this final cause, and as such will be picked out by the middle term.

This picture is largely consistent with the example of why one walks after dinner in *Post. An.* 2. 11. The question why one walks after dinner parallels the biological question why, for instance, a certain part is present in a certain animal. The question is answered by identifying the final cause: in the case of walking, health; in the case of biological parts, the function of that part. In both cases, the middle term will have to pick out the conditionally necessary antecedents that for the most part will bring about the end that constitutes the final cause.

I shall strengthen this general picture by an analysis of the most common types of teleological explanation that Aristotle uses in *De partibus animalium*.

4.2. *The place of final causes in actual teleological explanations*

4.2.1. *The explanation of the presence of parts: final cause is subsumed under the formal cause* The most common question in *De partibus animalium* is why a certain animal has a certain part, and Aristotle typically answers this question by pointing out the function that part plays within the particular animal kind that has that part. The presence of parts is thus explained teleologically through reference to their function, but usually the presence of these functions themselves is explained by reference to the definition of the substantial being of the animal.

Let me explain this by giving an example. The question why birds have wings is answered by reference to the function of flying as a part of the definition of the substantial being of birds: birds are essentially flyers, and flyers necessarily have wings.[54] In a formalization of this example, the middle term would be 'flyers' (which picks out a functionally defined essence), not 'flying' (which picks out the function or final cause). It is this definition of the substantial being of birds that is explanatorily basic, and which is thus picked out to explain why certain parts with certain functions hold of cer-

[54] *PA* 4. 12, 693^{b}10–14: 'For the substantial being of the bird is that of the blooded animals, but at the same time also that of the winged animals . . . and the ability to fly is in the substantial being of the bird.' (Cf. *PA* 4. 13, 697^{b}1–13; 3. 6, 669^{b}8–12.)

tain animal kinds.[55] From the definition of birds as blooded flyers not only the presence of wings can be demonstrated, but also many of the bird's other features, such as the having of two feet (rather than four, or six: *PA* 4. 12, 693^{b}2–13).

Additionally, Aristotle sometimes explains the presence of parts in subspecies by reference to the functions that are part of the definition of the substantial being of the wider kind. The fact that birds are essentially flyers explains, according to Aristotle, why ducks have wings for the sake of flying. Here, the functions (the final causes) tend to be subsumed under the essence (the formal cause) of the animal or its wider kind. Wings belong to ducks because ducks are essentially birds.

In these cases, functions are picked out by the predicate term and only 'indirectly' through the middle term as being part of the definition of the substantial being of something—that is, as being included in the formal cause.[56] Final causes of parts are demonstrated to belong to parts through the functionally defined substantial being of an animal, and it is this formal cause that is explanatorily basic.

4.2.2. *The explanation of differentiations of parts: differentiae are causally basic* Another common question in *De partibus animalium* is why a part has the structural and material properties it has in the particular animal that has it. Or, in other words, why the part is differentiated in the way it is in this particular animal, relative to other parts with the same name and approximately the same function in other animals.

Take the example of eyes: both birds and insects have eyes for the sake of vision, but birds have eyes made of fluid eye jelly, while insects have hard eyes. This material differentiation of eyes cannot be explained by reference to the function of vision as such, which only requires eyes to be made of some transparent stuff (the general function explains only the presence of parts, not their differentiations). Aristotle explains these differentiations by claiming that they are for the better: that is, they are for the sake of the functional optimization of that part within the particular animal kind (*PA* 2. 2, 648^{a}14–19):

[55] For features belonging to the substantial being of animals, see A. Gotthelf, 'First Principles in Aristotle's *Parts of Animals*', in A. Gotthelf and J. G. Lennox (eds.), *Philosophical Issues in Aristotle's Biology* (Cambridge, 1987), 167–98 at 190–1.

[56] *PA* 1. 1, 640^{a}33–5: 'Hence we must in particular say that since this is what it is to be a human being, on account of this it has these things; for it cannot be without these parts.' (Cf. *Phys.* 2. 9, 200^{a}14; *PA* 1. 1, 639^{b}13–14.)

ὑπολεπτέον ἔχειν τὴν διαφοράν, τὰ μὲν πρὸς τὸ βέλτιον ἢ χεῖρον, τὰ δὲ πρὸς τὰ ἔργα καὶ τὴν οὐσίαν ἑκάστῳ τῶν ζῴων, οἷον ἐχόντων ὀφθαλμοὺς ἀμφοτέρων τὰ μέν ἐστι σκληρόφθαλμα τὰ δ' ὑγρόφθαλμα, καὶ τὰ μὲν οὐκ ἔχει βλέφαρα τὰ δ' ἔχει πρὸς τὸ τὴν ὄψιν ἀκριβεστέραν εἶναι.

They [i.e. parts] should be assumed to possess a differentiation, in some cases relative to what is better or worse, in other cases relative to each animal's functions and substantial being. For instance, two animals may both have eyes, but in one these eyes are hard, while in the other they are of fluid consistency; and while the one does not have eyelids, the other does—both being for the sake of a greater accuracy of vision.

Aristotle thus explains the (relative) fluidity of the eyes of birds as being for the sake of *better* vision in birds: birds have fluid eyes to be better able to see. However, Aristotle explains this functional optimization by reference to the specific nature, habitat, and needs of the animal in question. That is, the explanatorily basic features in these explanations are the four differentiae of the animal kind, which are the other parts (and functions) the animal has, the animal's *bios* (lifestyle and habitat), its activities, and its disposition. These four *differentiae* immediately necessitate the variation among parts through conditional necessity. The *differentiae* demand a functional fine-tuning of the part, and this will in its turn conditionally necessitate material-structural changes or a relocation of the part. This is clear in the following example (*PA* 2. 13, 657^{b}22–9):

τὰ δὲ τετράποδα καὶ ᾠοτόκα οὐ σκαρδαμύττει ὁμοίως, ὅτι οὐδ' ὑγρὰν αὐτοῖς ἀναγκαῖον ἔχειν καὶ ἀκριβῆ τὴν ὄψιν ἐπιγείοις οὖσιν. τοῖς δ' ὄρνισιν ἀναγκαῖον· πόρρωθεν γὰρ ἡ χρῆσις τῆς ὄψεως. διὸ καὶ τὰ γαμψώνυχα μὲν ὀξυωπά (ἄνωθεν γὰρ αὐτοῖς ἡ θεωρία τῆς τροφῆς, διὸ καὶ ἀναπέτονται ταῦτα μάλιστα τῶν ὀρνέων εἰς ὕψος), τὰ δ' ἐπίγεια καὶ μὴ πτητικά, οἷον ἀλεκτρυόνες καὶ τὰ τοιαῦτα, οὐκ ὀξυωπά· οὐδὲν γὰρ αὐτὰ κατεπείγει πρὸς τὸν βίον.

The four-footed, egg-laying animals do not blink in the same way as the birds, because since they are terrestrial, it is unnecessary for them to have moist and accurate vision. But for the birds it is necessary, since they use vision to see from a great distance. Accordingly, crook-taloned birds have sharp vision (for they search their food from above, which is also why these most of all soar to the heights), while those which are terrestrial and incapable of flight, such as domestic fowl and the like, do not have sharp vision. For nothing related to their way of life requires them to have it. (Trans. Lennox)[57]

[57] J. G. Lennox (trans. and comm.), *Aristotle:* On the Parts of Animals [*Parts*] (Oxford, 2001), 39–40.

A reconstruction of the premisses involved in this example shows that the fact that crook-taloned birds search for their food from above explains why they need accurate vision, and it is this need for accurate vision that conditionally necessitates the moistness of the eyes of these birds. However, the ability of crook-taloned birds to see accurately *follows* from the material differentiation of eyes: the specific material disposition of each kind of eye explains the accurateness of vision of the animal that has those kinds of eye.[58] Again, the final cause is part of the conclusion of the demonstration, while the middle term refers to formal or material-efficient causes.

4.2.3. *The explanation of luxurious parts: secondary teleology* A third type of explanation that is fairly common in *De partibus animalium* is the so-called 'double-barrelled' explanation. In these cases Aristotle explains the presence of a part or its differentiation both by reference to a final cause and by reference to material necessity. This type of explanation usually pertains to parts or functions that are not of vital or essential importance for the animal (and therefore not necessary in a strict sense), but 'merely' contribute to its well-being. Examples of such parts are horns, spurs, hoofs, nails, teeth, hair, and eyebrows; these parts all serve the luxury function of defence or protection. The doubleness of the explanation indicates that these parts are due to what might be called 'secondary teleology'.[59] That is, the *coming to be* of the materials out of which the luxurious parts are constituted is due to material necessity (see e.g. *PA* 4. 3, $677^{b}22$–29; 4. 4, $678^{a}3$–10). The *presence* of these parts, on the other hand, and their organization and distribution in an animal's body are due to the goal-directed actions of the formal nature of the animal. Aristotle describes the action of the formal nature of the animal in these cases as *making use* of materials that are present of necessity for a good purpose, rather than as *producing* those materials for the sake of some function.

Take the example of horns (*PA* 3. 2). First, Aristotle explains that horns are present in the animals that have them for the sake

[58] For habitat being picked out as an explanatory basic feature, see A. Gotthelf, 'The Elephant's Nose: Further Reflections on the Axiomatic Structure of Biological Explanations in Aristotle', in Kullmann and Föllinger (eds.), *Aristotelische Biologie*, 85–95 at 85–9; and Charles, 'Substance', 249–50.

[59] My usage of the term 'secondary teleology' derives from Lennox's notion of 'indirect teleology' (Lennox, *Parts*, 248–9), although our interpretations of the causal pattern underlying this type of teleology are different.

of self-defence and attack (*PA* 3. 2, 663^{b}21–2). Next, he poses the following question (*PA* 3. 2, 663^{b}22–4):

πῶς δὲ τῆς ἀναγκαίας φύσεως ἐχούσης τοῖς ὑπάρχουσιν ἐξ ἀνάγκης ἡ κατὰ τὸν λόγον φύσις ἕνεκά του κατακέχρηται, λέγωμεν.

We must say what the character of the necessary nature is, and, how nature according to the account has made use of things present of necessity for the sake of something.[60]

The necessary nature of the animal indicates, I submit, the amount and kind of materials that come to be as a result of material necessity, as a by-product or surplus of conditionally necessitated processes (without being themselves conditionally necessary). As Aristotle explains, large animals seem to produce more earthen material than is conditionally necessary (and necessitated) for the production of their bones, and it is this residue which is then 'used by nature for the sake of protection and advantage' (*PA* 3. 2, 663^{b}25–35).

In cases like this, the function that explains the presence of the part *follows* from the potentials the available material has.[61] The earthen residue is used by the formal nature of an animal to produce parts such as horns, *because* this kind of material has a defensive potential.[62] Formalizations of examples like these are not easy, but for our purposes it suffices to notice that again a final cause is demonstrated to belong to some feature through another more basic feature, in this case the presence of materials with certain material potentials.

Let me end this exposition of common types of teleological ex-

[60] Here Ogle's translation (W. Ogle (trans.), *Aristotle:* De partibus animalium (Oxford, 1912): 'Let us now consider the character of the material nature whose necessary results have been employed by rational nature for a final cause') is grammatically closer to the Greek than Lennox's (*Parts*, 51: 'Since there is a necessary nature, we must say how the nature according to the account makes use of things present of necessity for the sake of something'). *πῶς* should be taken with *ἐχούσης* in the genitive absolute, *and* with *κατακέχρηται*: as soon as we know what kind of thing the necessary nature is, we can explain how nature makes use of the things that are present on account of this necessary nature.

[61] This is what Aristotle explains in *PA* 2. 9, 655^{b}4–12: 'All these [uniform parts, such as horns] the animals have for the sake of protection . . . Of necessity all of these parts have an earthen and hard nature; for this potential is of the defensive kind.' Cf. *GA* 2. 6, 744^{b}12–27.

[62] *Pace* Lennox, *Biology*, 194–5, who holds that 'such material is present for the sake of constituting parts which must have a material propensity suitable for defense'.

planation in *De partibus animalium* by pointing out that although the actual explanations are more complicated than the example of walking after dinner in the *Posterior Analytics*, the basic structure and the role of final causes seem to be the same. In biology, Aristotle attributes functions to (differentiations of) parts in order to explain the presence of the latter. However, the holding of these functions follows from other, more basic features, such as the animal's essence (that comprises functions), its lifestyle, or the availability of certain material potentials. It thus seems that in practice too, final causes are what is attributed to a subject, and not what can be picked out by an explanatory middle term.

5. Conclusion

In the preceding sections I have argued that *Post. An.* 2. 11 shows how each of the four types of explanation is brought out through an explanatory middle term, which need not express the same type of causality as the explanation does.

This interpretation, supported by the lexical difference between *aitia* and *aition*, takes away the need to rearrange Aristotle's syllogistic example of walking after dinner for the sake of health. Nothing in the text of the *Posterior Analytics* suggests that final causes *must* be picked out by the middle term in a teleological demonstration. A comparison with the use of *μεταλαμβάνειν* in the *Prior Analytics* and the *Topics* shows that the expression *μεταλαμβάνειν τοὺς λόγους* should be taken as referring to some kind of procedure of substitution that Aristotle has applied himself while setting out his example, rather than as an admonition to us to change the order of the terms or premisses. The fact that in teleological explanations the end for the sake of which the event is undertaken comes to be chronologically last, together with Aristotle's requirement that explanations have to reflect real causal sequences, explains why it is impossible to construct a syllogism in which the middle term picks out this end as a final cause.

A short analysis of Aristotle's methodological remarks about demonstration in the natural sciences and of his actual practice of teleological explanation in *De partibus animalium* confirms the general picture found in the *Posterior Analytics* with regard to the structure of teleological explanations. Functions explain the pre-

sence (or differentiations) of parts, but the holding of these functions by those parts is demonstrated through the discovery of some other basic explanatory feature. Final causes are the starting-points from which the conditionally necessary antecedents are to be traced back, but it is the presence of these prerequisites that causes—for the most part, and if nothing interferes—the coming to be of ends.

This does not mean that final causes have only a heuristic value: because final causes are part of the conclusion that is being demonstrated, the demonstration demonstrates the very existence of natural teleology.

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APPENDIX

Translation of *Post. An.* 2. 11, $94^{a}20$–$94^{b}26$

Since we think we have [scientific] knowledge when we know the explanation, and there are four types of explanation—one, what it is to be a thing and another, given what things being the case it is necessary for that to hold; another, what first initiated the motion; and fourth, the for the sake of what—all of them are brought out through the middle term. For, 'given what thing being the case it is necessary for this to hold' does not occur when one proposition is assumed, but when at least two are. This is the case when they have one middle term. Thus when this one is assumed, it is necessary for the conclusion to hold. It is clear too in the following way. Because of what is the angle in a semicircle a right angle? Given what thing being the case is it a right angle? Suppose, then, that right is A, half of two rights B, the angle in a semicircle C. Thus of A's—right—holding of C—the angle in a semicircle B is the cause. For this [B] is equal to A and C to B, because it [C] is of two rights—half. Thus given B, half of two rights, being the case, A holds of C (for that was it that [necessitates] the angle in a semicircle being a right angle). And that [B] is the same as what it is to be it, since the definition signifies this [i.e. what it is to be it].

Now it has also been shown that the middle term is explanatory of the essence.

For what reason did the Persian war come upon the Athenians? What is an explanation of the Athenians' being warred upon? Because they attacked Sardis with the Eretrians. For that initiated the movement. War, A; being the first to attack, B; Athenians C. B holds of C, the Athenians being the first to attack, and A holds of B, because people make war on those who have wronged them first. Therefore A holds of B, being warred

upon to those who first began, and this, B, holds of the Athenians—for they first began. And in this case, too, the cause, that which initiated the movement, is the middle term.

Regarding the cases in which the causal relation is that something is for the sake of something—for example: for what reason does he walk? In order to be healthy. For what reason is there a house? In order to protect the possessions. In the one case it is in order to be healthy, in the other in order to protect. There is no difference between for what reason it is necessary to walk after dinner and for the sake of what it is necessary. Call 'walking after dinner' C, 'the food not floating on the surface' B, and 'being healthy' A. Suppose, then, that to make the food not floating on the surface at the mouth of the stomach holds of walking after dinner, and suppose the first is healthy. For it is thought that B, the food not floating on the surface, holds of to walk, of C, and that thereof (of B) A, healthy, holds. What, then, is the causal factor for C of A's—the for the sake of which—holding of it? B, the not floating. This is like a definition of it [of A]; for A will here be explained in this way. And for what reason does B hold of C? Because that is what being healthy is: being in such state. Surely one must substitute the definitions, and in that way each of them will become clearer. Here the events occur in the opposite order from the cases where the causes are according to motion. For in the latter the middle term must occur first, while here C, the ultimate term, [must occur first], and last the for the sake of which.

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