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Petter Sandstad*

# The Formal Cause in the *Posterior Analytics*

In the *Posterior Analytics* (*APo*) Aristotle discusses scientific demonstrations, which are syllogistic proofs of a scientific law or theorem, and identifies the cause of a scientific fact. It is unclear in the current literature how this is related to Aristotle's four causes. In this paper I argue for the unorthodox view that the *APo* is centred upon formal causation. Formal cause is here understood differently from the typical hylomorphic account that Aristotle gives in *De Anima*, *Physics*, and *Metaphysics*, where form is fundamentally understood in opposition to matter. Aristotle does not make use of the distinction between form and matter in *APo*, thereby presenting a much more subject-neutral theory. In *APo* formal cause is rather understood in a more innocent sense, namely as a kind such that everything that is of that kind has a certain property; irrespective of whether it is a kind of material (bronze) or substance (man).[1] For those readers who object to this use of the term "formal cause", feel free to replace it with "explanation by what it is (τί ἐστι)" or "explanation by essence".[2]

Although there are also discussions of the other causes, especially efficient causation, my argument is that Aristotle first and foremost has formal causation in view in his discussion. While this is an unorthodox view today, it once used to be the orthodox view (e.g., Ross 1949). And there is a recent, though still marginal, trend in favour of this view.[3] However, due to limited space I will not engage much with competing interpretations.



1 Ferejohn (2013) similarly applies the term formal cause. Ferejohn further argues that Aristotle's account of form in *APo* represents an early part of his development, later rejected in favour of a hylomorphic account. I criticize Ferejohn's developmental account in Sandstad (forthcoming).

2 Thanks to Robert Bolton & James G. Lennox for pressing me on this point.

3 More recently a similar view to mine has been defended by Ferejohn (2013: 105-106) and Tierney (2001: 151 n.8). Bronstein (2016) is closer to Ross, arguing that efficient and final causation can be part of formal causation.

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A distinguishing feature of my work (in contrast especially to Ferejohn 2013), is that I show that Aristotle had very detailed procedures for identifying the formal cause, and that he was aware of several problems which might lead one to erroneously identify the wrong form as the cause. This result is important, making it evident that Aristotle's theory has great potential for application in scientific practice today.[4]

Section 1 gives several non-conclusive indications pointing towards my thesis. Section 2 describes, from *APo* I, the syllogistic structure of demonstrations, and the criteria put on *the fact that* (ὅτι) and *the reason why* (διότι). Section 3 defends Aristotle's doctrine of the primary universal (πρῶτον καθόλου). Section 4 presents Aristotle's procedures and methods for identifying the formal cause (and also the material cause), from II 13-18. The last section adapts Aristotle's theory, as hinted at in II 11-12, to demonstrations of efficient and final causation.

## 1 – Non-conclusive indications

### 1.1 – The four causes in *APo* II 11

*Prima facie* the discussion in II 11 seems the most relevant, as this is the chapter of *APo* where Aristotle discusses the four causes (αἰτία), while the causes are scarcely mentioned elsewhere in *APo*. However, read in isolation the chapter is highly deceptive, not only about the relation between the four causes and scientific demonstrations, but also about the nature of the four causes. Let us briefly, due to limited space passing over much excellent discussion of II 11 in the literature, go through each of the four causes in turn.



First, while Aristotle mentions all four causes in II 11, all he says there on the formal cause (or rather, essence) is: "The middle term has also been proved to be explanatory of what it is to be something." (94a35-36)[5]

Second, what is sometimes taken to be the material cause seems to fit poorly with what Aristotle says elsewhere. Rather, he presents something like a ma-

[4] There are very strong similarities between Aristotle's theory in *APo* and Basic Formal Ontology (BFO), a foundational ontology now used by more than a hundred projects in applied ontology (cf. Arp/Smith/Spear 2015). However, I will not in this paper be making many references to BFO.

[5] Throughout I use the translation, occasionally slightly modified, of Barnes (1993).

terial conditional (→): if the middle term holds, then the conclusion holds. In some cases, the middle term will be the formal cause (94a34-35), but the material conditional also holds when the explanation is reversed (it also follows from there being an eclipse that the earth is in the middle, but it is the latter that is the explanation of the former, cf. II 16). Thus, Aristotle presents the notion of a necessary condition – he does not introduce a demonstration involving matter as the cause.

Third, the efficient cause seems to order events, i.e. the efficient cause is the middle term and the events of the major and minor premise precede the conclusion. But this fits poorly with the stress on universals in the rest of the work. Not only because events are not universals as they are ordered in time, but also because the example he gives (i.e. Persians attacking the Athenians because the Athenians attacked Sardis) is contingent. Further, Aristotle is throughout his works hostile towards Humean event-causation.

Fourth, the final cause, when read using the rest of the doctrine in *APo*, seems *prima facie* to be terribly confused. Aristotle says that the middle term is the cause, but the final cause seems to be given as the minor term (viz. healthy), and the middle term is "the foodstuffs not remaining on the surface".

My point is that Aristotle does not discuss the formal cause in II 11 because it is discussed throughout the rest of *APo*, and in this chapter Aristotle argues that his theory can be adapted (with some modification) to the other three causes. Commenting on II 11, Ross puts the point thus:

> It is not that the middle term in a demonstration is sometimes the formal cause of the major term, sometimes its ground, sometimes its efficient cause, sometimes its final cause. It is always its formal cause (or definition), or rather an element in its formal cause; but this element is in some cases an eternal ground of the consequent (viz. when the consequence is itself an eternal fact), in some cases an efficient or a final cause (when the consequence is an event) [...] (Ross 1949: 640)



I would not put it exactly this way. Rather, the efficient and final cause, as depicted in II 11, do not fit with the doctrine presented in the rest of *APo* because they were never meant to fit with it. The general doctrine concerns the formal cause. That is the case which he is elaborating upon throughout the rest of the

work, and in this chapter he merely indicates how it can be adapted to the other three causes. However, elsewhere in *APo* Aristotle discusses different notions of material and efficient causation, where the middle term is matter (e.g., bronze) or a process (e.g., solidification of the sap).[6] For these two cases, adaptation of Aristotle's theory of formal causation needs only minor changes (cf. section 5), and thus one is able to make more sense out of II 11.

### 1.2 – Aristotle's preferred choice of examples

Amongst Aristotle's examples in *APo*, the most frequently used are very definitely formal causes, especially his geometrical[7] examples:

- *Isosceles*[8] has 2R internal angles because of *Triangle* (e.g., 73b38-39)
- *Isosceles* has 4R external angles because of *Rectilineal figure* (e.g., 85b38-86a3)
- *An animal* has manyplies and lack upper incisors because *Horn-bearer* (98a17-19)
- A plant sheds its leaves because of *Broad-leaved* (e.g., 98a37-98b4)

Notably, there is great variety in Aristotle's cases, although most are only mentioned once or twice. However, amongst these there are clear examples of efficient causation:

- *Broad-leaved plants* shed leaves because of solidification of the sap (e.g., 98b36-38)
- The moon is eclipsed because the light leaves it when the earth screens it (e.g., 98a37-98b4)

### 1.3 – Aristotle's discussion of definition in *APo* II 1-10 & 13



If Aristotle is primarily concerned about formal causation then his detailed discussion of definition, division, and its relation to demonstration (II 1-10 & 13) makes perfect sense. Aristotle holds that a real definition states the essence of a form. And division concerns forms. Rather than being seen as a lengthy detour away from the main topic, these chapters can be seen as intricately connected

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6 Thanks again to Robert Bolton & James G. Lennox.

7 That the geometrical cases are very frequent in the *APo*, and that these are cases of formal causation, I take to be widely accepted. A recent case: "Aristotle recognized four types of cause [...] In the *APo* he focuses on the formal cause [...]" (Bronstein 2016: 35 n. 23.)

8 Universals are throughout indicated by capital first letter and italics.

to the rest of the work. This is also inconclusive, as there are other possible accounts of these chapters (e.g., Charles 2000; Bronstein 2016).

## 2 – The syllogistic structure of demonstrations

The general structure of a demonstration (ἀπόδειξις) by formal cause is as follows. Aristotle applies his theory of the syllogism from the *Prior Analytics*, however for demonstrations he requires that premises and conclusions be universal and affirmative, viz. has the modus *Barbara* (cf. *APo* I 14-15 & 24-26). In the *Prior Analytics* this is an inference from the premises to the conclusion:

S is M
M is P
therefore
S is P

In contrast, in a demonstration the conclusion precedes the premises (cf. 87a17-19). Aristotle says that by nature the middle term and the premises are prior to the conclusion (*APo* I 26, 87a17-19), while the conclusion is to us. One begins with the conclusion (S is P), namely the fact to be explained (ὅτι), the *explanandum*. Next one finds the explanation and cause of the fact (διότι), the *explanans*. This is the middle term, 'M', which connects 'S' with 'P'. The demonstration is read (e.g., 81b10-11):

S is P
because
S is M
M is P

Or alternatively the demonstration can be abbreviated through the application of the modifier *qua* (ᾗ): S is P *qua* M. By the rules of the syllogism one can check that the constructed figure (*Barbara*) is valid, and thus that the middle term in fact connects the major and minor. This is the benefit that the application of the syllogism provides. It is not used for drawing inferences, but rather for ensuring consistency.

The terms of a syllogism are logical variables, which can be replaced by either particulars or universals. By contrast, in a demonstration the variables can only be replaced by universals (including universals only instantiated by a single thing, e.g., the moon). Because of this I will, following Aristotle, quite innocently speak of the subject-, predicate-, and middle-term throughout this paper, when what I actually mean is the universal which replaces the term-variable in a demonstration.

That particulars cannot feature in (ideal) demonstrations is sometimes rejected in the literature, but is evident from his discussion of the case that "Coriscus is musical" (*APo* I 24, 85a25-27). This is not a particularly quantified proposition (viz. some S is P), but rather a proposition involving a particular, viz. Coriscus. Aristotle concludes in I 24 that it is better to know that *Triangle* has 2R, than it is to know that some geometrical figure has 2R, or than it is to know that *Isosceles* has 2R, or than it is to know that the figure I just drew has 2R. And this should be unsurprising, since science is generally held to be primarily about generalizations and generic laws, and only secondarily about certain particulars to which these generalizations are applicable (cf. Arp/Smith/Spear 2015: 12-13). However, Aristotle does hold that a scientific demonstration is applicable to particulars (e.g., Coriscus, *qua Man*).

Second, Aristotle puts strong criteria on *the fact that*. Especially relevant is that neither of the terms be incidental, but that they must be necessary or for the most part (I 6, 19, & 30; II 12). This excludes both cases like "that man is white", because *Whiteness* is incidental to *Man*; but also "that white thing has two legs" because "that white thing" is incidental in that it fails to pick out something necessary (i.e. it excludes what is sometimes called unnatural predications). This implies that Aristotle requires the minor term to be a substantial universal (e.g., *Man*, *Isosceles*) and the major term a non-substantial universal that is not accidental (e.g., *Two-legged*, 2R).



Third, the criteria for *the reason why* are principally given in I 4-5. The formal cause must be universal (καθόλου), viz. it must belong (1) to all (κατὰ παντὸς), (2) *per se* (καθ' αὑτὸ), and (3) *qua* itself (ᾗ αὑτὸ) (cf. *APo* I 4, 73b25-7). All three of these conditions are sometimes misunderstood in the secondary literature (e.g., in Ferejohn 2013; cf. Sandstad forthcoming). (1) to all (κατὰ παντὸς); this requirement is a general guideline, and is an important step in the procedure

for finding formal causes, but importantly it does allow for exceptions. E.g., the blind mole which lacks the essential (*qua* footed vivipara) property of sight (cf. Sandstad 2016). (2) *per se* (καθ' αὑτὸ); contrary to Ferejohn (2013: 83-95) this is not a requirement of analyticity. Rather, it requires that the attribute should belong essentially and not accidentally to the form. (3) *qua* (ᾗ αὑτὸ); this requirement says that the intensional context of the attribute is the given form, even when one is not primarily speaking about that form, but rather e.g., its species (cf. Lennox 2014b). It cannot be merely extensional, as is evident from the discussion of the possibility of separate explanations for the same thing in *APo* II 17, 99a1-99b6 (cf. section 4.3). To summarize, a purely extensional reading (viz. every instance of A is B) should be rejected in favour of a non-extensional reading (viz. the universal A is B). The copula is a transitive (and, following Malink 2009, reflexive) relation. Examples of such relations are "*Man* is an *Animal*" (species to genus), or "*Solidifying of the sap* is part of *Shedding of leaves*" (part to whole).[9] We will see in section 4 that Aristotle makes use of the extensional reading in his procedures for identifying the formal cause, i.e. he uses the first criteria. However, the resulting demonstration uses the intensional reading.

## 3 – The doctrine of the primary universal

Against Barnes, one of the main authors responsible for the dismissal of the view that I am defending, I defend the doctrine of the primary universal (πρῶτον καθόλου), viz. the commensurate universal. Barnes (1993: 258f.) rejects the presence of this doctrine in *APo*, but his arguments are all based upon the misunderstanding that the doctrine requires the terms of a demonstration to be convertible. Actually, the doctrine says that the middle term is the primary universal, viz. the universal that satisfies all the three criteria. Further, the primary universal is commensurate with the major term; viz. *Triangle* is commensurate with 2R. For two universals (*Triangle* and 2R) to be commensurate it is required that everything that has 2R is a *Triangle*, and that every Triangle has 2R. This means that the predicate term either is a part of the essence (and thus the definition) of the primary universal, or that it follows from the essence as a *proprium* of the primary universal. For some reason Barnes refuses to accept the case of *propria*, but 2R is certainly a proprium of *Triangle*. He, and Ferejohn (2013), seem



[9] *Pace* Corkum (2015), I do not want to assimilate all such relations to that of parthood, as this would introduce unwarranted equivocity.

to be under the misconception that commensurability is the same as analyticity, and thus requires intersubstitutability *salva veritate* ("definitions convert: hence some premisses of some demonstrations will deal with commensurate universals."; Barnes 1993: 259). Aristotle allows for this between a species and its definition, viz. its genus and *differentia*. Therefore Barnes wants to restrict the doctrine to the *differentia*, and to exclude the *propria*. But there seems to be no ground for such exclusion.

Barnes in addition misreads II 16-17 as rejecting the doctrine. But the conclusion is clear: "Thus it is possible for there to be several explanations of the same feature—but not for items of the same form." (99b4-5) Aristotle does not reject the doctrine; rather he presents an important addition. The primary universal is commensurate with the major term within the relevant division of kinds (and studied by a specific science), as presented in II 13-14. E.g., *Rationality* (λόγος) is commensurate with *Man*. This is in no way contradicted by the case of the unmoved mover also having *Rationality*, because the unmoved mover does not share any form with *Man*, they are studied by separate sciences, and belong to separate taxonomies. A similar argument can be given for the wings of birds, insects, and the bat (cf. Sandstad 2016). To conclude, the doctrine is in no way refuted by Barnes' arguments.

## 4 – Aristotle's methods for finding the formal cause in II 13-18

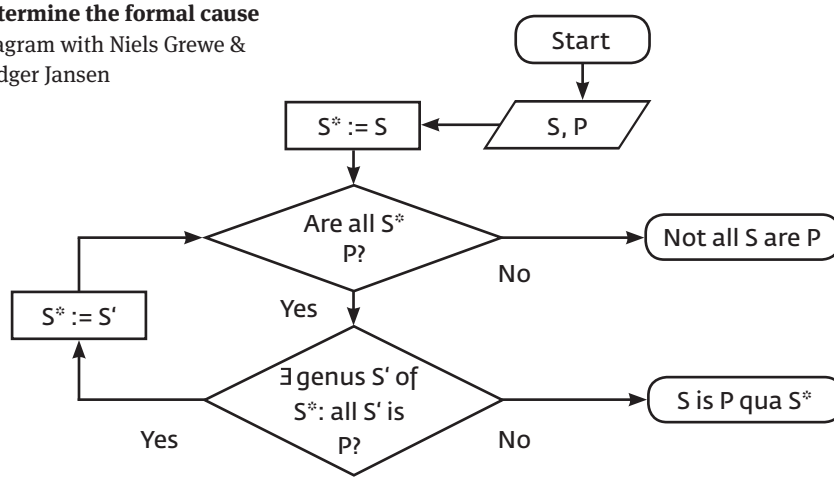
I will elucidate Aristotle's methods and procedures for finding the primary universal in II 13-18, elaborating on work by Lennox. However, where Lennox argues that Aristotle does not give procedures for identifying causes in *APo* (Lennox 2014a: 33), I argue that Aristotle presents two generic procedures for identifying causes. I will assume that the inquirer already has composed a preliminary taxonomy for the science, including stating the axioms i.e. the summa genera of the taxonomy, and defining each substantial universal (excluding the axioms) in terms of genus and differentia (cf. II 1-10, summarized at the beginning of II 13). Basically, this procedure will be the construction of what is today called a domain ontology (cf. Arp/Smith/Spear 2015). In II 13-18 Aristotle presents several methods and procedures for discovering formal causes, thus continuing the discussion from II 1-10.

### 4.1 – The basic procedure (II 13)

Closely related to the requirement of belonging to all (κατὰ παντὸς), Aristotle introduces the rule that "the essence of something is the last such predication to hold of the atoms." (96b12-13) This refers back to the procedure given especially in I 5 and I 24, where one proceeds from the *infimae species*, e.g., *Isosceles*, and then proceeds to the highest genus where all members also have the given attribute. E.g., one proceeds from *Isosceles* having 2R, and then examines its genus *Triangle*, finding that it also have 2R, and then examines its genus again, *Figure* or *Limit* and finds that it does not have 2R.[10] From this one can conclude that 2R essentially belongs to *Triangle*.

This basic procedure can be illustrated by a chart, and is applicable to the demonstration of any formal cause. One starts with the input, which is *the fact that*. First one checks that all S are in fact P, and in case they are not, then *the fact that* fails a basic criterion and must be restated. The next step is to check if the next immediate genus S' is also such that all of its instances have P. If not, then S is the formal cause. While if there is such a genus, then you need to check if it, in turn, has a genus S'' such that all of its instances have P. If not, then S' is the formal cause. If it is, then you again check if there is a genus S''', etc.

**Aristotle's basic procedure to determine the formal cause**
Diagram with Niels Grewe & Ludger Jansen




[10] Barnes (1993: 125) mistakenly reverses the direction in his discussion of *APo* I 5, interpreting it as proceeding from the *summa genera*.

This procedure can be extended to material causation. Then one begins not with the species, but instead with the matter. One first asks whether *bronzen* isosceles triangles have 2R. In this example the matter is irrelevant. However, if *the fact that* is bronze isosceles triangles having melting point of about 950 °C, then *the reason why* will be *Bronze*, a material cause.[11] Thus in cases where there might be a material cause, one begins the basic procedure with the matter. And if it holds for the matter, but for none of the forms, then the matter will be *the reason why*. However, Aristotle seems to mention 'bronze' merely as a point on the side (74a40-74b1), rather than as a fully worked out theory. And, as already mentioned, Aristotle seems innocent of the distinction between matter and form in *APo*. However this mere mention is sufficient to disprove Ross' suggestion that Aristotle realized "that he could not work the material cause into his thesis that the cause is the middle term" (Ross 1949: 639). Presumably, had Aristotle fully worked out a theory of material causation in the *APo*, then he would have realized that matter can be more or less determinate, and come in different granularities. A property might be materially caused by being bronzen, or by being an alloy (if it holds for all alloys, and not just bronze). Likewise, rather than being materially caused by being bronzen, it might be materially caused by e.g., the copper constituent of the bronze. Thus, talking about *the* matter is a simplification, and an account of material causation would have to apply the basic procedure to identify the correct determinate and granular level of matter.

This also raises the question of how demonstrations can be made at the level of parts of substances, rather than at substances. To clarify, these would be demonstrations where the subject term and the middle term are parts of substances, rather than substances. Elsewhere (*Partibus Animalium* I 1, 640b17-28), Aristotle makes the distinction between uniform parts (e.g., flesh, bone, blood) and non-uniform parts (e.g., face, hand, foot). One would perhaps be more inclined to view uniform parts as matter (Socrates consists of flesh, bone, and blood) since they are mass terms, and non-uniform parts as form (Socrates has a face, a hand, a foot) since they are count terms. In either case, it is of little significance whether we call demonstrations involving parts material or formal.



[11] This view seems to be quite similar to the reading of Barnes (1993: 226-227). Of course, for the process of *Melting* there will also be the efficient cause *Heat*.

### 4.2 – The top-down procedure of excerpting

II 14 gives a procedure of discovering formal causes through a top-down approach, "by supposing the kind common to all the items and excerpting [ἐκλέγειν]." (98a2-3) Whereas the basic procedure begins with the *infimae species*, this top-down procedure instead begins with the *summa genera*. E.g., if the science is zoology, then on this method one begins with the genus *Animal*, in contrast to the basic procedure which would begin with e.g., *Hawk*. A further difference is that the basic procedure is used to identify only a single formal cause of a single property at a time. While the top-down procedure, through executing the procedure once, can identify several formal causes for several properties.

The top-down procedure works as follows. The zoologist first makes a list of all those properties studied in zoology (including variations in granularity and more or less determinate). To this list there corresponds a set, call it Set I, viz. $\{P_1, P_2, P_3, P_4, P_5 \ldots\}$. Further, one presupposes a preliminary taxonomy, with one or more *summa genera*, e.g., *Animal*. This is the input, viz. the starting point, of the procedure.

The next step is to check, separately, for each of the properties from Set I, whether every member of the *summum genus* has the property. That means, whether every animal has $P_1$, and whether every animal has $P_2$, etc. For each of these properties, if the answer is affirmative, then *Animal* is its formal cause.

The third step is to construct a new set, call this Set II; such that it contains all those members of Set I which does not have *Animal* as formal cause. In other words, for all those cases where the answer was affirmative in the previous step the property is excerpted (viz. removed or pulled out) from the original list of properties. Thus Set II might end up as $\{P_1, P_4, P_5 \ldots\}$. And the relative complement of Set II with respect to Set I, viz. $\{P_2, P_3, \ldots\}$, will be the set of the excerpted properties of which *Animal* is the formal cause.



The fourth step is similar to the second step, with the difference that it uses Set II instead of Set I, and it uses the immediate species of the *summum genus*, e.g., *Bird* and *Fish*. Note that all co-ordinate species (i.e. they have the same immediate genus) make use of the same set of properties. Thus, one asks separately for each of the properties, and for each of the co-ordinate species, whether every member of a species has the property. E.g., whether every bird has $P_1$, and

whether every bird has $P_4$, etc. And whether every fish has $P_1$, and whether every fish has $P_4$, etc.

The fifth step is similar to the third step, only here we will have two sets of properties. One, Set III $\{P_1, P_4, \ldots\}$, for those where one has excerpted those properties which have *Bird* as the formal cause. Another, Set IV$\{P_1, P_5 \ldots\}$, for those where one has excerpted those properties which have *Fish* as the formal cause.

The next step will follow the familiar practice. On one hand, one will investigate for each immediate species of *Bird*, using the properties in Set III, whether every member of one of the co-ordinate species has any of the properties. E.g., assume for simplicity that *Duck* and *Hawk* are the only co-ordinate species of *Bird*. Then check whether every duck has $P_{1,}$ whether every duck has $P_4$, etc. And whether every hawk has $P_{1,}$ whether every hawk has $P_4$, etc. On the other hand, one will similarly investigate for each immediate species of *Fish*, using the properties in Set IV.

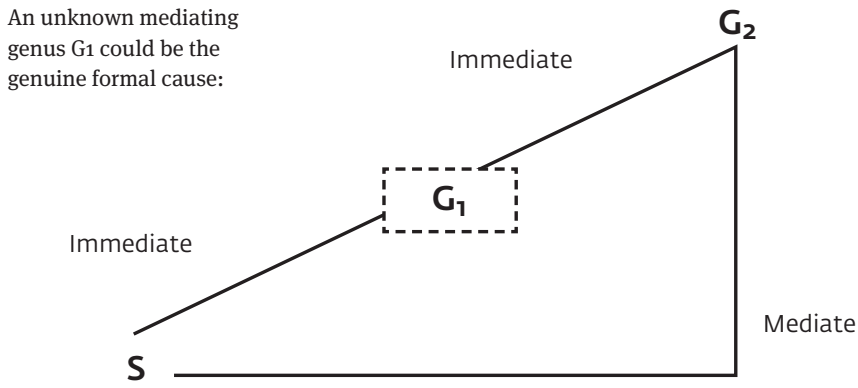
Finally, having performed the procedure all the way down to the *infimae species*, one will have identified the formal cause for many properties. Some of the properties will have several formal causes, namely where there are separate formal causes in separate branches of the taxonomy. Presumably there will also be some properties from the original list, Set I, for which no formal cause is identified, viz. some properties may not have been excerpted at any step of the procedure. Perhaps there is no formal cause for these properties, i.e. they are accidental. Or perhaps there is an unknown formal cause.

### 4.3 – Fallibilism: unknown forms, analogy, equivocation, and exceptions



Both the basic procedure and the top-down procedure have one serious drawback: they presuppose that we have a complete and true taxonomy of the science. Specifically, there might be an unknown form. This unknown form $G_1$ could be mediate between two others, such that it is the immediate genus of a species S, and the genus $G_2$ which we thought was the immediate genus of S is in fact the immediate genus of $G_1$. In this case, perhaps $G_1$, instead of S or $G_2$, is the relevant formal cause for our demonstration.

Aristotle is aware of this drawback in II 14-18. And at several places he seems to indicate some principle of fallibilism, more precisely he is open to cases of false




(though truthlike) scientific demonstrations. Through revisions of the taxonomy one can come to correct one's scientific demonstrations. He gives at least four lines of inquiry by which one can arrive at revisions:

**4.3.1 – Unknown forms:** In cases where several species of the same genus has a property, but separately and not because of the genus, check if there is an explanatory mediate genus

II 14 (98a13-19) concerns cases where there is no common name for the substantial universal. One starts with an attribute that seems to be shared among several forms. But if these forms can be joined by a common genus, thus modifying the taxonomy, then this common genus is the formal cause. E.g., having manyplies and lacking upper incisors follow from being a *Horn-bearer*.

But it might also be that there is no common genus, and in II 16-17 Aristotle discusses the possibility of an attribute having several primary universals. Related, II 15 discusses cases where an attribute can be explained first on one level, then a genus (or determinable) of that attribute can be explained at another level (e.g., echo, mirror, and rainbow are all types of reflection). Or one attribute can have a mediate and an immediate cause (e.g., end of month being more stormy, and this because the moon is waning). Aristotle seems to reject a reduction of one to the other. Instead he says that in these cases there are two separate, though related, problems; each with separate, though related, causes. However, in II 18 he argues that one of them can be more primary (cf. 4.3.4). In either case, one should investigate if there might be a hidden common genus.

**4.3.2 – Analogy:** In analogous cases, check if there is a common genus

In analogous cases (II 14, 98a20-23) we do not have good enough evidence for there being a common genus. But for each of the analogous species one should compare them and see if they also share further attributes. In the end this might yield sufficient evidence for a common genus. E.g., the analogous properties pounce, spine, and bone.

**4.3.3 – Equivocation:** Replace any equivocal terms with unequivocal terms

Equivocation (viz. homonymy) is an obvious fallacy, as also use of metaphorical language (II 13, 75b14-39; II 17, 99a6-15). If the subject- or predicate-term is equivocal, metaphorical, or analogous, then there will not be a single *reason why*; and thus the middle-term will also be equivocal, metaphorical, or analogous.

**4.3.4 – Exceptions:** In cases where a property is demonstrated both at a higher genus and a lower species (e.g., the blind mole), the lower species is the primary cause

II 18 discusses a problematic case, where the attribute has different formal causes depending on the granularity of the attribute (partly paralleling II 15). Aristotle gives only a schematic example, and interpretation is difficult. Aristotle is asking the question; which formal cause explains why the particular has the attribute? Aristotle answers that it is the closest to the particular, i.e. the most determinate attribute and its corresponding formal cause. My example would be the blind mole, in which case the problem is; why does the blind mole have underdeveloped eyes under its skin? The blind mole is a footed vivipara, and therefore it has eyes (viz. *Footed Vivipara* is the formal cause of having eyes). But there is a more determinate explanation: the blind mole is a species of *Mole* lacking sight, or more precisely, having underdeveloped eyes under the skin, and this property has the more specific formal cause *Blind mole*. Through this rule Aristotle is able to deal with exceptions. The rule says that when there are several formal causes of the attribute, then the most determinate formal cause overrides the less determinate.[12]



[12] In Sandstad (2016) I further connect this with Aristotle's view of embryological development, as proceeding from the more general to the more specific according to von Baer's law (which Aristotle recognized).

In addition to those discussed here in section 4, there are of course many more rules specific to each science (e.g., to biology as given in *Partibus Animalium* I 1, cf. Lennox 2014a: 33).

## 5 – Efficient and final causation as process universals

We have seen that Aristotle's discussion in II 11, where efficient causation seems to be a type of Humean event-causation, fits poorly with the rest of *APo*. However, Aristotle usually defends a non-Humean type of causation. Events are often identified in terms of their time and location, and as something which happens between various substances. Since the term "event" is associated with Humean event-causation, I instead use the term "process" which, hopefully, will not have these connotations. In contrast to Humean events, processes are changes occurring in a substance, and are identified by the substance they depend upon, and the kind of change the substance undergoes at that time – i.e. a process is defined in terms its start- and end-states.[13] Further, as argued in the *Physics* and *Metaphysics* Θ, the beginning of the process involves the actualization of two powers (viz. dispositional properties), one passive and one active (where the active power often belongs to a separate substance). A process has temporal parts (in contrast to substances, on an Aristotelian view), and is ontologically dependent upon the substances in which it occurs. But one can also speak about kinds of processes, i.e. of process universals. In contrast to particular events (like Athens attacking Sardis), process universals satisfy Aristotle's criteria for scientific demonstrations.

For example from *APo* II 16-17: *Broad-leaved trees* have *Shedding of leaves* because of *Solidifying of sap*. Contrast this demonstration of the efficient cause with the corresponding demonstration of the formal cause: *Trees* has *Shedding of leaves* because of *Broad-leaved*. In the case of the formal cause, the middle term is a form, and the predicate term is perhaps most naturally read as a power possessed by trees. In contrast, in the case of the efficient cause both the middle term and the predicate term are most naturally read as processes occurring in trees. Thus, even though the two seem to give distinct *reasons why* to the identical *fact that*, as it turns out there are two distinct *facts that*: the one involving efficient causation has a process as the predicate term, while the one involving



[13] Hennig (2009) also argues that efficient and final causation concerns processes. However, his account differs in several other ways from mine.

formal causation has a power as the predicate term. These are closely related, in that the power is what makes the substance capable of undergoing a certain type of change (i.e. to have the process occurring in the substance).

Further, the formal cause will feature as the subject-term of a demonstration of efficient (or final) cause. Thus one goes from a formal demonstration where a form is the middle term, and the middle term defines the subject term (what Lennox calls an A-type explanation); to an efficient demonstration where the form is the subject term while a process is the middle term, and the middle term defines the predicate term (a type of what Lennox calls a B-type explanation), cf. Lennox (2001: 10 & 2014a: 32).

The next crucial question is how the two process universals are related to each other, such that the middle term is the efficient cause of the predicate term. Aristotle' discussion of this in II 16-17, and more in-depth in II 11-12, is far from clear. What is clear is that *Solidifying of sap* takes place earlier than *Shedding of leaves*. And conversely for final causation, the final cause takes place last. Aristotle notes this difference between final and efficient in II 11:

> Here [sc. in final causation] the process of change [γενέσεις][14] occur in the opposite order compared to explanations in terms of change [sc. in efficient causation]: there the middle term must occur first; here *C*, the last term, occurs first, and the ultimate thing to occur is the purpose. (*APo* II 11, 94b23-26)

Now, taking first efficient causation, this is consistent either (1) with the two being distinct processes, and where the change which is the result of the first process is a condition of the second process occurring, or (2) with the first process being a part of the second process.[15] The difficulty with the first position is that trees



[14] Barnes (1993) translates it as "event". The neutral way to translate γενέσεις would be as "becoming". Here I translate it as "process of change", which I take to be a paraphrase of becoming. In the *Physics*, κίνησις is often best translated as process, however κίνησις does not appear in *APo*.

[15] Lennox (2001) is neutral on this point. At one point he seems to express the first option: "Shedding leaves is a process resulting from a more basic process of solidification." (Lennox 2001: 13). But at the end of that paragraph he says something like the second option: "For this causally basic process is both what shedding is, and the cause of certain plants shedding their leaves." (Ibid.)

can shed their leaves because an animal is pulling off the leaves, so it cannot be a necessary condition. Nor is it a sufficient condition, since often a further condition is necessary, e.g., a strong wind. In these regards, the second position seems preferable. Commenting on II 12, 95b1-12, Apostle suggests something like this:

> Perhaps Aristotle is considering relations among outcomes or stages in a changing thing, as in the case of a continuous development or motion of that thing. One may wonder, for example, what kind of analysis would explain the way in which one part of a change leads to (or perhaps causes, as some think) another, or how the parts are held together to constitute a single change. (Apostle 1981: 262)

I suggest that the notion of parthood is exactly what Aristotle needs in order to adapt his account to efficient and final causation. Especially, parthood is what is required to ensure simultaneity of terms, which is a criterion that Aristotle defends in *APo* II 12. To take an example, the process of (natural) *Shedding of leaves* involves a subsidiary process, which happens at the beginning of the primary process, viz. *Solidifying of sap*. And this subsidiary process is the efficient cause of *Shedding of leaves* because it is the earliest part of the process of *Shedding of leaves*, and *Solidifying of sap* is a necessary and sufficient condition for *Shedding of leaves*.

> If it is because of solidification of the moisture, then if a tree sheds its leaves solidification must hold, and if solidification holds—not of anything whatever but of a tree—then the tree must shed its leaves. (*APo* II 16, 98b36-38)

The process of solidification is here identified as a change in trees, later specified as "of the sap at the connection of the seed" (99a29). Any earlier subsidiary process cannot be the efficient cause, since a process might consist of many subsidiary processes. Aristotle here adds that the subsidiary process must be a necessary and sufficient condition for the completion of the total process. In syllogistic structure:



*Broad-leaved trees* (S) undergo *Shedding of leaves* (P)

because

*Broad-leaved trees* (S) undergo *Solidifying of the sap* (M)
*Solidifying of the sap* (M) is part of *Shedding of leaves* (P)

How would one identify the efficient cause, in this case solidifying of the sap, using Aristotle's two procedures? In the case of formal and material causation, the two procedures presuppose a taxonomy of genera and species, and the relation which the procedures make use of is that where A, e.g., *Animal*, is a genus of B, e.g., *Man* – or conversely where B is a species of A. For efficient and final causation we instead use the relation where C, e.g., *Solidifying of the sap*, is a part of D, e.g., *Shedding of leaves* – or conversely D has a part C.

Normally, a process will consist of several sub-processes (e.g., yellowing of leaves, reddening of leaves, browning of leaves.) In efficient causation you are looking for the earliest part (or state) of the process *Shedding of leaves* (viz. the predicate process). Thus the sub-processes are distinguished by the position they hold in that process. The efficient cause is the process that is the earliest process that is a part of the predicate process; and is such that if you go to the process that is immediately earlier, then that process is not a part of the predicate process. The procedure for identifying the efficient cause would thus be a variant of the basic procedure. And for final causation the procedure would be the same, with the difference that the final cause is the final part of the process – namely the end result or state, that which it is a change into, or more technically it is the end limit (πέρας, cf. *Metaphysics* Δ 17 and *De Motu Animalium* 6, 700b14-16) of the predicate process. For example (based loosely upon 95b32-36):

*Stone foundation* (S) participates in *House construction* (P)

because

*Stone foundation* (S) participates in *House* (M)
*House* (M) is part of *House construction* (P)

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This example highlights a *prima facie* problem with Aristotle's account of efficient and final causes: it is circular. *House construction* is defined as a change from its beginning state, the laying of the foundation (the efficient cause), to its end state, the finished house (the final cause). Yet, in order to identify the efficient and final cause we must first know the predicate process *House construction*. Thus we have a vicious circle; one must first know *the reason why* in order to know *the fact that*, and one must first know *the fact that* in order to know *the reason why*. This *prima facie* circularity is not merely a fault of my interpretation, as Aristotle himself seems committed to it in *APo* II 8-10. The apparent circularity can be solved if one, following *inter alia* Charles (2000) and

Bronstein (2016), makes the distinction between a preliminary definition and a real definition. For instance, one could give a preliminary definition of *Shedding of leaves* as a change from slightly yellow leaves to the leaves falling off. After which one could identify the efficient cause of *Shedding of leaves*, namely *Solidifying of the sap*.

## 6 – Conclusion

All four variants of scientific demonstration, from the paradigmatic formal causation to the other three, can be represented as follows:

| | Subject-term | Predicate-term | Middle-term |
|---|---|---|---|
| Formal cause | Substance | Attribute | Form |
| Material cause | Substance | Attribute | Matter |
| Efficient cause | Substance, often a formal or material cause | Process | Process, which is the first part of the predicate process |
| Final cause | Substance, often a formal or material cause | Process | Process, which is the final part of the predicate process |

I hope to have shown that much of Aristotle's discussion first and foremost concerns formal causation. I have further shown that Aristotle had very detailed procedures for identifying the formal cause, and that he was aware of several problems which might lead one to erroneously identify the wrong form as the cause. Finally, I have shown that Aristotle's account can indeed be adapted to material causation, and through some modifications, hinted at in *APo* II 11-12 & 16-17, also to efficient and final causation. Indeed, my reading of these two chapters supports my hypothesis that the rest of the *APo* is primarily concerned with formal causation.[16]



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