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ARTICLE



Aristotle on multiple demonstration

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ABSTRACT

How many scientific demonstrations can a single phenomenon have? This paper argues that, according to Aristotle's theory of scientific knowledge as laid out in the *Posterior Analytics*, a single conclusion may be demonstrated via more than one explanatory middle term. I also argue that this model of multiple demonstration is put into practice in the biological writings. This paper thereby accomplishes two related goals: it clarifies certain relatively obscure passages of the *Posterior Analytics* and uses them to show how Aristotle explains biological phenomena by reference to both final and material causes in the *Parts of Animals*. The first part of the paper explains the account of multiple demonstration present in the *Posterior Analytics* and distinguishes it from another kind of plural explanation rejected by Aristotle. The second part of the paper turns to the biological explanation in the *Parts of Animals* and shows how Aristotle's account of multiple demonstrations works in practice. The paper thus provides evidence for the claim that the 'applied' reasoning on display in the biological works is in harmony with the framework of the logical treatises, and thus may also shed light on questions of the unity of the Aristotelian corpus.

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How many scientific demonstrations can a single phenomenon have? This paper addresses the possibility of one demonstrable natural phenomenon having multiple valid demonstrations in Aristotle's theory of scientific knowledge. Aristotle discusses the problem of multiple demonstrations (*pleious apodeixeis*; hereafter MD) at several points in both the first and the second books of the *Posterior Analytics* (*APo*).¹ Though the examples he uses to illustrate his points – as is so often the case in the *APo* – are frequently rather obscure, the possibility of MD is of

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¹All English citations of the *Posterior Analytics* will be from Jonathan Barnes' translation (*Aristotle's Posterior Analytics*) with emendations as noted. I will give the Greek text of extended quotations in footnotes, from W.D. Ross' edition and commentary (*Aristotle's Prior and Posterior Analytics*), which is the basis for the 1957 OCT. Greek for other texts is from the *Thesaurus Linguae Graecae* (stephanus.tlg.uci.edu)

crucial importance for understanding the relationship between Aristotle's scientific methodology on the one hand and practice on the other.

Twenty-five years ago, Jonathan Barnes memorably characterized the *APo* as the 'Cinderella of the Aristotelian pantomime' – formerly ignored only to be besieged by suitors ('Aristotle's Philosophy of the Sciences', 225). That characterization is by now itself somewhat out of date: no longer a parvenu, the *APo* is firmly established as one of the key texts in the Aristotelian corpus. This more secure status has allowed for attention to be paid to the question of whether – and if so, how – Aristotle's methodology coheres with his actual scientific practice.² The importance of MD lies precisely there: throughout his biological works, Aristotle presents multiple explanations for a single phenomenon. To take one example, he tells us at *Parts of Animals* ii.14 that humans have hairy heads for two reasons: (i) because they have particularly moist brains and their heads are full of sutures (the combination of moisture and heat escaping from the head cause hair to grow) but also (ii) for the sake of protection (the hair provides much needed insulation for the hot, moist brain underneath) (658b2–10). This and other examples shall be discussed at length in Part II. For now, the point is that if MD is present in the biological works, coupled with the *prima facie* plausible assumption that Aristotle's practice of science coheres with his theory of scientific knowledge, then we ought to look for an account of multiple demonstration in the *APo*.

That account is to be found at *APo* i.29, where Aristotle explicitly lays out a formal scheme for MD. Yet despite the increase of attention on the *APo* generally, and its connection with Aristotle's scientific practice particularly, the passage has been generally unremarked. Barnes, one of the few recent commentators who has dealt with MD directly, has discounted the rather brief discussion at i.29 because it seems to conflict with a related – though I will argue different – sort of inferential scheme at *APo*. ii.16–17. The first part of this paper will reconstruct the account at i.29 and then show that, *pace* Barnes, it coheres with the discussion at ii.16–17. Then, in the second part, I shall discuss the philosophical motivation for MD: Aristotle's doctrine of the so-called 'four causes'. It is surely one of his best known (which is not to say best understood) doctrines that the question 'why', that is the demand for explanation, can be answered in at least four distinct ways. Aristotle explicitly incorporates this explanatory pluralism into his scientific methodology at *APo* ii.11 which argues that all four kinds of cause can be cited as middle terms – the explanation of why a predicate holds of a subject – in scientific demonstrations. Finally, I move beyond Aristotle's theoretical writing on scientific methodology and conclude by showing how the *Parts of Animals* (*PA*) contains examples of MD in practice. While my focus remains squarely on Aristotle, the

²See especially Lloyd, 'The Theories and Practices of Demonstration', Leunissen, 'The Structure of Teleological Explanation in Aristotle', Leunissen, *Explanation and Teleology in Aristotle's*, Ebrey, *Theory and Practice in Aristotle's Natural Science*; cf. Tuominen, 'Alexander and Philoponus on *Prior Analytics* I 27–30'.

basic concerns that MD addresses continue to resonate: Does scientific understanding admit of multiple paths to establishing knowledge? Particularly important is the question of whether biological phenomena are properly understood only in purely physical terms or whether such understanding may also take into account the apparent purposiveness of living beings. We shall see in the second part of this paper that this sort of pluralism is precisely what MD accounts for in Aristotle's thinking. Contemporary framing of the issue of 'mechanism versus teleology' may owe more to its re-emergence in the early modern period – and in particular its central place in Kant's third critique – than it does to Aristotle. Nevertheless, Aristotle's emphasis lies less on the *tension* between multiple modes of explanation and demonstration and more on their co-existence. So, while my primary aim is to reconstruct a crucial facet of the *APo*, it is also to recover a view that retains philosophical, as well as historical, value.

I. MD in the *APo*

1. The positive account of MD

At *APo* i.29 Aristotle tells us explicitly that there may be multiple demonstrations of one and the same fact:

(T1) It is possible for there to be multiple demonstrations of the same thing not only by taking a non-continuous middle term from the same chain – e.g. *C* and *D* and *F* for *A B* – but also by taking a middle term from a different chain. E.g. let *A* be altering, *D* changing, *B* enjoying, and again *G* coming to rest. Now it is true to predicate both *D* of *B* and *A* of *D*; for the man who is enjoying himself is changing, and what is changing is altering. Again, it is true to predicate *A* of *G* and *G* of *B*; for everyone who is enjoying themselves is coming to rest, and one who is coming to rest is altering. Hence the deduction is through middle terms that are different and not from the same chain – yet not in such a way that neither is said of the other; for it is necessary for them both to belong to some one thing.

(87b5–87b16; trans. modified)

Let us unpack what sort of demonstrations Aristotle is accepting here and what sort he is ruling out. First, Aristotle explicitly says that he is employing 'multiple demonstrations' (*pleious apodeixeis*) not to refer to taking different middle terms from the same chain. This, of course, would be a valid move – it simply refers to a scenario in which one or more middle terms in a demonstration containing multiple such terms are left out of the exposition or understood implicitly. To expand Aristotle's example, if *A* holds of all *B*, *B* of all *C*, *C* of all *D*, and *D* of all *F*, then it is clear that by repeated iteration of *barbara* (three times, to be precise), we can show that *A* also holds of all *F*.³ The reference

³*Barbara* = $AaB, BaC \vdash AaC$. For \vdash , read 'entails' or 'therefore' (distinguishing between syntactic and semantic consequence is not necessary for the purposes of this paper). For the premises, I use the traditional medieval abbreviations, which are to be read as follows: for AaB read 'A holds of all B' or 'Every B

here to ‘non-continuous’ middle terms is to a situation in which one of these applications of *barbara* is not stated explicitly – i.e. in which one of the middle terms is treated *as if* it held primitively of terms of which it was predicated. This is made clearer by considering that in scientific or mathematical practice, one would not need to explicitly prove each theorem every time one makes use of it; rather, one can assume it based on prior demonstration.

Aristotle envisions two chains of demonstration, both leading to the conclusion AaB , which can be formalized as follows (keeping the variables from T1):

- (1) whatever is changing is altering (AaD), whatever is enjoying is changing (DaB), therefore whatever is enjoying is altering (AaB), and
- (2) whatever is coming to rest is altering (AaG), whatever is enjoying is coming to rest (GaB), therefore whatever is enjoying is altering (AaB)

In purely symbolic form, this is represented:

- (1) $AaD, DaB \vdash AaB$
- (2) $AaG, GaB \vdash AaB$

The example Aristotle chooses to formalize here is not immediately apparent. It seems inspired by various of Plato’s discussions of pleasure (*hêdonê*), e.g. in the *Philebus* (42b) and perhaps the *Phaedo* (63ff). However, this is a view of pleasure that Aristotle himself rejects (see *EN* vii.11 1152b13; vii.12 1152b31ff.), it also seems to rest on the notion that ethical proofs can be scientific (a controversial claim and one which Aristotle himself seems to reject at *EN* i.7, 1098a25ff).⁴ Moreover, it is unclear why ‘coming to rest’ (*êremizesthai*) does not itself fall under the broader heading of ‘change’ (*kineisthai*), in which case the latter would hold universally of the former (GaD). If this were so, this would be a case of what Aristotle calls middle terms from ‘the same chain’.

It seems, then, that chapter functions, in practice at least – whatever Aristotle’s intention – less as a genuine case of MD and more as providing a *model* for MD. Assuming for present purposes only universal affirmative syllogisms in *barbara*, for a demonstrable proposition AaC (Cf. *APo* i.14, 79a18), we may have multiple demonstrations as follows:

- (1) $AaB_1, B_1aC \vdash AaC$
- (2) $AaB_2, B_2aC \vdash AaC$
- ... $AaB_N, B_NaC \vdash AaC$

is A ; for AiB read ‘ A holds of some B ’ or ‘Some B is A ’; for AeB read ‘ A holds of no B ’ or ‘No B is A ’; for AoB read ‘ A does not hold of all B ’ or ‘Some B is not A ’.

⁴Henry and Nielsen, *Bridging the Gap Between Aristotle’s Science and Ethics*, collects arguments for various positions on just this question. In particular, Karen Nielsen’s essay argues for the strong thesis that ethics, for Aristotle, is a scientific discipline.

The lack of clear example in i.29 may make one hesitate as to what purpose MD, as presented there, is meant to serve. Indeed, it might lead one to ask whether the chapter is about demonstration at all: for although Aristotle uses his standard term for demonstration, *apodeixis*, this same term also occurs both in other works and in the *APo* itself (e.g. at i.13) for arguments that are very different from the sort in which Aristotle is *primarily* interested in the *APo*.⁵ (Geoffrey Lloyd has catalogued a variety of these – for example *apodeixis* used in the *Rhetoric* for arguments aimed at producing conviction in the listener [*pistis*].) Is it possible, then that the ‘multiple demonstrations’ of i.29 are simply a reference to these other uses of the term *apodeixis*? If that were so, the chapter would be of interest for a study of Aristotle’s use of the term, but would shed little light on the crucial question of a plurality of *explanations* and how these might be incorporated into Aristotle’s account of science. Yet such a reading seems to run counter to the context in which the i.29 occurs. The chapter comes after a series of chapters evaluating the criteria for successful demonstration and ranking their varieties: universal affirmative syllogisms being the best, with negative definition and *reductio* inferior but still acceptable. These different modes, however, are not so radically different as to render *apodeixis* multivocal, as it is between its uses in the *APo* as compared with, say, the *Rhetoric* (to take the furthest example). Yet for the same reason, there would be no obvious motivation or indeed function for an acknowledgment of the multiplicity of *apodeixis* in the context of the *APo*.

More fundamentally, however, the worry that i.29 doesn’t concern multiple demonstration properly speaking is one that can only be answered properly in the course of subsequent argument. The obscurity of the example quite simply means that the schematic outline of MD presented in i.29 is somewhat underdetermined. The question then is what need the brief discussion at i.29 might answer: what function MD as present there might serve. I have mentioned already that MD will turn out to look particularly well-suited to account for the multiple forms of explanation much beloved of every teacher of introductory lectures on the history of philosophy: the so-called four causes. We shall soon see that while i.29 is the only place where Aristotle addresses MD head on, multiple explanations are also discussed in the second book of the *APo* and are a feature of Aristotle’s biology. So even if Aristotle’s example at i.29 is not unambiguously about explanation, both the immediate and broader context make it clear that Aristotle is talking about demonstration in the strict sense of the term. However, before turning to the *application* of MD, we must first address another worry: that the formal scheme is itself inconsistent.

⁵Thank you to an anonymous reviewer for pressing me on this point.

2. Apparent problems with MD

With the formal sketch of MD as laid out at *APo* now in view, we may turn to evaluating the cogency of the scheme. Given the brevity of i.29, we shall need to turn elsewhere to accomplish this task: first to other chapters of the *APo* itself and subsequently to other works of Aristotle. Besides Philoponus' rather brief remarks, pre-modern commentators generally mention the passage only in passing.⁶ Among recent writers Barnes is an exception, probably due more to the fact that he is in the business of writing a line-by-line commentary than anything else. (Ross, however, is even more cursory).⁷ Barnes concludes that

Aristotle shows only that there can be several valid arguments for the same conclusion, not that there can be several demonstrations of the same fact; the latter thesis entails that there may be several explanations for the same fact: how far this is the case is discussed at *B* 16–18.

(Aristotle's Posterior Analytics, 191)

He is correct in noting that the final chapters of Book ii of the *APo* bear on MD; however, the connection is not entirely straightforward. Turning now to ii.16 and 17, we shall see that those chapters seem initially to be in direct contradiction with the picture of MD at i.29.

At ii.16, Aristotle poses a question, the answer to which will come in the following chapter:

(T3) Or is it possible for there to be multiple explanations of one thing? If the same thing can be predicated of several items primitively, let *A* hold of *B* primitively and also of another term *C* primitively, and let these hold of *D*, *E*. Therefore *A* will hold of *D*, *E*; and *B* is explanatory for *D* and *C* for *E*. Hence when the explanation holds the object holds; but when the object holds it is not necessary for everything explanatory to hold – rather, something (but not everything) must hold.

(APo, ii.16, 98b25–32)

Unlike i.29, we do not get any examples here. However, the inferences in T3 are formalized as follows:

(1*) $AaB, BaD \vdash AaD$

(2*) $AaC, CaE \vdash AaE$

Recall now the deductive scheme for MD as laid out in i.29:

(1) $AaB_1, B_1aC \vdash AaC$

(2) $AaB_2, B_2aC \vdash AaC$

... $AaB_N, B_NaC \vdash AaC$

⁶e.g. Aquinas (*In APo* i.29, lectio 42) and Averroes (*Kitab al-burhan* §90) both simply offer a close paraphrase of i.29; neither offers much, if anything, by way of interpretation.

⁷For example, two prominent recent works on the *APo*, Leunissen, *Explanation and Teleology in Aristotle's* and Bronstein, *Aristotle on Knowledge and Learning*, make no mention of i.29.

It is not immediately clear, from the surface of the text, that MD as it is articulated at i.29 is indeed the subject matter announced at ii.16. At ii.16, Aristotle is concerned with the possibility of using multiple middle terms to demonstrate one predicate holding of multiple subjects. At i.29, he is concerned with using multiple middle terms to demonstrate a single predicate holding of a single subject. This is what we have been calling MD up to now; let us call the inferential scheme presented at ii.16 MD*. What is the relation, then, between MD and MD*? More importantly, does the acceptance or rejection of one entail the rejection of the other? *Prima facie*, it seems that it must: if a predicate, *A*, can be demonstrated to hold of a single subject, *C*, through two different middle terms, *B*₁ and *B*₂, then why shouldn't the same thing be true of its holding of multiple subjects, *D* and *E* through multiple middle terms, *B* and *C*? This must be something like Barnes' position when he claims that the full answer to the question of MD at i.29 comes only in the discussion inaugurated at ii.16. And since Aristotle seems to deny that a demonstration of *A* holding of *D* and *E* can be achieved through multiple middle terms, it seems that the status of MD at i.29 is imperiled.

This will need to be refined, however. For Aristotle's answer to the question posed in ii.16 is given in ii.17 and runs as follows:

(T4) Thus it is possible for there to be multiple explanations (*pleiō aitia*) of the same feature – but not for items of the same form. E.g. the explanation of longevity for quadrupeds is their not having bile, while for birds it is their being dry (or something else).

(99b4–7)

Aristotle thus *rejects* the possibility of a single predicate being explained 'multiply' for 'items of the same form'. How we are to understand this qualified rejection of MD* will be of the utmost importance. But initially, at least, things do not seem to look promising for MD. Recall that MD involves multiple explanations of a common predicate that applies, not to many different subjects, as in MD*, but to one and the same subject. Since there is a single subject term in MD, it is *a fortiori* of 'the same form' (as itself) and therefore Aristotle's answer at T4 to the question posed at ii.16 seems to be to rule out MD while preserving some version of MD*. Nevertheless, before writing off i.29 as conflicting with the position articulated at ii.16–17 (or vice versa), we should ask if there is a way of bringing them into harmony.

We can begin to do so by noting that Aristotle takes himself to be answering the question at ii.17: 'Can it or can it not be the case that what is explanatory of some feature is not the same for every item but different for different items?' (99a1–3). It is this latter possibility that Aristotle rejects in T4. The formulation in terms of 'features' and 'items' (to use Barnes' rendering of what, in a more traditional register, might be rendered 'predicates' and 'subjects') allows us to draw an initial contrast: whereas MD is concerned with the

same feature, same item, and multiple explanations, MD* is concerned with the same feature, different items, and multiple explanations. With MD*, but not MD, we can distinguish two sorts of multiplicity of explanation:

Exclusive MD* = def A holds of D on account of B and not on account of C ;
 A holds of E on account of C and not on account of B .

Inclusive MD* = def A holds of D on account of B and on account of C ;
 A holds of E on account of C and on account of B .

MD, since it is concerned with one predicate holding of one subject through multiple explanatory middle terms, is necessarily inclusive and not exclusive. Inclusive MD* is a case of MD; exclusive MD* is not. As a result, it is only if Aristotle were calling Inclusive MD* into question at ii.17 that a conflict would be generated with the model of MD at i.29. However, what Aristotle is worried about, at T4, it seems, is Exclusive MD*, a scenario in which the longevity of one instance of something of form F is explained through B (and not through C), while another thing of the same form F 's longevity is explained through C (and not through B).

What precisely does he mean by 'items of the same form' (*tois autois tôi eidei*) in T4? Barnes' suggestion is that 'there cannot be different explanations of the same attribute for different *individuals* of the same species; but there *can* be different explanations of the same attribute for different *types* of thing' (*Aristotle's Posterior Analytics*, 255; emphasis in original). Barnes seems to be using 'type' here to be equivalent to species; his position is thus that two members of a species cannot have a common property explained through different middle terms, but a property holding of two different species may be so explained. This is unlikely to be right, however: Aristotelian demonstration is generally concerned with universal statements about the essences of kinds, not with showing things about particular tokens. Moreover, the term *eidos*, which can of course denote species (as opposed to genus), should not be taken in the present context as doing so. After rejecting Exclusive MD* for 'items of the same form', Aristotle goes on to say that it *would* be acceptable to explain longevity differently for quadrupeds and birds – in the one case it is a matter of 'not having bile' while in the other it is one of 'being dry (or something else)' (see also *On length and shortness of life* 6, 465a6–9). Birds and quadrupeds are not 'of the same form' (*autoi tôi eidei*) in two senses: they are different species, but more importantly, they constitute different genera. Indeed, birds are used to illustrate the technical sense of genus (*genos*) at HA i.1, where they are contrasted with fish. There, Aristotle notes that there are many species of both fish and birds (486b4); much the same thing applies to quadrupeds. Moreover, while *eidos* and *genos* do have the fixed, technical meanings 'species' and 'genus' in some Aristotelian

texts (such as the *HA*), they do not always, and do not uniformly, have that technical sense in the *APo*.⁸

On this reading, T4 is making the claim that, for different genera, Exclusive MD* is acceptable, whereas it is not so for any given pair of species falling under a common genus.⁹ That is, it cannot be the case that a given attribute is demonstrated as holding of each one *exclusively* through different middle terms. If *A* can be shown to hold of a genus *G* through middle terms B_1, B_2, \dots, B_N (corresponding to MD as presented at i.29), each *B* on its own will be sufficient for demonstrating *A* as holding of the species ($S_1, S_2 \dots S_N$) falling under genus *G*. Thus, it seems that *A* could be shown to hold of S_1 through B_1 , of S_2 through B_2 , and so on (*A* holds of S_N through B_N), apparently violating the constraint imposed at ii.17 (T4). This however should not be taken to conflict with Aristotle's worry at T4. This is because, for the pair of individuals in question, it must be at the very least *possible* for the attribute to be demonstrated through the same middle term or set of middle terms. That is, the middle term or terms must pick out a feature or features shared by all species of the genus *qua* genus-members, which is required if these are to be *per se* predications. If all these middle terms (B_1, B_2 etc.) hold of the genus *G* in itself, then they will also hold of the species falling under it. So, while it may be *possible* to give demonstrations of a feature holding of species through distinct middle terms, these middle terms are also always shared if they hold of the species in virtue of their membership in the genus. As such, it will be equally open for the scientist to give *multiple* demonstrations of attribute *A* for each and every individual species of the genus *C*.¹⁰

This reading, then, leaves room for 'what is explanatory' not to be confined to a single middle term. This meets the demand for consistency of explanation between species of a given genus, while allowing for the possibility of

⁸For a comprehensive overview of the *genos-eidos* distinction in the corpus, see Balme, 'Γένος and Εἶδος in Aristotle's Biology'.

⁹One might object that we are not really talking about the same feature at all. I am grateful to Marko Malink for raising this worry about MD*. See also Hankinson, *Cause and Explanation in Ancient Greek Thought*, 165 for a similar suggestion. An initial way of putting this thought is that 'longevity' is somehow homonymous between quadrupeds and birds. This, however, seems implausible given the tests for univocity Aristotle gives at *Top.* i.15: the contraries of the two senses of longevity are the same (106a10-21); the 'difference of kind' is not 'at once obvious' (106a25); both uses *have* a contrary (106a36); both have intermediates (106b4-106b12). The other homonymy/univocity tests are not obviously relevant. The more likely alternative is that longevity is analogically said of the different genera, much as at *HA* i.1 486b18 (to choose one example somewhat at random) Aristotle claims that bones are to land animals as spine is to fish. Just in the case of longevity, the phenomenon has a common name. See Hesse, 'Aristotle's Logic of Analogy', Lloyd, 'The Unity of Analogy' on analogy.

¹⁰It is worth noting, though I will not discuss the implications in detail here, that this reading of ii.17 lends itself to a reading of Aristotle's method in *APo* as concerning the proper way of displaying already made scientific discoveries, rather than a guide to making such discoveries. This implicit distinction between scientific *demonstration* and scientific *discovery* is largely in the spirit – though does not commit one to the precise content – of Barnes' 'Aristotle's Theory of Demonstration' claim that *APo* should be understood as above all a pedagogical text.

multiple middle terms being explanatory both of a single feature holding of one item (MD) and of one feature holding of multiple items (Inclusive MD*, and, when the items belong to different genera, Exclusive MD*). In the remainder of the paper, I would like to suggest some broader philosophical motivation for the presence of multiple demonstration in *APo* and then briefly examine MD in the wild – as Aristotle employs it in the *Parts of Animals*.

II. Motivating multiple demonstration

1. MD at *APo* ii.11

What is the motivation for asking the question I have posed in this essay? That is, why is it *philosophically* important, beyond establishing internal consistency between various passages, that Aristotle's account in the *Posterior Analytics* can be read as permitting multiple demonstrations? I want to suggest two reasons. First, because some of his theoretical commitments, notably related to causality, seem to support – if not require – it, and second, because Aristotle's own scientific work seems to make use of it.¹¹ We shall see each of these motivations in turn. My focus in this section of the paper is on MD, not MD*; of the two schemes, it is MD that provides the clearest link between the *APo* and Aristotle's natural philosophy.

First, in the *APo*, Aristotle states that for a syllogism to count as a demonstration, the middle term must pick out the *aition* – that on account of which a predicate term holds of a subject term universally: 'The explanation (*to aition*) is the middle term and in all cases it is this which is being sought' (*APo* ii.2, 90a7–8). The implications of this commitment to 'aitiological' explanation become particularly clear at *APo* ii.11, where Aristotle brings his classification of causes to bear on his account of demonstration.

(T5) Since we think we understand something when we know its explanation (*tên aitian*), and there are four sorts of explanation (one, what it is to be a thing [formal cause]; one, that if certain items hold it is necessary for this to hold [material cause]; another, what initiated the change [efficient cause]; and fourth, the aim [final cause]), all these are proved through the middle term.

(*APo* ii.11, 94a20–23)

¹¹A third possible piece of evidence in support of this view might be the presence of multiple valid proofs in mathematics, which Aristotle emphatically considers to be a major part of the scientific enterprise (e.g., he bases his claim that demonstrations in the first figure are 'especially scientific' on the fact that mathematics uses it [*APo*, I.15, 79a18–21]). For example, there are hundreds of proofs of the Pythagorean theorem, including two in Euclid's *Elements* (I.47 and VI.31), written shortly after Aristotle's lifetime. However, the relationship between mathematical proof and deduction – let alone demonstration – is ambiguous in the context of ancient Greek mathematics and logic. As Ian Mueller writes: 'Aristotle's references to mathematics seem to be either supportive of general points about deductive reasoning or, when they relate specifically to syllogistic, false because based on syllogistic itself rather than on an independent analysis of mathematical proof' (Mueller, 'Greek Mathematics and Greek Logic', 37). Thus, while mathematics *may* be a fruitful source of evidence for multiple demonstration, it seems best to proceed with caution and save this as an avenue of research for a later date.

At ii.11 Aristotle uses the feminine noun *hê aitia*, not *to aition*, the neuter substantive used at ii.2. On the basis of the fact of linguistic difference, Mariska Leunissen has proposed that ‘within the *Posterior Analytics* it is [...] implied that *hê aitia* itself is a kind of larger *logos* or *sylogismos* containing an explanatory middle term, where *to aition* is a subordinated element of *hê aitia*’ (*The Structure of Teleological Explanation in Aristotle*, 152). Following Leunissen’s reading,

there might be a distinction between the type of causality expressed in the *explanation* of a state of affairs [...] and the type of causality expressed in the middle term that picks out the explanans of this state of affairs.

(*The Structure of Teleological Explanation in Aristotle*, 249)

However, T5 refers specifically to the various *aitiai* being proved ‘through the middle’ (*dia tou mesou*). The specific reference to middle terms, rather than a syllogism (*sylogismos*) or demonstration (*apodeixis*) gives strong reason to prefer a specific role for the middle term in picking out the various modes of causation/explanation. This qualification, I believe, presses us to choose – *pace* Leunissen – either between a model of demonstration in which the four *aitiai/aitia* are proved through one and the same middle term, or one in which each *aitia* corresponds to a particular *aition* standing as a middle term. Either way of reading the singular *to meson* is possible, but given the emphasis in ii.11 on multiple demonstration in practice (as we shall soon see), it is best to understand the singular *to meson* not as referring to all four explanations/causes being shown (*deiknuntai*) through a single common middle term, but to understand the phrase *to meson* as denoting middle terms more generally. (Compare the use of the generic singular in ‘The lion has sharp teeth’, which has the same meaning as ‘Lions have sharp teeth’). Moreover, while Aristotle’s allusion to all four *aitiai* being ‘shown’ or ‘proved’ (*deiknuntai*) in the last line of T5 may be ambiguous, later in ii.11 he explicitly endorses the possibility not only of all four types of causes (*ta aitia*) functioning as middle terms, but also of precisely the sort of MD that is the subject of this paper.

Toward the end of ii.11, Aristotle gives a number of imagined demonstrations in which a single phenomenon is shown to obtain through multiple middle terms (i.e. instances of MD as opposed to MD*). Rather like the cryptic example at i.29, they are somewhat frustrating and hard to take seriously, since they don’t seem to be about anything particularly scientific in content or form, just as the (Platonic) account of pleasure discussed at i.29 raised broader questions about the possibility of something like a ‘science of ethics’ for Aristotle:

(T6) The same thing may hold both for some purpose and from necessity – e.g. light shining through a lantern: the finer body passes through the larger pores from necessity (if light does permeate this way), and also for some purpose (in order that we may not stumble). If something may be the case in this way, may things also come about

thus? E.g. if it thunders because when the fire is extinguished it is necessary for it to sizzle and make a noise, and also (if the Pythagoreans are right) for the purpose of threatening the denizens of Tartarus and making them afraid.

(*APo* ii.11, 94b28–34)

This first example, of light passing through a lantern, is best understood not as an instance of *apodeixis*, but as a sort of toy example useful for helping to understand scientific demonstrations which similarly hold both to ‘some purpose’ (*heneka tinos*) and ‘from necessity’ (*ex anagkês*), a version of MD which we shall soon see is quite common in Aristotle’s biological works. This avoids committing Aristotle to having simply chosen a ‘quite inappropriate example’ (Barnes, *Aristotle’s Posterior Analytics*, 232).¹² The thunder example is hardly more plausible as an actual instance of *apodeixis*, but does help clarify the contrast between demonstrations making reference both to teleology and to material necessity of one and the same event or phenomenon.

When Aristotle appears to be arguing for the possibility of multiple demonstration in *APo*, the examples he gives are at best unconvincing, often opaque, and sometimes seem to strain at the limits of our comprehension. Are we really to take seriously, for example, his example of thunder being explained both by the extinguishing of fire and by its being for the sake of terrifying the ‘denizens of Tartarus?’ The possibility that this example in particular is a self-consciously absurd or ironic one, perhaps inserted to act as a sort of *reductio* of multiple demonstration, would not be entirely implausible were there not actual, clearly good-faith instances of multiple demonstration. For Aristotle’s biology is replete with examples of double demonstration that are not only obviously meant in earnest, but are also eminently plausible given Aristotle’s theory of science. In *PA*, Aristotle explains repeatedly why certain animals have certain parts due to more than one explanatory fact. First, he explains why a given part is necessarily present according to the material nature of the animal. Then, he explains the part’s presence with reference to a beneficial function it performs for the animal in question, which is to say, with reference to a final cause (E.g. *PA* 691b31–692a8; *PA* 679a25–30, *PA* 663b29–35). However, we shall see that trying to formalize such cases of MD involving a teleological component is tricky, leading to scepticism about MD in practice, if not in theory.

2. Final causes as middle terms

In *APo* ii.11, Aristotle gives the example of a person (viz. Socrates) walking after dinner for the sake of being healthy. This is not explicitly a case of MD, but is

¹²In fact, the lantern example seems plausibly to be a reference to Empedocles, who analogizes the eye letting in light to a porous lantern (DK B 84). If this is indeed the case, we might read this example as containing a latent criticism of Empedocles (or Aristotle’s materialist pre-cursors more generally) for failing to take purpose into account when explaining the design of what he takes to be clearly functional parts, i.e. organs.

meant to illustrate how final causes work in demonstrative syllogisms. Unfortunately for Aristotle, however, many commentators have found his account deficient:

(T7) A walk after dinner *C*, the foodstuffs' not remaining at the surface *B*, being healthy *A*. Suppose that making the foodstuffs not remain on the surface holds of walking about after dinner, and that this is healthy. *B*, the foodstuffs' not remaining on the surface, is thought to hold of walking about, *C* and *A*, healthy of *B*. Then what is explanatory – the purpose – for *C* of *A*'s holding of it? – It is *B*, not remaining on the surface. And this is as it were an account for *A*; for *A* will be elucidated in this way. Why is *B* explanatory for *C*? Because being in such a state is what being healthy is.

(94b13–22)

The deduction here can be written out as follows: being healthy holds of the foodstuffs' not remaining on the surface (*AaB*); the foodstuffs' not remaining holds of walking after dinner (*BaC*); therefore being healthy holds of walking after dinner (*AaC*). The syllogism is clearly valid, but the middle term does not seem to make any reference to final causes whatsoever, but rather only to material or efficient causation. The final cause, health, is mentioned only as the major term.¹³ This is problematic, because this is the primary example in ii.11 that Aristotle gives for cases in which the 'purpose is explanatory'. Leunissen has suggested two ways to get around this problem. The first is the one she ascribes to (pseudo-)Philoponus¹⁴ in his commentary, which is to introduce intentional language:

(T8) He [Aristotle] takes as middle term *B*, i.e. the food not floating on the surface at the mouth of stomach. And he infers syllogistically as follows: the person who walks after dinner has the want for the food not floating at the mouth of the stomach. And who is in want for that, to him belongs being healthy.

(Philoponus, *In APo*, 378,32–379,1)

Leunissen objects that such intentional language is not satisfactory for picking out final causes. While objects of desire are for Aristotle teleologically explanatory (see *MA* 6, 700b4–701a5), Leunissen is right to note that introducing psychological language into the syllogistic structure is difficult at best and likely impossible.¹⁵ As an alternative, she suggests that we leave Aristotle's syllogism as it is, with its middle term picking out an efficient or material cause. She motivates her interpretation by the above-mentioned distinction between *to aition* and *hê aitia*, writing that 'a teleological explanation is demonstrated through a middle term, which picks out a material cause' ('Aristotle and Philoponus on Final Causes', 198).

¹³Detel, *Aristoteles*, 707, calls this 'extrem problematisch'.

¹⁴The authorship of commentary on Book ii of *APo*.

¹⁵Moreover, Philoponus introduces intentional language to teleological explanation in order to make the example work (the causal relation underlying the syllogism is of one person wanting something instead of something being for the sake of something else), and it is not clear that Aristotle would need (or want) that here' ('Aristotle and Philoponus on Final Causes', 193).

However, I do not believe that we need to be forced into the choice between psychologizing the example, on the one hand, and abandoning the search for a final cause as a middle term, on the other. It is possible that Leunissen is correct that (pseudo-)Philoponus is injecting psychological language into Aristotle where it is not needed or wanted. But it is more likely that he is using the notion of ‘need’ (*chreia*) impersonally: that is, that he is not saying that the after-dinner-walker *desires* food not floating, but that this is something needed or *desirable* for this person. Read in this impersonal and non-psychological – indeed objective – way, we can begin to see how the middle term might function as a final cause.¹⁶

Recall again the syllogism about walking after dinner from T8:

Health holds of food-not-floating (AaB)
 Food-not-floating holds of walking (BaC).
 Therefore, health holds of walking (I–AaC)

It is true, as Leunissen and others have noted with some regret, that the middle term, *B*, is a material (or perhaps efficient) cause of health. This overlooks, however, the possibility that food-not-floating is also serving as a final cause – not of health, but of walking. That is, walking (after dinner, at least) is *for the sake* of food-not-floating. We can see the teleological status not only of the major, but also the middle term by inserting teleological language (‘*X* is for the for sake of *Y*, *X esti tou Y heneka*’) directly into the predicative structure of the syllogism itself. Take the syllogism from T8 with ‘as the end of’ inserted post-positively after the copula (‘*is/esti*’) linking the minor and middle terms:

Health holds of not food-not-floating (AaB); food-not-floating holds (as its end) of walking after dinner (BaC); therefore, health holds of walking after dinner (AaC).

What I am suggesting is that, upon being told that ‘*B* holds of *C*’, we can perfectly sensibly ask ‘How?’ And one way that this question can be answered is, ‘As its end (*telos*)’. (In T8, this applies to the conclusion, too: health holds of walking after dinner as its end just insofar as walking after dinner is for the sake of being healthy.) In some cases, being the natural end of an action may also overlap with being a consciously held goal; in the case of walking after dinner for the sake of food-not-floating, and thus being healthy, it may very well be. But this is ultimately incidental; ends of actions and intentional goals are not co-extensive for Aristotle.¹⁷

¹⁶Even if Philoponus may be reading the passage non-psychologically, Michael Ferejohn clearly does not: ‘there isn’t any obvious way to formulate’ Aristotle’s example of walking after dinner such that “health” occurs as the middle term, at least without illicitly transforming it into an ‘efficient cause’ explanation of the walking in terms of beliefs and desires’ (‘Aristotle on Necessary Truth and Logical Priority’, 107).

¹⁷See Morrison, ‘Natural Goals of Action in Aristotle’.

3. MD in practice

At T8, Aristotle is not concerned with MD; nevertheless, examining the passage allows us to begin to see how final causes can serve as middle terms, a lesson which will be invaluable in examining not only the cases of MD from *APo* ii.11, but also from the biological works. Let us then consider one of each of these in turn.

First, consider again the lantern example from ii.11 (T6) as the following case of MD:

Final (<i>heneka tinos</i>):	light shining holds of not stumbling (AaB_1); not stumbling holds of lanterns – i.e. as their purpose (B_1aC); light shining holds of lanterns (AaC)
Material (<i>ex anagkês</i>):	light shining holds of light-passing-through-small-holes (AaB_2); light-passing-through-small-holes holds of lanterns (B_2aC); light shining holds of lanterns (AaC)

There may be some immediate suspicion of the major premise of the first demonstration: is it really defensible to ascribe to Aristotle the view that ‘light shining’ holds of ‘not stumbling?’ Clearly there are cases in which not stumbling is unconnected with light shining – through a lantern or anything else. But what if we restrict the universe of discourse, as it were, to a situation in which we are walking about outdoors on a moonless night. Light shining holds of not-stumbling by hypothetical necessity: if we are not to stumble in such a circumstance, we need some light; if we are to have some light, given the absence of the moon and any other source, we need a lantern.¹⁸ There are limits to how far this example will take us; for in the domain of human agency (as lanterns surely are), even hypothetical necessity may seem a stretch. It is important to remember, however, that this example is a model of a demonstration, not a real one.

Leaving aside lantern-lit post-prandial strolls, then, let us also leave the *APo* and venture into the biological treatises. Consider the following example, in which Aristotle explains the particular hairiness of humans’ heads in two ways:

(T10) With respect to the head, humans have the most hair of animals, *from necessity*, on account of the moistness of the brain and on account of the sutures (for where there is such moisture and heat there must be much growth), and *for the sake of protection*, so that it may provide covering, warding off the extremes of both cold and heat. And since the human brain is the moistest, it is also most in need of this protection; for what is moist boils and freezes most easily, while what is in the opposite state is less easily affected.

(*PA* ii.14, 658b2–10; trans. Lennox, modified emphasis in original)

The explanation here is obviously not presented in syllogistic form, but we may try to formalize it. In Aristotelian fashion, we can do so in the following way. Let A be ‘hairy headed’, B_1 be ‘having sutures and a moist brain’, B_2 be

¹⁸The *loci classici* for Aristotle’s view of hypothetical necessity are at *PA* i.1 642a11–12 and *Phys* ii.9 200a5–15. See also Cooper, ‘Hypothetical Necessity’.

‘in need of protection’ and *C* be ‘humans’. The first demonstration is straightforward: whatever animal has a moist brain has a hairy head, humans have moist brains, therefore humans have hairy heads, or: $AaB_1, B_1aC \vdash AaC$. (To get the superlative version of Aristotle’s claim – not simply that humans have hairy heads, but the *hairiest* heads – one simply needs to rewrite the major and middle terms to include the superlative degree – e.g. something like ‘whatever has the moistest brain has the hairiest head’.)

The second, teleological, version of the demonstration seems initially to come out less felicitously. $AaB_2, B_2aC \vdash AaC$, written out gives us something like: hairy head holds of protection, (being in need of) protection holds of human beings, therefore hairy-headed holds of human beings. This may seem not to work, indeed to be obviously false, since, according to Aristotle’s biology and our own, not all protection takes the form of a hairy head. (For example, horns perform this function for bulls at 663a34–b39; ink for cuttlefish at 679a25–30; and flexibility for snakes at 691b31–692a8). Nevertheless, if we consider the aim (i.e. protection) not only from the starting point of humans’ need for protection in general, but also the specific sort of protection in question (i.e. protection of the superlatively moist human brain) as well as humans’ material nature (i.e. the matter that is ‘available’ to serve this purpose¹⁹), the expanded version of the major premise may be plausible: ‘Whatever animal is in need of protection for its moist brain and has such-and-such matter available for this, this animal will have hair (in proportion with the degree of moisture in its brain)’.

We should also note an interesting difference between the lantern example (T6) and the case of human hair (T10). In the former example, both the major term (‘light shining’) and the middle term (‘not stumbling’) are final causes of lanterns; there is, indeed, final causality operative in all three premises of the demonstration. In the latter case, meanwhile, the middle term (‘protection’, which is the purpose for which humans have hairy heads) is a final cause, as is the minor term (insofar as the protection, and thus hairy-headedness, is in turn for the sake of humans themselves), but the major term (hairy-headedness) is not. It may be fruitful to understand the difference between these two instances of teleological demonstration as mirroring the difference between the first two instances of *per se* predication at *APo* i.4. Just as in *per se* I predications, where the predicate holds of the subject by virtue of the subject’s essence, the predicate in the hairy-headed example holds of the subject term for the sake of the subject: humans’ hairy heads are there for the sake of humans (by protecting them). Similarly with *per se* II predications and the lantern case: just as the predicates of *per se* II predications hold of their subjects by virtue of what the predicates are, the light shining

¹⁹Hair is what Leunissen calls a ‘luxury part’ (*Explanation and Teleology in Aristotle’s Science of Nature*, 19), a part that nature ‘makes’ for the sake of its possessor qua beneficiary out of matter left over from the process of primary generation. (Cf. the distinction between final cause as aim and beneficiary at *DA* ii.4, 415a23; *Phys.* ii.2, 1094a35; *Meta.* xii.7, 1072b3.)

(predicate) holds of lanterns (subject) as their goal or purpose: alternatively formulated, the subject is *for the sake of (heneka)* the predicate. The claim is not that these two cases are literal cases of *per se* I and II predication respectively, but that the relations of priority between the subjects and predicate parallel one another in each case.

III. Conclusion

While I have disagreed with Leunissen on precisely how Aristotle would want to incorporate the variety of the *aitia/i* into demonstrations, I am very much in agreement with her general interpretive principle of unifying the applied and theoretical scientific works: 'Aristotle intended his biology to be a proper demonstrative science that approximates and builds upon the 'guidelines' of his *Analytica Posteriora*' (*Explanation and Teleology in Aristotles Science of Nature*, 77). This contrasts with a more pessimistic position, that Aristotle's biological explanations cannot be fit into the syllogistic form of demonstration presented in the *APo*. James Lennox, for example, writes:

... any attempt to syllogize [biological explanations] would eliminate the causal content of the explanation. (...) The effect of formulating all predications in a neutral 'belongs to' language is to obscure distinctions between various types of predications (...) and distinctions between various causal relationships holding among the predicates in question.

(*'Divide and Explain'*, 111n40)

Now, in some sense this is right: the multiple ways of expressing the same basic relation, namely how the terms of a syllogism hold of one another – holding of, being said of (*legesthai*), belonging to (*huparchein*), being predicated of (*katêgoreisthai*) – do not specify the causal relations that ground the predication relations. But they do not *obscure* this underlying relation so much as leave it unspecified. Significantly, because the various Aristotelian causes can coincide (cf. *Phys.* ii.7, 198a27), a single predication relation can express multiple causal relations. Consider once more the lantern case from T6. The conclusion of the syllogism, 'Light shining holds of lanterns', contains (at least) two underlying causal relations: (i) light is the purpose of lanterns (final cause); (ii) light is produced by lanterns (efficient cause). One of these is elucidated through a demonstration via a final-causal middle term, the other via an efficient-causal middle term. This is not to be confused with the claim that there is more than one conclusion, a different one for each term: it is one and the same conclusion, proved via different middle terms. The virtue of MD is that the different causal role of each middle term illuminates a different causal relationship underlying the conclusion.²⁰

²⁰Noting this role for MD relates to a long-standing question about the status of final causes: Are they ontologically independent and irreducible to material-efficient explanations, or are they heuristics

All this points to a final observation. We should continue to treat the *APo* as a guide to reading Aristotle's biology. But this goes the other way, too: by bringing the *PA* (T10) to bear on the content of *APo*, I have also shown that the form of MD operative in the *PA* can be fruitfully taken into consideration when interpreting *APo*. On its own, *APo* ii.11 may be insufficient to firmly establish that Aristotle really endorses middle terms picking out all four causes, which would provide an instantiation of the formal model for MD at *APo* i.29. But the presence of double explanation in the biological works provides strong evidence that Aristotle not only formulates a model for MD, but also puts it into practice.

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Bibliography

- Balme, David. 'Ἔνός and Ἐἰδος in Aristotle's Biology'. *The Classical Quarterly* 12, no. 1 (1962): 81–98.
- Barnes, Jonathan. 'Aristotle's Theory of Demonstration'. *Phronesis* 14 (1969): 123–52.
- Barnes, Jonathan. *Aristotle's Posterior Analytics*. 2nd ed. Oxford: Clarendon Press, 1993a.
- Barnes, Jonathan. 'Aristotle's Philosophy of the Sciences'. *Oxford Studies in Ancient Philosophy* 10 (1993b), 225–41.
- Bronstein, David. *Aristotle on Knowledge and Learning: The Posterior Analytics*. Oxford: Oxford University Press, 2016.
- Cameron, Rich. 'The Ontology of Aristotle's Final Cause'. *Apeiron* 35, no. 2 (2002): 153–79.
- Cooper, John. 'Aristotle on Natural Teleology'. In *Language and Logos*, edited by M. Nussbaum and M. Schofield, 197–222. Cambridge: Cambridge University Press, 1982.
- Cooper, John. 'Hypothetical Necessity'. In *Knowledge, Nature and the Good: Essays in Ancient Philosophy*, 130–47. Princeton/Oxford: Princeton Univ. Press, 2004 [1986].
- Detel, Wolfgang. *Aristoteles: Analytica Posteriora*. Berlin: Akademie Verlag, 1993.
- Ebrey, David, ed. *Theory and Practice in Aristotle's Natural Science*. Cambridge, UK: Cambridge University Press, 2015.
- Euclid's Elementa*, edited by E.S. Stamatic, post J.L. Heisberg. Leipzig: Teubner, 1969.
- Ferejohn, Michael. 'Aristotle on Necessary Truth and Logical Priority'. *American Philosophical Quarterly* 18, no. 4 (1981): 285–93.

that are ultimately liable to reduction to statements about material interactions? The latter position would pose problems for MD as we have seen it in practice: if final causes are reducible to material and efficient ones, then the final causal component of a multiple demonstration will also be of illustrative or heuristic value. (See Nussbaum, 'Aristotle on Teleological Explanation' and Sauvé Meyer, 'Aristotle, Teleology, and Reduction' for defenses of a reductionist reading.) Yet rather than using the possibly (merely) heuristic status of final causes as grounds for arguing against MD, one might rather see the presence of MD both in the *APo* and *PA* as grounds for arguing against an understanding of final causes as heuristic/reducible (with e.g. Gotthelf, 'Aristotle's Conception of Final Causality', Cooper, 'Aristotle on Natural Teleology', Johnson, *Aristotle on Teleology*, Cameron, 'The Ontology of Aristotle's Final Cause').

- Ferejohn, Michael. *Formal Causes*. New York: Oxford University Press, 2014.
- Gotthelf, Allan. 'Aristotle's Conception of Final Causality'. *The Review of Metaphysics* 30, no. 2 (1976): 226–54.
- Hankinson, R. J. *Cause and Explanation in Ancient Greek Thought*. Oxford: Oxford University Press, 1998.
- Henry, Devin, and Karen M. Nielsen, eds. *Bridging the Gap between Aristotle's Science and Ethics*. Cambridge: Cambridge University Press, 2015.
- Hesse, Mary. 'Aristotle's Logic of Analogy'. *The Philosophical Quarterly* 15, no. 61 (1965): 328–40.
- Johnson, Monte R. *Aristotle on Teleology*. Oxford: Oxford University Press, 2005.
- Mueller, Ian. 'Greek Mathematics and Greek Logic'. In *Ancient Logic and Its Modern Interpretations: Proceedings of the Buffalo Symposium on Modern Interpretations of Ancient Logic, 21 and 22 April, 1972*, edited by J. Corcoran, 35–70. Dordrecht: Springer Netherlands, 1974.
- Lennox, James. 'Divide and Explain: The *Posterior Analytics* in Practice'. In *Philosophical Issues in Aristotle's Biology*, edited by A. Gotthelf and J. Lennox, 90–119. Cambridge: Cambridge University Press, 1987.
- Lennox, James. *Aristotle's On the Parts of Animals*. Oxford: Clarendon Press, 2001.
- Leunissen, Mariska. 'The Structure of Teleological Explanation in Aristotle: Theory and Practice'. *Oxford Studies in Ancient Philosophy* 33 (2007): 145–78.
- Leunissen, Mariska. 'Aristotle and Philoponus on Final Causes in Demonstrations in *Posterior Analytics* II 11'. In *Interpreting Aristotle's Posterior Analytics in Late Antiquity and Beyond*, edited by F. A. J. de Haas, M. Leunissen, and M. Martijn, 183–201. Leiden: Brill, 2010a.
- Leunissen, Mariska. *Explanation and Teleology in Aristotle's Science of Nature*. Cambridge: Cambridge University Press, 2010b.
- Lloyd, G. E. R. 'The Theories and Practices of Demonstration'. In *Aristotelian Explorations*, 7–37. Cambridge: Cambridge University Press, 1996.
- Lloyd, G. E. R. 'The Unity of Analogy'. In *Aristotelian Explorations*, 138–59. Cambridge: Cambridge University Press, 1999.
- Morrison, Benjamin. 'Natural Goals of Action in Aristotle'. *Journal of the American Philosophical Association* 1, no. 4 (2015): 583–600.
- Nussbaum, Martha. 'Aristotle on Teleological Explanation'. In *Aristotle's De motu animalium*, edited by M. Nussbaum, 59–99. Princeton: Princeton University Press, 1978.
- Philoponus. In *Aristotelis Analytica Priora commentaria cum anonymo in librum II*. Edited by M. Wallies. Berlin: Preussische Akademie der Wissenschaften, 1909.
- Philoponus. *Philoponus (?): On Aristotle Posterior Analytics 2*. Translated and edited by O. Goldin. London: Duckworth, 2009.
- Philoponus. *Philoponus: On Aristotle, Posterior Analytics 1.19-34*. Translated and edited by O. Goldin, and M. Martijn, London: Bristol Classical Press, 2012.
- Ross, W. D. *Aristotle's Prior and Posterior Analytics*. Oxford: Clarendon Press, 1949.
- Sauvé Meyer, Susan. 'Aristotle, Teleology, and Reduction'. *The Philosophical Review* 101 (1992): 791–825.
- Shields, Christopher. *Order in Multiplicity: Homonymy in the Philosophy of Aristotle*. Oxford: Oxford University Press, 1999.
- Tuominen, Mira. 'Alexander and Philoponus on *Prior Analytics* I 27-30: Is There Tension between Aristotle's Scientific Theory and Practice?' In *Interpreting Aristotle's Posterior Analytics in Late Antiquity and Beyond*, edited by F. A. J. de Haas, M. Leunissen, and M. Martijn, 137–254. Leiden: Brill, 2010.