Aristotle and the necessity of scientific knowledge

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(This is a translation, made by myself, of the paper to be published in Portuguese in the journal *Discurso*, 2020, in honour of the late professor Oswaldo Porchat.
Please find a Warning about the Translation at the end of this file.)

Abstract: *I discuss what Aristotle was trying to encode when he said that the object of scientific knowledge is necessary, or that what we know (scientifically) cannot be otherwise etc. The paper is meant as a continuation of previous papers—orientated towards a book on the Posterior Analytics—and thus does not discuss in much detail key passages, as the very definition of scientific knowledge in APo I.2, or passages from APo I.4 and I.6 (for these, I refer to my previous papers). This paper is mainly focused on Aristotle's references to his notion of scientific knowledge both in other passages from the APo and in other treatises. I intend to show that there is a progressive, intrinsic relation between the two requirements by which scientific knowledge is defined. It is not true that each of these requirements stems from a different source. The Causal-Explanatory requirements gives Aristotle the general heading. Then, the Necessity Requirement ranges over the explanatory relation between explanans and explanandum and thereby specifies what sort of cause is sctricly required for having scientific knowledge of a given explanandum. Now, Aristotle was also concerned with the necessary truth of the elemental predications that constitute a demonstration. My claim that the Necessity Requirement ranges over the explanatory relation does not ignore that concern, and does not deny it. My claim is that Aristotle's main focus, and main concern, consists in stressing that the explanatory factor to be captured in scientific knowledge of a given explanandum is such that cannot be otherwise.*

Keywords: *Demonstration. Necessity. Causality. Essencialism. Explanation. Predication.*

We can surely attribute to Aristotle the thesis that the object of scientific knowledge is necessary, as well as the thesis that, in order to attain scientific knowledge of a given object, one must know that that object is necessary. Indeed, formulated on this level of generality, those theses seem to capture what Aristotle has said. However, what do those theses mean exactly? If one should paraphrase and develop them, how should they be paraphrased and developed with exegetical correctness?

Let me start with the passage in which Aristotle defines scientific knowledge in the *Posterior Analytics* (henceforth, *APo*), which runs as follows:

> **T1**: "We think we have knowledge of something *simpliciter* [i] (and not in the sophistical way, incidentally), [ii] when we think we know of the cause because of which the explanandum holds that it is its cause, [iii] and also that it is not possible for it to be otherwise" (71b9–12, Barnes's translation modified).

In this paper, I will not address section (i) of T1, let alone what is meant by the contrast between knowing something *simpliciter* and knowing something in a sophistical way, on the basis of a concomitant factor.[1] I take T1 to be defining the specific notion of *scientific* knowledge, instead of aiming at the general notion of knowledge. Sections (ii)-(iii) of the passage advances two requirements in the definiens: scientific knowledge of *X* depends on knowing the cause of *X* —and Aristotle emphasizes that what is at stake is to know that that cause is the cause of *X*—, and depends on knowing that "this" cannot be otherwise. The first requirement is reasonably clear. But the second requirement raises two crucial questions: first, what exactly the pronoun "this" retrieves; secondly, what does Aristotle exactly mean in stating that *this* cannot be otherwise. Since these two questions are crucial for my purposes, my next step consists in examining the second requirement in more detail.

2. Examining the issue:

Scientific knowledge of *X* (whatever *X* happens to be) requires these two conditions:

A. Knowing the cause on the basis of which *X* is;

B. Knowing that *this* is necessary (i.e., cannot be otherwise).

(Henceforth, in order to make the references easier, I will employ the expressions "Requirement A" and "Requirement B" respectively to refer to these conditions advanced in T1.)

Requirement B is so generic that there is a bunch of interpretative options. Now, generality does not imply falsity. It is certainly true that you have eaten *food* in the lunch today. However, if someone wants to know exactly what it is that you have eaten (think of a doctor, or a nutritionist), it is not enlightening to answer in that way, "I have eaten food" (or "I have eaten hot food" etc.). Similarly, an exact exegesis of Aristotle's text must ascertain what is exactly meant with Requirement B.

Most interpretations take the pronoun "this" at 71b12 as referring to "*pragma*" in Aristotle's text.[2] But "*pragma*" can be taken in many ways: it can be taken with the force of 'object' in an abstract and vague way (as opposed to *proposition*, and covering items so distinct from each other

[1] However, the examination of T16 will lead me to say something about this contrast in T1.

[2] See Philoponus 20.29; Ross 1949, p. 507; Porchat 2001, p. 35; Barnes 1993, p. 90-91; McKirahan, 1992, p. 23; Pellegrin, 2005, p. 67; Mignucci 2007, p. 151; Bronstein 2016, p. 36, 51. It is doubtful what exactly Philoponus has understood (cf. 20.29-30-4).

as a natural kind, the Sun, the triangle or god); or it can be taken with the force of '*proposition*' or '*state of affairs*', or, in better words and to simplify the point, it can be taken as what is exactly encoded in the conclusion of a demonstrative syllogism (cf. 71b17-19). On the light of this, there are two important options to understand Requirement B (let me call these options 'B1' and 'B2'):

B1. Knowing that the *object* is necessary (i.e., cannot be otherwise).

In this case, requirement B turns out to be equivalent to the condition of knowing that a given object of scientific knowledge is necessary in the sense that it exists eternally and does not change its characteristics over time—for instance, knowing that the abstract object named 'triangle' is eternally as it is, without changing its characteristics over time.

B2. Knowing that the proposition in question is necessary (—is always true and can never become false).

In this case, requirement B turns out to be equivalent to the condition of knowing that the proposition in question is necessarily true.

Option B2 is seductive, but—as almost all admit—a little bit embarassing. As I will explore in section 5.1.2, there are robust reasons to consider it an embarass, but let me start with the reason accepted by (almost) everyone, which is this: for Aristotle himself, such a requirement will only be satisfied in a few domains (say, mathematics, cosmology and theology), but will not be satisfied exactly in those domains (e.g., biology) in which Aristotle himself has conducted his most successful scientific investigations. Given this embarass, most scholars believe that B2 deserves a charitative interpretation, which ends up in the following, attenuated option:[3]

B2*. knowing that the proposition in question is necessarily true *or (in the domains in which necessity fails) true for the most part*.

[3] See Ferejohn 2013, p. 82; Bronstein 2016, p. 36, n29; Mignucci 2007, p. 238; Barnes 1993, p. 92, 192. Indeed, there is some plausible justification for applying the principle of caritativeness. But see further ahead the distinction between the questions Q1 and Q2. Mignucci 1981 has argued in favour of taking the 'for the most part' propositions as equivalent to necessary (and eternal) propositions. Against this, see Judson 1991, p. 87-89.

Before discussing B2*, let me note that there is still a different option for interpreting Aristotle's point. The pronoun "this" ("τοῦτο", 71b12) can be taken as referring to the previous sentence in Aristotle's text, namely, "that [its cause] is the cause of *that*" (in Greek, ὅτι ἐκείνου αἰτία ἐστι, where "ἐκείνου" refers to "*pragma*").[4] In this case, what Aristotle is trying to encode in Requirement B is something different from the previous options: what cannot be otherwise is the explanatory relation between the *explanandum* and its *explanans*—i.e., the relation between the cause and the state of affairs it explains.

However, this move still results in a generic option, for the nature of the relation that cannot be otherwise can still be specified in many different ways. To avoid confusion, I say in advance that I will argue for option B5 below. But a careful consideration of the available options is in order, even if just for the sake of exhausting the possible scenarios. Thus, I examine step by step other possible options for taking the referent of the pronoun "τοῦτο" as the relation between *pragma* and cause. Thus, the following options (B3-B5) can still be conceived:

B3. knowing that the relation between the cause and its *pragma* cannot be otherwise in the (logical) sense that it is a relation of necessary consequence.

In other words: given the cause as the content of the premises (in a scientific syllogism or whatever), the conclusion that expresses the *pragma* follows necessarily.

B4. knowing that the relation between the cause and its *pragma* cannot be otherwise in the (metaphysical) sense that, if the cause obtains (as an objective state of affairs in the world), it is not possible for the *pragma* (of which that cause is the cause) to fail in obtaining.

In other words, this option B4 takes the cause as an item that necessitates the occurrence of the *pragma* from a metaphysical standpoint.

[4] Objecting that "τοῦτο" can only refer to "πρᾶγμα" for (supposed) "grammatical reasons" is so wrong that I am surprised to find this objection regularly in scholarly discussions. Pronouns can take up whole sentences or propositions—not only in Greek, but in English and many other languages. If a list of cases in Aristotle is needed (to my surprise), see *An. Post.* 94a33; *Top.* 101b2; *Gen. An.* 716a7, 13; 735a18; 744a11; 747a32; 758b19; 786b19; 732a16; 766a34; 768b12; 783a14; 784b14. For discussion of this point in T1, see Angioni 2009a, p. 67, n14; 2012a, p. 44, n72. To my knowledge, the only scholar to have flirted with this option—but in a footnote, almost as an aside—was Lloyd 1981, p. 157, n2.

B5. knowing that the relation between the cause and its *pragma* cannot be otherwise in the (explanatory) sense that it is exactly *that* cause (not any other cause) that appropriately explains the *pragma* in question (but not a different *pragma*).

In this case, the relation between the cause and its *pragma* is not being highlighted as a relation of logical consequence (even if it involves, indeed, a relation of logical consequence), nor as a relation of metaphysical necessitation (even if it is, indeed, a relation of this sort). Of course, option B5 has corollaries in the domains of logic and metaphysics. But B5 takes Aristotle to be focusing in an explanatory requirement. In order to have scientific knowledge of a given *pragma*, what is required is the knowledge of *this, appropriate cause* (not any other cause).[5]

3. Two Distinct Questions:

It is of *utmost importance* for my purposes to insist in the distinction between two different questions. Henceforth, these two questions will be referred to as Q1 and Q2 respectively:

Q1. What propositions, from those involved in B1-B5, are taken as true by Aristotle in the *Posterior Analytics* (or even in his work as a whole)?

Q2. Which one—among those propositions involved in B1-B5—the definition of scientific knowledge in 71b9-12 (T1) is meant to encode and express?

To make the distinction clearer, let us take B1. One question is Q1: "is it true for Aristotle that the object of scientific knowledge must be something that necessarily exists?". Another question is Q2: "does the requirement that the object of scientific knowledge must be something that necessarily exists correspond to what Aristotle has exactly meant to encode in T1?". Let us take B3, in turn. One question is Q1: "is it true for Aristotle that the logical relation between explanans and explanandum is a relation of necessary consequence?". Another question is Q2: "does the requirement that the logical relation between explanans and explanandum be a relation of necessary consequence correspond to what Aristotle has exactly meant to encode in T1?".

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[5] Perhaps the sentence "ὅτι ἐκείνου αἰτία ἐστι" (which is what the pronoun "this" refers to) might be translated in a more enlightening way: "that it is *of this* that the cause is the cause". I thank Adam Crager, Tim Clarke and Ben Morison for discussions that helped me to clarify the point. See Ribeiro 2014, p. 147-152, 156.

Now, a conflation between questions Q1 and Q2 can be a disaster for the exegesis of Aristotle's text. The two questions are distinct from each other, even if related to each other in important ways. It is clear that any definiens must have true content—at least, a content that Aristotle himself takes to be true. Thus, it is clear that any positive answer for Q2 must entail a positive answer for Q1. But—importantly—not vice-versa. The two questions are really distinct from each other. For any definiendum *X*, its definition need not encapsulate all that is true about *X*. For instance, the definition of human being need not contain every truth about human beings, and does not even need to state that human beings are mammals, or animals capable of smiling etc. The situation is not different, when the *X* to be defined is scientific knowledge (as it is in T1). This is important because, in saying that *being mammal* need not be included in the definition of human being, one is not thereby denying that human beings are mammals. In the same way, in denying that (e.g.) B3 is not included in the definition of scientific knowledge, one is not thereby denying that B3 is (or might be) true for Aristotle.

On the light of these distinctions, I give a preliminary map for the ensuing discussion. Let me start with Q1, which must be cashed out in terms of asking whether Aristotle has indeed considered B1-B5 as conditions for scientific knowledge. For the traditional interpretation, Aristotle takes as true requirements B1, B2 (as well as B2*, which follows from B2), B3 and, perhaps, B4. Actually, there can be more subtleties about B4, which I will not discuss.[6] My purpose in this paper consists in stressing that traditional interpretations have not even dreamed of B5 as an option—not even in the domain of question Q1. On my part, I stress that, in the domain of question Q1, conditions B3, B4 and B5 are taken as true by Aristotle, but B1 and B2 are false. Given that discussing B1 is not important for my purposes here, I stress that B2 is, stricly speaking, false and should be replaced with B2*. So much for question Q1.

Let us now consider question Q2, which focuses strictly on what Aristotle has encoded in the definition of scientific knowledge in T1. Almost all scholars think that Requirement B in T1 must be understood in terms of B2 or (on the light of other texts) B2*. On my part, I argue that Requirement B must be understood in terms of B5. What Aristotle has attempted to encode in his definition of scientific knowledge in T1 was a requirement about explanatory adequacy.

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[6] For instance: material causes, or even some final causes, do not satisfy B4.

However, before developing my answer to question Q2, I stress two points of utmost importance to understand what exactly I am proposing.

First, confusion about the exact nature of what is being defined in 71b9-12 (T1) might raise resistance against B5—as an answer to either Q1 or Q2. Many scholars believe that what Aristotle wants to define in T1 is scientific *understanding*, as "understanding" is taken in some contemporary epistemological discussions, namely, as the mastery over a body of propositions systematized as a scientific discipline.[7] In this picture, Requirements A and B are taken as conditions that anyone must satisfy to be considered an expert mastering a given discipline (e.g., a geometer). Now, I believe that Aristotle is also interested in such questions as what determines an expertise, what makes a body of propositions a scientific discipline etc. However, his exact focus in T1 is different. Aristotle is defining, in T1, what it is to have scientific knowledge of *each thing*, namely, of a given explanandum in a given domain. (More on this below). Requirements A and B state conditions that must be satisfied to have scientific knowledge of a given explanandum within a given discipline (e.g., to have scientific knowledge of 2R as an attribute of triangles).

It is important to stress that the two questions implied in the last paragraph are indeed different questions—even if they are intrinsically inter-related. We may ask: (1) "when [i.e., on what conditions] has a geometer attained the ultimate explanation *of a given theorem*?", but this is different from asking: (2) "when [i.e., on what conditions] has someone attained *full mastery over the discipline as a whole*?". Of course, having scientific knowledge of a given theorem requires some mastery of the discipline, as well as, conversely, having full mastery over the discipline as a whole requires sistematic knowledge of a significant number of theorems. However, even so, specific requirements applying to the first question are different from specific requirements applying to the second question. As we know, being different from does not imply being independent from.[8] Now, my contention is that—although Aristotle is concerned with both questions at large—what Aristotle is attempting to define in T1 is the former question, namely, what it is to have scientific knowledge *of a specific explanandum within a given discipline*. Now, resistance against B5 might stem

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[7] See Burnyeat 1981; Burnyeat 2011, p. 19; Lesher 2001. On "systematic knowledge", see Charlton 1992, p. 1; Broadie & Rowe 2002, p. 365. For discussion, see Bronstein 2016, p. 36.

[8] For instance: the requirement that the terms of an appropriate demonstration be coextensive with each other applies to having scientific knowledge *of a given explanandum* (as I argued for in Angioni 2018, p. 178-182), but does not apply indifferently to every proposition that constitutes a discipline —for in this discipline there will be several other items, such as "application arguments" (borrowing the terminology from McKirahan 1992, p. 177-187), and several other propositions, in which the terms need not be coextensive.

from the opinion that it is a requirement too strong (or even inadequate) for scientific knowledge taken as the full mastery over a discipline. If Aristotle's requirement is taken in this way, the resistance will be on the right track, for the full mastery over a discipline requires mastering over several propositions and deductive procedures that go beyond the causes which are exactly appropriate to each explanandum. However, B5 is not a requirement for knowing every item involved in the systematic mastery of a discipline. B5 is a requirement for the scientific knowledge *of a given explanandum*—for this is what Aristotle targets in T1: scientific knowledge of a given, specific explanandum within a discipline.

Second, my claim in favour of B5 sometimes finds resistance because one precipitately believe that B5 implies getting rid of B2 and B2*, as if I were claiming that B2* itself is a false requirement. To be clear: I reject requirement B2 as false—and in this I am not alone.[9] However, my claim in favour of B5 (which I take to satisfy both questions Q1 and Q2) is far from being incompatible with accepting B2* as a satisfactory answer for Q1, which is tantamount to saying that the propositional content of B2* is itself true, even if it is not what Aristotle is expressing in T1. Thus, for Aristotle, having scientific knowledge of a given proposition (taken as an explanandum within a given discipline) surely involves knowing that the proposition at stake is true necessarily or for the most part. However, the crucial difficulty consists in ascertaining whether Aristotle's definition of scientific knowledge in T1 (71b9-12) is expressing B2* or not. I insist, therefore, in the distinction between questions Q1 and Q2. For it is perfectly possible for a given thesis, as B2*, to be true on Aristotle's eyes but not to have been expressed in T1—as it is perfectly possible that what delivers a positive answer to Q1 does not deliver a positive answer to Q2. At last, I stress that B5, far from being incompatible with B2* in general, can even be taken as entailing B2*. B5 ranges over the explanatory relation between explanans and explanandum. Now, once this is settled, it is possible to ask what requirements apply to the elemental propositions that express respectively the explanans and the explanandum—or, in other words, what requirements apply to each of the predications themselves (premises and conclusions) that constitute a demonstration. Thus, one can ask: must the propositions expressing the explanans and the explanandum be themselves necessarily true or at least true for the most part? Even if we answer "yes", and I do, this answer does not prove that B2* is the correct answer for question Q2.

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[9] See Barnes 1993, p. 92-93; Ferejohn 2013, p. 82; Bronstein 2016, p. 36, n29.

The correct answer for Q2 is B5, which entails B2* as a correct answer for Q1, and this has naturally misled readers.

4. The necessity requirement as explanatory appropriateness (B5):

I start now the discussion of Q2: among the propositions involved in B1-B5 (i.e., among the five options to understand the requirement B in T1), which of them is the target of the definition of scientific knowledge? Or, in other words: which of them is the definition of scientific knowledge in T1 meant to encode?

Options B1, B2, B3 and B4 can surely be discarded as answers for question Q2—they have been considered in my survey only to map the terrain in an exhaustive way. Indeed, B1 implies B2 or even collapses into B2 at least in the domain of question Q2. For, in the domain of scientific knowledge, propositions that define an object *X* or ascribe characteristics to the object *X* play the most important role, so that the proposition that *X* exists can be taken somehow as a background presupposition.[10] Furthermore, *X*'s existence is treated from the standpoint of scientific knowledge mainly (or exclusively) when analysed in terms of a characteristic attribute occurring in a given subject—for instance, thunder's existence is treated in terms of a certain kind of noise occurring in the clouds. Consequently, sentences such as "*X* necessarily exists" collapse—and should be carefully analysed—into predicative sentences, like "*P* necessarily holds of *S*", "*P* necessarily holds of *X*" or "*X* necessarily holds of *S*".[11]

B3 can also be discarded. Aristotle surely requires that the relation between the cause and its *pragma* be expressed as a sound syllogistic deduction, in which true premises expressing the causal relations entail the truth of the conclusion. However, this requirement (about the expression of the *logical* necessity) is not what he has encoded in T1. As we know, Aristotle is far from reducing the notion of scientific knowledge (and, more particularly, the notion of scientific demonstration) to the notion of sound deduction.[12]

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[10] On presuppositions in the domain of a scientific discipline, cf. 76b16-19.

[11] See 89b37ss. I need not go into details. I have dealt with this issue in Angioni 2014b, p. 86-88. See Almeida 2017. I disagree with the interpretation that take the *hypotheseis* (defined in 72a18-24) as existence statement of the form "S exists". For discussion, see Gomez-Lobo 1977, Charles 2000, p. 197-220, and Barnes 1996.

[12] For discussion, see Angioni 2014b, p. 64-68. Among other passages, the most intuitive to clarify this point is *Posterior Analytics* 78a26-b4. I will allude to B3 again when discussing T14.

B4 can also be easily discarded as an answer for question Q2. Aristotle surely believes that the cause (at least in some important domains) is so that metaphysically necessitates the occurrence of its *pragma*. Nonetheless, he was not targeting this point in T1. Strictly speaking, Aristotle is committed to a stronger thesis: that the cause and its *pragma* are metaphysically correlated, and that their linguistic expressions (properly elaborated) are coextensive or co-entailing (cf. 78b13-28, II.16, 98a35ss.).[13] Even so, Aristotle is far from reducing the notion of an appropriate cause to the condition of mutually entailing its *pragma*.

It results that, in order to map the answers to question Q2, the most important point is the following: whereas traditional interpretations believe that the definition in T1 expresses the Requirements A and B2 (or B2*)[14], I argue that the definition in T1 expresses Requirements A and B5. However, I stress the importance of the distinction between Q1 and Q2. Thus, my claim that the definition in T1 expresses Requirements A and B5 as answers to Q2 is perfectly compatible with accepting that B2* is true in the range of Q1. Thus, I stress that my interpretation takes B2* itself as true: scientific knowledge of *X* requires knowing propositions about *X* that are necessarily or for the most part true, and requires (more strongly) knowing that propositions about *X* are true necessarily or for the most part. However, even so, B2* is not part of the content expressed by Aristotle in his definition of scientific knowledge in T1. The definition advances Requirement B5, which concerns the explanatory appropriateness of the cause to be selected as explanatory factor.

Now, my reader might be annoyed with the fact that I have so far avoided the (presumed) "strong evidence" that favours the traditional interpretation in terms of B2 or B2*—the evidence presumably found at the beginning of *APo* I.4 (73a21-24) and chapter I.6 as a whole. I have discussed most of those key passages elsewhere.[15] This present paper is mostly concerned with addressing other passages in which Aristotle refers to his notion of scientific knowledge, besides those in the *APo* which presumably favours options B2 and B2*. Even so, I will explain how I understand those key passages that seem to favour the traditional interpretation (Section 5.a.1)

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[13] For details, see Angioni 2018, p. 163-177; Zuppolini 2018b, p. 230-240.

[14] See, e.g., Barnes 1993, p. 90-91; McKirahan 1992, p. 22-23; Mignucci 2007, p. 151, 162-3; Ferejohn 2013, p. 82; Bronstein 2016, p. 36, 43; Mendelsohn 2019, p. 102-3.

[15] See Angioni 2014a; Angioni 2016, p. 100-102; Angioni 2013a, p. 262ss.; Angioni 2019.

5. Aristotle's own references to his notion of scientific knowledge:

Aristotle's treatises, the *APo* included, have several references to his definition of scientific knowledge. Do these references (or allusions) favour one of the options for understanding Requirement B in T1? The underlying issue (from the previous section of this paper) consists in identifying what requirements have been exactly encoded in Aristotle's definition of scientific knowledge—i.e., question Q2, but not question Q1. On this light, the new issue I have just formulated amounts to examining how Aristotle's own references to his definition of scientific knowledge contribute to answer question Q2.

First, I will argue that Aristotle's references to his definition of scientific knowledge within the *APo* confirm the interpretation in terms of B5. These references are divided into two groups: on the one hand, those that appear to refer to B2 (or B2*****), but, on closer examination, show that the notion of explanatory appropriateness is at stake and thereby favour the interpretation in terms of B5; on the other hand, those that explicitly refer to Requirement A with no allusion to Requirement B at all. I will be brief about the first group of these references, for I have dealt with them in previous papers—and, unfortunately, a detailed discussion of chapter I.6 as a whole does not fit this paper (I would need fifty pages more!).

Secondly, I will highlight a fact about Aristotle's references outside the *APo* and discuss its significance. The fact is that several (or even most) references to Aristotle's notion of scientific knowledge as officially defined in T1 *does not* mention Requirement B, but only refers to Requirement A. There are two important exceptions, which are usually employed as evidence for the traditional interpretation: *Ethica Nicomachea* VI.1-3, *Metaphysics* VII.15.[16] Now, it would be too long to examine the *Metaphysics* passage in this paper, for a satisfactory tracking of the argument (which is a discussion against some version of the Theory of Forms) would lead us far away. Besides, and most importantly, all Aristotle says in *Metaphysics* VII.15 involves the distinction between scientific knowledge and opinion in such a way that can receive the same treatment as *APo* I.33. The distinction appears to hinge on a modal difference, as if the object of scientific knowledge were necessary predications and as if the object of opinion were restricted to contingent things. Now, I have already developed my view about the distinction between scientific

[16] Actually, the passages I am concerned with (1139a6-8, b18-35) belong to the common books of *Nicomachean* and *Eudemian Ethics*. But it is immaterial to my purposes here to discuss whether these passages originally belong to the *Nicomachean* or to the *Eudemian Ethics*. Just to make references easier, I will refer to them as *Ethica Nicomachea* VI, but nothing important hinges on that conventional way of referring to the passage.

knowledge and opinion in *APo* I.33. Since I believe that *Metaphysics* VII.15 can be treated in the same way as *APo* I.33, I will not discuss it in this paper.[17]

5.a) Aristotle's references to his notion of scientific knowledge within the *Posterior Analytics*:

5.a.1) What might seem evidence for B2* (or B2) confirms B5:

In *APo* I.4, 73a21-24, Aristotle resumes what I have labelled Requirement B: "that of which there is scientific knowledge simpliciter cannot be otherwise" (see a similar sentence in 71b15-16), and a few lines further ahead, he concludes:

> ***T2***: "what is known with demonstrative knowledge is necessary. Demonstrative is the knowledge we have by having demonstrations. Thus, a demonstration is a syllogism that depends on [or proceed from] necessary items". (73a22-24)

The first sentence of T2 is as general and vague as the formulation found in T1. The traditional interpretation has been precipitate in taken T2 as decisive evidence for understanding T1 in terms of B2.[18] Option B2 relies on the assumption that "what is known with demonstrative knowledge" refers exclusively to the conclusion of a demonstration. Thus, T2 is taken to be reasoning from the "definitional" fact that the conclusion must be necessarily true (in terms of B2) to the result that the premises must also be necessarily true. Besides other problems—such as the clash with Aristotle's theory of modal syllogisms, as well as the same false results that stems from T4 (which I will explore below)— this interpretation of T2 is problematic because it takes its assumption as being the only option. But it is not. Now, the important question is this: what does the expression "what is known with demonstrative knowledge" refer to? Predications playing the role of conclusion are far from being the only option. What we know, when we acquire demonstrative knowledge of the 2R theorem (or of the lunar eclipse), is a highly complex explanatory relation between the explanandum and the explanans, which Aristotle wants to be

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[17] See Angioni 2019, Angioni 2013a, p. 262-4. For different views on I.33, see Fine 2010; Moss & Schwab (2019); Morison (forth.); Peramatzis (forth.).

[18] See Filopono 57.22-29, 58.18-19; Barnes 1993, p. 110-11; Barnes 1993b, p. 230; McKirahan 1992, p. 81-83; Mignucci 2007, p.162-3. See also Ferejohn 2013, p. 82, in favour of B2*. Ross 1949, p. 526 is neuter on this, for he repeats Aristotle's words with the same vagueness and generality. Porchat 2001, p. 137, seems to embrace B1 e B2 at once.

parsed as a relation between the conclusion and the premises of the demonstrative syllogism.[19] Thus, merely necessary predications (in which the predicative tie is necessarily true) are far from being thereby qualified for the role of "necessary *items* on which demonstrative knowledge depends". The necessary *items* (i.e., principles) on which demonstrative knowledge depends are premises that, being true necessarily or for the most part, are here called "necessary" in terms of B5: they are *the necessary ones* for the most appropriate explanation of the explanandum in question. The fact that being necessary in terms of B5 requires predications that are necessary or for the most part true in terms of B2* does not modify the story.

Further ahead in the *APo*, chapter I.6 is completely devoted to exploring the thesis announced in I.4 (T2), namely, that "demonstration is a syllogism that depends on [or proceeds from] necessary items". The two most important passages are the following:

> ***T3:*** "Given that demonstrative knowledge depends on [or proceeds from] necessary principles, and given that necessary are the attributes that apply to the things [sc. the explananda] in themselves […], it is clear that a demonstrative syllogism depends on [or proceeds from] items of this kind; for everything applies either in this way or on the basis of a concomitant factor, but concomitant factors are not necessary" (74b5-13).

> ***T4:*** "If something has been demonstrated, it is not possible for it to be otherwise; therefore, the syllogism must proceed from necessary [items], for from true [items] you can deduce without demonstrating, but from necessary [items] you cannot deduce without demonstrating—this is precisely the mark of demonstration". (74b14-18).

There are two main reasons why it is embarassing to understand the Necessity Requirement in T1 in terms of B2. The first reason—which is actually less important—is that, by Requirement B2, only a few disciplines, such as mathematics, cosmology and theology, will deserve the title of "scientific knowledge", whereas the disciplines which Aristotle himself has developed, like several branches of biology, will not deserve that title. The traditional interpretation tries to get rid of this trouble through a speculative hypothesis that has no textual evidence, namely, that Aristotle would have changed his mind when developing his explorations

[19] I have developed this view with more details in Angioni 2019, p. 173-5, 191-5.

in the field of biology etc., leaving aside the exaggerated requirements found in the *APo*.[20] (The only presumed evidence for this fictitious narrative is *APo* I.30, which I will discuss further ahead).

Much more important is the second reason why it is embarassing to understand the Necessity Requirement in T1 in terms B2—for the second reason also affects B2*, which is the traditional way of dealing with the difficulty involved in the first reason. If understood in terms of B2, passage T4 would be saying that *any sound deduction with necessary propositions* (e.g., any sound Barbara-syllogism with premises and conclusion necessarily true) would count as a demonstration. Understood in terms of condition B2*, passage T4 would be saying that *any sound deduction with propositions that are true (at least) for the most part* would count as a demonstration. However, there is a significant set of passages with robust evidence against these interpretations, namely, against reducing demonstrations to sound deductions with propositions that are necessarily true or (at least) true for the most part.[21] In contrast, if T4 be understood in terms of B5, there is a perfect harmony in the way Aristotle conducts his discussion in order to flesh out with more accurate detail what has been briefly encoded in the definition of scientific knowledge in T1.

I will be brief on this point here, because I have already dealt with it in detail.[22] The robust evidence against the Reduction—and, consequently, against the interpretation of the Necessity Requirement in terms of B2 or B2*—is fundamentally found in chapters I.5 and I.9, in passages that clearly resume the terms in which the definiendum was phrased in T1, namely, "knowing each thing simpliciter", which is tantamount to knowing each thing (within a scientific discipline) in the specific way that counts as scientific knowledge. Thus, in 74a32ff., Aristotle is clearly concerned with specifying more fine-grained criteria to discern "when one knows simpliciter"—

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[20] This is the style found in LeBlond 1939; there is also a flirt with that suggestion in Barnes 1993, p. 192. In a different style, see also Smith 2009, p. 60, who believes that T4 works with another definition of demonstration, different from T1.

[21] About the falsity of such a reduction, see Barnes 1993, p. 126; Mignucci 2007, 171; Hankinson 1998, 161; Angioni 2014a, p. 90-92. The robust set of evidence against that reduction includes the six requirements for the premises in 71b20-32, the insistence on *per se* predications (73b16-18, 75a29-31), the requirement for principles that are *suggenes* (75b3-12, 76a8-9, 29-30) and appropriate to their explananda (71b22-23, 72a5-6, 74b25-26, 75b36-40, 76a4-7). It is surprising that most interpretations (following Ross 1949) do not have any comments on T4 (or have paltry ones, as Philoponus, 84.18-34). Some suppose that Aristotle has in mind a mysterious equivalence between necessary predication and *per se* predication (cf. Barnes 1970, p. 139-140: "the *Posterior Analytics* states that holding 'in itself' and holding necessarily are equivalent (*A* 74b5-12)". But this trick is far from solving the problem, as I have shown in Angioni 2016, p. 156-63, and Angioni 2019, p. 200-2.

[22] I discussed this issue focused on T4 in Angioni 2014a and Angioni 2019, p. 175-191. See also Angioni 2016, p. 100-102; Angioni 2012a, p. 44-47.

more particularly, "when one knows simpliciter why the attibute 2R is attributed to that to which it is properly attributed". There is an important motive for Aristotle to be concerned with refining these criteria. Sometimes an attempted demonstration which fails at delivering "knowledge simpliciter" gets unnoticed as the failure it is. Such an attempted demonstration satisfies some important conditions (being, for instance, a sound deduction of its conclusion) but do not demonstrate in the most appropriate way what was targeted as demonstrandum (74a4-6). In chapter I.9, 76a26-30, Aristotle comes back to the same issue:

> ***T5:*** "It is difficult to tell whether you have [scientific] knowledge of something or not, for it is difficult to tell whether or not our knowledge of something proceeds from its principles—and this is what it is to know something. We think we have scientific knowledge of something if we possess a syllogism from some true and primary items, but this is not so" (76a26-30).

T5 is the final section of chapter I.9, in which Aristotle has discussed more fine-grained criteria to tell when (i.e., on what conditions) do we really have scientific knowledge of a given explanandum. In the beginning of the chapter, he has said: "it is not possible to demonstrate each thing unless from the principles *of each one* […]" (75a37-38). The requirement of demonstrating each thing from the principles *of each one* (*qua* each one is exactly itself) is exactly the same requirement of explanatory appropriateness which, in T1, is encoded in the conditions A and B5 (and, besides, is expanded into the six requirements for the premises, cf. 71b22-23). Further ahead in the same chapter I.9, the reference to T1 is even more explicit: "We have scientific knowledge of each thing not on the basis of a concomitant factor when we know it on the basis of that in virtue of which it is [what it is], from the principles of that thing *qua* itself" (76a4-6).

All the passages from I.5 and I.9 I have been considering are extremely dense.[23] Now, all of them make clear Aristotle's concern with specifying in a more fine-grained way the conditions to tell that one has attained scientific knowledge of a given explanandum *X*—and Aristotle's target

[23] Unfortunately, these passages have not received the attention they deserve. Chapter I.5 has had a better luck, with Ferejohn 2013 and Hasper 2006. The commentaries on I.9 found in Barnes 1993 amount to less than three pages (p. 134-7), and there is no specific discussion for T5 (76a26-30), which is a passage of utmost importance. The same happened with Ross 1949, p. 535-7, who, besides, has erroneously taken I.9 as a mere warning against the *metabasis eis ello genos* (about the *metabasis*, see Steinkrüger 2018). No passage from I.5 and I.9 is devoted to a full examination in McKirahan 1992, nor in Bronstein 2016 (who at least says something on 76a4-6 in note 21, p. 56).

is not limited to the more general conditions to tell that someone is an expert in a given domain. Aristotle's strategies to satisfy that concern have several fronts. He insists that the terms in an appropriate demonstration must be coextensive with each other (74a1-3), but he also insists in intensional aspects stemming from the notion of *per se* predication (73b26-39; 74a25-32).[24] He identifies the risk of erroneous understanding of some of the six requirements he has laid down in 71b20-33, as the requirement of selecting primary and indemonstrable premises (75b37-40, 76a26-30).[25] Now, the crucial point for the more fine-grained specification of this requirement consists in the notion of explanatory appropriateness: the cause or principle to attain the scientific demonstration of *X* must take *X* exactly as being *X* (or *qua X*).

One might say that Aristotle seems concentrated on the condition A when refining these requirements. But I argue that his effort in refining his requirements paying attention to the notion of explanatory appropriateness, in T3-T4 (as well as other passages from I.5-6 and I.9), is better understood as an effort to clarify how the Necessity Requirement in T1 must be taken.[26] And it is especially T4 that confirms that Requirement B must be understood in terms of B5, namely, in terms of explanatory appropriateness. Option B5 says that the cause to be selected in the scientific demonstration of *X* is such that *it could not have been a different one*. What must be selected in the scientific demonstration of *X* is that cause which, taking *X* exactly as *X*, explains in the most appropriate way why *X* is what it is. For this reason, that cause may receive the title of "necessary principle", namely, the principle that is explanatory necessary for the scientific explanation of *X*—the principle that could not have been a different one. Taken in this way, T4 does not generate any false, embarassing claim, but delivers instead a claim that is perfectly consistent with many passages from the *APo*.[27]

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[24] See Angioni 2016, p. 95-102; Ferejohn 2013, p. 81-90; Hasper 2006; Zuppolini 2018a, p. 129-132.

[25] On this point, see Angioni 2012a, p. 42-52. For a different view, ver Ferejohn 2013, p. 72-74.

[26] See Angioni 2014a, Angioni 2016, p. 100-102. Moreover, my interpretation allows us to take T1 as a *programme* that ties together most of the discussions actually found in the following chapters. Thus, discussions about the *per se* attributes (I.4-6), coextensiveness between the terms in the demonstrative syllogism (I.4-5, I.13), necessary principles (I.6), *metabasis eis allo genos* (I.7), explanatory inadequacy of too generic principles that apply in common to different explananda (I.9), primary causes (I.13)—all this can be understood as a fine-grained cashing out of the Requirements A and B. For the other interpretations, the relations between many of those discussions is much more obscure, sometimes are taken to be rhapsodic. Ferejohn 2013, p. 65-66, 72, has acknowleged the lack of relation, but he attempts to mitigate it by proposing a division of work between I.1-3 (general conditions for any epistemology) and I.4 onwards (Aristotle's specific philosophy of science).

[27] See references on note 21.

Thus, in saying that scientific demonstrations depend on "necessary principles" in T3 (74b5-6), Aristotle is not saying that scientific demonstrations stem from necessary predications (i.e., predications in which the predicative tie necessarily holds)—even if it is true to say that the proposition playing the role of explanatory principle for a given conclusion is, itself, necessarily true. What Aristotle encodes in the expression "necessary principles" in 74b5-6 (T3) is the claim that a scientific demonstration depends on a proposition that (being itself necessarily true or at least true for the most part) is the principle which is explanatorily necessary, i.e., the principle required to explain in the most appropriate way why *X* is as it is. The adjective "necessary" in 74b5-6 (T3), which ranges over the noun "principle", takes the principle *exactly as a principle* and tells something about its explanatory power. Something similar happens with the occurrences of the adjective "necessary" (with no noun explicitly attached to it) in T2 and T4. Thus, when Aristotle says that a scientific demonstration depends on (or proceeds from) "necessary items", his focus is not to encode the condition that a demonstration must proceed from premises that are necessarily true (or at least true for the most part)—even if this condition is true in itself, for, as I have emphasised, B2* delivers a positive answer for the question Q1. What Aristotle expresses, in T2 and T4, is the claim that a scientific demonstration depends on (and stems from) premises that turn out to be the principles without which the fully appropriate explanation of the explanandum in question is not attained.[28]

The points made in the previous paragraphs must be emphasised to discuss a crucial text, *APo* I.30, which supposedly would give support for taking the Necessity Requirement in T1 in terms of B2*. I stress, again, the importance of the distinction between the questions Q1 and Q2. The thesis that Aristotle advances in I.30, and which is confirmed in many other passages, is that "there is no scientific (or demonstrative) knowledge of what happens by chance" (87b19).[29] Aristotle's argument is simple: "what happens by chance is not either necessary or for the most part, but is what happens apart from these two; demonstration, however, is about one of these two" (87b20-22). It is also true that, further ahead in I.30, modal terminology seems to be applied exactly to the predicative relations encoded in each sentence of a demonstration, instead of applying to the explanatory relation between premises and conclusion. The text reads thus:

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[28] For details, see Angioni 2019, p. 179-191; Angioni 2014a, p. 91-103; Angioni 2016, p. 100-102; Angioni, 2012a p. 44-47.

[29] Cf. *Metaphysics* 1027a19-26; *Physics* 197a8-21. For excellent discussion, see Judson 1991.

"every syllogism proceeds from necessary *premises*, or from 'for the most part' *premises*; if the *premises* are necessary, the conclusion is necessary too; but, if the *premises* are 'for the most part', the conclusion will be of this kind too" (87b22-5, my italics).

Now, this passage gives support in favour of option B2* only in the domain of question Q1—but *not* in the domain of question Q2. Thus, it is true that, for Aristotle, scientific knowledge requires knowing that the propositions at stake are true necessarily or for the most part.[30] However, this does not prove that the Necessity Requirement in the definition of scientific knowledge in T1 must be understood in terms of B2*. As I have already argued, if the Necessity Requirement were understood in terms of B2 in T3-T4, Aristotle would be embracing a thesis that he himself takes to be false and, besides, is inconsistent with a significant part of the discussions developed in the *APo*—namely, the thesis that any sound deduction with necessarily true propositions would count as a scientific demonstration.[31] This trouble would not be solved if B2 gets replaced with B2*. Strictly speaking, B2* would deliver a thesis even more bizarre in T4, namely, the thesis that any sound deduction with 'quasi-necessary' propositions (i.e., propositions that are true for the most part, but not necessarily) would count as a scientific demonstration.[32]

Thus, the distinction between questions Q1 and Q2 is fundamental to understand Aristotle's theory of scientific knowledge. It is surely true that, for Aristotle, "every scientific knowledge is about that which holds necessarily or that which holds for the most part" (1027a20-21). This amounts to saying that the proposition underlying B2* is true — B2* delivers a positive answer to question Q1. However, question Q2 is a different one. What matters in Q2 is to discern whether B2* corresponds to the requirement encoded in the definition of scientific knowledge in T1. And the answer, in this case, is negative. Aristotle's references to the notion of scientific knowledge in important passages (e.g., T3-T5) show that the definition of scientific knowledge in T1 works with two requirements focused in the notion of explanation:

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[30] Cf. *Metaphysics* VI.2, 1027a19-21. I could have included the passage 1027a19-24 in this paper. However, this will take me too long, for the expression "συμβεβηκός" is being used differently from what is found in T1. I have dealt with these issues elsewhere (cf. Angioni 2016, p. 91-100).

[31] See references on note 21.

[32] Furthermore, my interpretation explains Aristotle's attitude in I.30 in a better way. On the traditional interpretation, the purpose of I.30 would be exactly to correct B2 in terms of B2*. However, it would be surprising if Aristotle had made such a correction with no announcement or preparation—and Aristotle was fully aware of the possibility of having his words wrongly understood, see *Incessu Animalium* 709b20-23. On my interpretation, Aristotle is not changing his mind; he is only warning us that the "necessity" terminology, which has been applied to explanatory relations, is now being applied to the premises themselves (as predicative ties).

Requirement A requires knowing that the cause of the explanandum *X* is in fact its cause; Requirement B, understood in terms of B5, requires acknowledging that *the fact that this cause is the cause of X* cannot be otherwise. Strictly speaking, Aristotle's efforts in clarifying the conditions on which we attain scientific knowledge of a given explanandum *X* are efforts to clarify how Requirement B must be understood.

5.a.2) Other passages from the *Posterior Analytics*:

I stress that, in two crucial passages from the *APo*, Aristotle refers to the notion of scientific knowledge without making any allusion to the notion of necessity as taken by the traditional interpretation (i.e., in terms of B2 or B2*).

Thus, in *APo* I.14, we read the following:

> ***T6:*** "Among the figures, it is the first that most provides knowledge. For it is through the first figure that mathematical sciences (like arithmetic, geometry and optics) and all the others conduct the investigation of the *why*. The syllogism of the *why* runs in this figure either in all cases, or for the most part and in most cases. Consequently, it is also the first figure that most provides knowledge, given that the most decisive for having knowledge is to identify the *why*" (79a16-24, my translation).

This passage involves several difficulties.[33] But only one point concerns me now—a point that applies to other passages too. If both requirements, Requirement A and Requirement B, are equally important in the definition of scientific knowledge in T1, then we must expect T6 to refer to the latter too. If Requirement B should be understood in terms of B2 or B2*, Aristotle could have said: "the most decisive for having knowledge is, besides identifying the *why*, knowing that the propositions in question are necessarily true (or true for the most part)". But he did not say that. He has highlighted that "the most decisive for having knowledge is to identify the *why*".

One might argue that Aristotle has not retrieved Requirement B in T6 because his subject —a comparison between the syllogistic figures—does not depend on it. It could be so. But the lack of any reference or allusion to Requirement B in T6 can be explained in a much more satisfactory way if Requirement B is understood in terms of B5. For, given that B5 requires the

[33] For detailed discussion, see Mendell 1998. See also Barnes 1969, p. 144; McKirahan 1992, p. 150.

full explanatory appropriateness of the cause in relation to its *pragma*, we can say that B5 is giving us *more specific conditions to cash out* Requirement A. The definition of scientific knowledge in T1 starts with Requirement A: it requires knowing the cause and the why. But this is not enough, for one must capture the cause that is *the primary* or *most appropriate one*. In this picture, it is completely understandable that Aristotle refers to the notion of scientific knowledge in the summarized and abbreviated way found in T6. My point is that, if Requirement B is understood in terms of B5, an explicit reference to the specific kind of cause able to explain its explanandum in the most appropriate way can be absent in contexts in which it does not matter—in contexts in which a generic description is enough. This is what happens in T6: Aristotle retrieves the notion of scientific knowledge by means of a generic description that is enough for his purposes in the context—much in the way we do when we say, e.g., that craft is a capacity, full stop. Besides, other passages make explicit reference to the notion of *primary* cause, which retrieves Requirement B understood in terms of B5, as I will now explore.[34]

In fact, if Requirement B is understood in terms of B2 or B2*, it will result in a condition completely different from Requirement A, a second condition that is extrinsically added to Requirement A. Thus, if Aristotle's definition of scientific knowledge works with two different requirements, blended together with no inner connection between them (as suggested in Barnes 1993, p. 92), the omission of one of them turns out to be more difficult to explain. More particularly, the lack of reference to Requirement B2 (or B2*) in passages such as T6 turns out to be more difficult to explain—even more difficult if, as Barnes (1993, p. 92) has suggested, mathematics were more concerned with necessity than with explanatoriness.

In *APo* II.11, we read thus:

> ***T7:*** "Given that we think we have scientific knowledge when we know the cause, and the causes are four […]; all them are displayed through a middle term" (94a20-24).

[34] Moreover, several uses of "τὸ αἴτιον" and "τὸ διότι" in Aristotle's works are such that the definite article "τό" plays the role of pointing out "*the* cause", namely, that cause which is the *one* required for the fully appropriate explanation (even with no adjectives attached to the term). In 78b15, "τὸ αἴτιον" is retriving "τὸ πρῶτον αἴτιον" mentioned in 78b3-4 (cf. Angioni 2018, p. 164). Something similar occurs in *Metaphysics* VII.17: in 1041b7, we find "τὸ αἴτιον", but in 1041b28 it becomes clear that Aristotle was talking about the αἴτιον πρῶτον. In 194b19-20 (which will be discussed below as T11), "*the* why" is taken as equivalent to "primary cause". See also 75a35, 93a4, 413a20.

If both requirements, Requirement A and Requirement B, are equally important in the definition of scientific knowledge in T1, and if the Requirement B must be understood in terms of B2 or B2*, then we must expect Aristotle to make an explicit reference to it in T7. Again, the lack of explicit reference to Requirement B is easily explainable if we take it in terms of B5. For, in this case, Requirement B—far from being a completely different requirement, concurrently added to Requirement A—turns out to be a *specification that clarifies in a more fine-grained way* the conditions on which knowledge of the cause (satisfying Requirement A) delivers scientific knowledge.

I am aware that my argument concerning T7 has a possible weakness, if taken in isolation. One might object—correctly, in a way—that the lack of explicit reference to Requirement B in T7 is easily explainable by the fact that T7 is stricly concerned with specifying the four kinds of causes, as a further refinement of Requirement A. So, the lack of reference to the Necessity Requirement in T7 hardly proves anything about the definition of scientific knowledge in T1.

However, the reason for including T7 in my present list is that T7 repeats a pattern found in many other passages in which Aristotle makes reference to his definition of scientific knowledge. Thus, T7, isolated in itself, would never be able to give robust evidence for my claim, but it has its importance even so, for it is on a piece with other passages outside the *APo* in which Aristotle refers to the notion of scientific knowledge. With two important exceptions—*Metaphysics* VII.15 and *Ethica Nicomachea* VI.1-3, the latter of which will be discussed below—all these passages do not have any explicit reference to Requirement B, and most of them make explicit reference to Requirement A. Aristotle's phrasing in most of those passages seems to imply that having scientific knowledge of a given explanandum *X* can be briefly summarised in one single characteristic: knowing the cause (or the primary cause) by which *X* is what it is. I intend to show that those passages, far from abandoning Requirement B as found in T1, can be much more satisfactorily understood in terms of B5.[35]

A supposedly recalcitrant case, which seems to count in favour of the traditional interpretation, will be discussed later with more detail—*Ethica Nicomachea* VI.1-3. Before examining it, I offer a survey of other passages.

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[35] I still add 71b30-31, as well as this passage from I.24: "if a demonstration is a syllogism that shows the cause and the why, and if the universal is more of a cause (…); therefore, also the universal demonstration is better, for it is, most of all, of the cause and of the why" (85b23-27). But my list of passages is large enough—and I would take me too long to argue that the passage from I.24 must be taken serioulsy in many aspects.

5.b) Beyond the *Posterior Analytics*:

5.b.1) No mention of Requirement B:

I start with two passages from the *Organon*. At the beginning of the *Topics*, Aristotle clarifies what he is calling "demonstration" in this way:

> ***T8:*** "A syllogism is a demonstration when it proceeds from true and primary [premises], or from [premises] such that the principle for knowing them is attained by means of true and primary [premises]". (100a27-29, my translation)

In order to clarify what he is calling "demonstration", Aristotle does not resume any of the requirements that define scientific knowledge in T1—neither Requirement A nor Requirement B. Given that "demonstration" is several times employed for the kind of argument that expresses scientific knowledge, it would be likely for Aristotle to resume those requirements.[36] However, the differences between T1 and T8 need not be exaggerated, for they can be well explained from the different concerns that predominate in each context. T1 belongs to a treatise devoted to explore what scientific knowledge consists in. Accordingly, T1 defines exactly the central notion Aristotle will be dealing with along the treatise. In contrast, T8 belongs to a treatise meant to be a kind of practical guide for dialectical reasoning. Furthermore, T8 does not define a central notion, but an auxiliary notion—a foil which will allow the reader to grasp the central notion in the *Topics*, i.e., the notion of dialectical argument, with more distinctness.

One might argue that the notion of *primary* premises includes some implicit allusion to the requirements that characterise scientific knowledge in the *APo*. The adjective "primary" (πρῶτον) is employed in a more generic way in several passages (cf. 71b21, 76a29), but in 72a5-6 it is associated with the notion of *appropriate principles*, which, from what has been said in 71b20-32, involves the notion of explanatory appropriateness.[37] However, this line of arguments is not promising. For, right in the next passage from the *Topics*, Aristotle elucidates what he means with the conjunction of the adjectives "true" and "primary", and what he says is this: "true and

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[36] The noun "ἀπόδειξις" (as well as the verb "ἀποδείκνυμι") is used in many ways in Aristotle (cf. *Rhetorics* 1355a5, 1396a33, 1403a15, 1417b21, 23, 1418a5; *Poetics*, 1450a7; 1450b11; 1456a37). See Barnes 1969, p. 138. But there is no doubt that, in T8, "ἀπόδειξις" is used with the force also found in *APo* I.2.

[37] For details, see Angioni 2012a, p. 12-23, 49-51.

primary are the items that are trustworthy in virtue of themselves but not due to something else" (100a30-b19). Now, this elucidation is far from being crystal clear, but one thing is certain—and is enough for my discussion. Aristotle does not associate the term "primary", in T8, to any characteristic that could be linked to the Causal Requirement in T1. Aristotle is employing "primary" in an epistemological way: the attitude and cognitive state of the person developing an argument is the rationale for calling a premise "primary" in this way. When Aristotle adds, a little further ahead, that "for the demonstrative principles, one need not ask the why" (100b19-20), he is not focusing on the explanatory power these principles would have for this or that explanandum; he is focusing instead on the fact that they bring by themselves the conviction about their truth, without requiring any further justification.[38] Aristotle has good reasons to employ the terms in this way in the *Topics*. For his aim is to characterize the kind of argument (namely, dialectical argument) in which the premises taken by the disputants are not taken because they seem true to them (even when they are indeed true), but because they are *endoxa*, namely, well accepted or acceptable to some group of people that turns out to be relevant for the dispute.[39] The most important item, for an argument to be dialectical, is this status of the premises. Within the limits of the dialectical dispute, the credentials of the premises stem from their being accepted or acceptable to some groups of people.[40] Dialectical arguments are confined within these limits—and this also gives Aristotle good reason to omit any reference to Requirement A in T8. (Had Aristotle referred to Requirement A in T8, his definition of dialectical argument could have implied, erroneously, that dialectical arguments, in contrast with demonstrations, could never engage in discussions about explanations or explanatory opinions.)

Besides, if Requirement B in T1 were to be understood in terms of B2 or B2*, the lack of reference to it in T8 would have been more surprising, for B2 or B2* would have given Aristotle an excellent foil to elaborate the contrast with dialectical arguments. We could have said then: "on the one hand, a syllogism is demonstrative when one knows that its propositions are necessarily true, whereas, on the other hand, a syllogism is dialectical when the propositions are

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[38] I disagree with Barnes 1981, p. 48: "the analysis of primitiveness at 100b18-21 implies […] explanatoriness […] and appropriateness is said to follow from explanatoriness".

[39] For details about this discussion, see Rapp 2018, p. 113-119; Frede 2012, p. 213-4; Smith 1997, p. xxiii, Mendonça 2014, p. 192-194; Mendonça 2015, p. 84-90. For a different view, see Reinhardt 2015.

[40] And this is why dialectical contenders can embrace (in different moments of the debate) contrary theses, whereas demonstration can only take what is true, *on the basis of its being true* (cf. 72a9-11).

assumed only because they are well accepted (or acceptable)".[41] Now, it is true that Aristotle's not having adopted this route in T8 does not prove anything about T1. But even so T8 adds some weight on my side, taken together with other passages in which Aristotle alludes to his notion of scientific knowledge or scientific demonstration.

Another important passage in the *Organon* is found in the *Sophistical Refutations*. Demonstrations, taken as expressions of scientific knowledge, are presented under the description of "didactic arguments":[42]

> ***T9:*** "Didactic arguments are those which deduce from the principles appropriate to each lesson, but not from the opinions of the answerer" (165b1-3, my translation).[43]

As in the beginning of the *Topics*, it is clear that Aristotle's concern is to highlight the contrast between different kind of arguments by means of the epistemic attitudes of those who are employing the arguments. But, differently from the *Topics*, the reference to appropriate principles in T9 connects with the notion of explanatory appropriateness as characterised in the *APo* (71b23, 72a5-6)—and it is uncontroversially clear that the notion of explanatory appropriateness presupposes Requirement A. In contrast, T9 does not make any allusion to Requirement B understood in terms of B2 (or B2*). Now, if my interpretation is right, the notion of appropriate principles can be understood as packing together both Requirements, A and B5.

Besides these passages from the *Organon*, there are relevant passages from the *Physics* and the *Metaphysics* in which Aristotle refers to his notion of scientific knowledge as defined in T1. We read the following in the beginning of the *Physics*:

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[41] Intepretations of dialectic that understand *endoxon* as "probable" would be even more tempted to take the contrast in modal terms (for criticisms of these interpretations, see Smith 1997, p. xxiii, Brunschwig 2002, p. 113-114; Barnes 1980, p. 498-502). Those interpretations would have even more difficulty in explaining the lack of reference to Requirement B in T8.

[42] Further ahead after T9, Aristotle makes it clear that he is talking about *scientific* demonstrations: "we have already spoken about demonstrative arguments in the *Analytics*" (165b8-9). See Barnes 1969, p. 140; Barnes 1981, p. 44; Hasper 2013, p. 289-291; Fait 2007, p. 105.

[43] I disagree with those who take "ἑκάστου μαθήματος" in 165b1 as "of each *discipline*". "Μάθημα" can also be taken as *lesson* either in the sense of a particular lesson (in which a bunch of theorems are conveyed to the learner) or in the sense of a particular theorem that one learner comes to learn. I prefer this last option, which makes 165b1 be together with many occurrences of "ἑκάστου/ ἕκαστον" (71b9, 75b38, 76a4, 27, 184a12, 194b18-19, 983a25, 996b19) referring to a particular explanandum within a given discipline.

> ***T10:*** "In all disciplines in which there is systematic knowledge of things with principles, causes, or elements, it arises from a grasp of those: we think we have knowledge of a thing when we have found its *primary* causes and principles, and followed it back to its elements." (184a10-14, Charlton's translation, my italics).

Aristotle's terminology in T10 might mislead some readers to wonder about subtleties involved in the differences of the verbs employed, "εἰδέναι", "ἐπίστασθαι" and "γινώσκειν". However—subtleties *à la Prodicus* aside—it is clear that Aristotle resumes his notion of scientific knowledge as defined in T1. Several passages employ "εἰδέναι" and "ἐπίστασθαι" as equivalent expressions—not only in the *APo* but in many other treatises.[44] If that were not enough, it is Aristotle himself who highlights the equivalence at the beginning of the *Physics*, if—as I take to be correct—the "καί" which connects them in T10 must be taken as epexegetic.

Given this preliminary remark about terminology, note that T10 alludes to the notion of scientific knowledge with a clear reference to Requirement A, but no reference to Requirement B. Having scientific knowledge of a given thing consists in acknowledging its (primary) causes and principles, but there is no allusion to the requirement of knowing that the propositions in question are necessarily true. One might object that the lack of any reference to Requirement B (taken in terms of B2) is more than natural, for the *Physics* (and natural science in general) deals with entities subject to change, so that the propositions about those entities are true only for the most part, but not necessarily. Now, this objection has many weaknesses, but I want to concentrate on one of them.[45] As we know, the domain of entities subject to change embraces almost all domains in which Aristotle has developed his scientific enterprises. Given that, why should we insist in (and start with) an interpretation of T1 that delivers a definition of scientific

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[44] For details about this issue, see Bronstein 2016, p. 18-21; Burnyeat 2011, p. 20-24. See Barnes 2014, p. 91 (although he takes T1 differently): "Among the different Greek verbs there are indeed differences of nuance or colour and differences in idiom so that in a given context one of the verbs may be more appropriate than the others. But there are no semantic differences, no differences in sense".

[45] For instance: it is precipitate to assume that all scientific propositions in the *Physics* are destined to be true *only for the most part*. Actually, this is false. *Physics* contains several propositions that Aristotle surely takes as necessarily true, as the propositions involving the chain of change leading to the Primary Mover (Book VIII), the consolidated definitions of infinite, time, place etc., as well as the thesis that any change requires an underlying subject. It is important to avoid conflation between the *Physics* and the treatises on natural sciences. But even the latter involve propositions that are necessarily true—at least several definitions are necessarily true. I do not see any evidence to deny that, for Aristotle, the proposition that (e.g.) sheep are blooded animals is necessarily true.

knowledge that turns out to be inadequate and incompatible with almost all scientific enterprises developed by Aristotle?

At this juncture, traditional interpretation has its usual stock of tales: Aristotle has changed his mind; the "*Posterior Analytics* formalism" has revealed incompatible with the more flexible notion of scientific knowledge stemming from Aristotle's empirical explorations, and so on.[46] However, there is no textual (or psychographed) evidence for this presumed change of mind. And the presumed incompatibility between the notion of scientific knowledge found in the *APo* and the scientific practices found in the biological treatises—an old clichê, very popular in past decades—is only a result of the inability to understand Aristotle's several discussions in their due contexts.[47] The definition of scientific knowledge in T1 works basically with the same characteristics found in T10. There is no explicit reference to Requirement B in T10. However, this lack of reference is not problematic, if Requirement B is understood in terms of B5. For, in this case, B5 consists in a more fine-grained specification of Requirement A, instead of being a completely different, additional requirement, about the necessary truth of the propositions involved in scientific knowledge. Thus, having scientific knowledge of *X* requires knowing what is the cause of *X*, and—to make the point clearer—requires knowing that this cause is *really* the cause of *X*, namely, this cause could never be a different one, for no other cause would explain *X* in the most appropriate way. On this perspective, it is clear how the definition of scientific knowledge in T1 was meant to work: Requirement A is, in *some* way, the main requirement, the one that can be employed as a *heading*, able to do the job in several contexts in which details are not needed and a generic characterisation is enough. Requirement B, far from adding a completely different condition, only specifies what kind of cause is required for having scientific knowledge.

Furthermore, it is important to note that T10 does not speak of causes in a generic way, but makes explicit reference to *primary* causes and *primary* principles. The term "primary" ("πρῶτον") is used in several ways (cf. 71b21, 26; 72a28, b5, 73b40, 74a11-13, 74b25, 75a36, 76a29, 76a32, 76b14), and I have already remarked that, in T8, it has an epistemological connotation that has nothing to do with the notion of explanatory appropriateness. However, in several contexts—

[46] The style is found in LeBlond 1939. But see also Barnes 1993, p. 92.

[47] Lennox 2001 is monumental against the alleged incompatibility. See also Angioni 2009c, p. 65.

some of which will be examined below—the term "primary" is used exactly to mark the notion of explanatory appropriateness (cf. 72a4-6) . Furthermore, applied to "cause" (cf. 78a25-6, b4) or "middle term" (cf. 99a25) or even with no noun attached to it (cf. 72a31, 74b25), "primary" picks up exactly the explanatory factor that delivers the most appropriate explanation. This being so, we can say that the explicit reference to *primary* causes and *primary* principles, in T10, retrieves precisely the Requirement B understood in terms of B5.[48] [49]

Further ahead in the *Physics*, we read thus:

> ***T11:*** "we think we have knowledge of a thing only when we grasp 'the why' [τὸ διὰ τί] about it, and that is to grasp the *primary* cause" (194b18-20, Charlton's translation modified, my italics).

Aristotle refers only to Requirement A, but not to Requirement B. Again, my argument could be objected with the same reasoning applicable to T7. Both in *Physics* II.3 and in *APo* II.11, Aristotle is basically concerned with his theory of the Four Causes, so that it is natural for him to refer to the notion of scientific knowledge only through Requirement A, omitting Requirement B.[50] But, in this case, this objection raises a discomfort. It is true that Aristotle's predominant concern with his theory of the Four Causes might explain the lack of any reference to Requirement B understood in terms of B2 (or B2*). However, the remark that modern editors put into parenthesis—"and this [*sc.* grasping the why of each thing] is to grasp the primary cause" (194b19-20)—is not well fitted into the objection's story. The adjective "primary" attached to "cause" is commonly used by Aristotle to indicate precisely that cause which, among others, is the most important and the most appropriate for the scientific explanation of a given explanandum.[51] On my interpretation, Aristotle is perfectly justified in emphasising the notion of *primary* cause in his reminder that retrieves the notion of scientific knowledge as defined in T1.

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[48] *Pace* Pellegrin 2002, p. 70, n1, and several others who follow the ancient commentators, as Ross 1936, p. 457.

[49] I suggest that something similar can be associated with the expression "up to the elements" at the end of T10, which can be taken as a way of stressing that the primary causes consist in the essential elements on which something depends to be what it is. Besides, in 84b22, Aristotle states that the elements of demonstrations are indemonstrable premises (on this, see Crager 2015, p. 52, 92, and a different opinion in Malink 2017, p. 173-186).

[50] There are differences between *Physics* II.3 and *APo* II.11 concerning the theory of the Four Causes, but they are irrelevant for my purposes here.

[51] See Angioni 2018, p. 164. Cf. note 28. About T11, it is noteworthy that Ross 1936, p. 512, takes the adjective "primary" with the force of "proximate", although he has a different opinion about T10.

For Requirement B, understood in terms of B5, specifies with more exactness that the cause required for scientific knowledge of each thing is precisely that cause which cannot be a different one—the cause fully appropriate to explain the explanandum in question or, in the terminology with which T11 refers to Requirement B, the *primary* cause.

Similar to T11 is the passage from the beginning of the *Metaphysics* which precedes the critical evaluation Aristotle is going to give of his predecessors about the first principles and the highest causes. This is what we read:

> ***T12:*** "Given that it is clear that we must come to know the causes that hold as principles (for we state that we know each thing precisely when we think we have spotted its *primary* cause)" (983a24-26, my translation, my italics).

Aristotle's reference to his notion of scientific knowledge in T12—as well as in T11—gives central weight to the notion of *primary* cause. Now, one might raise the following objection: there is no trace of the notion of primary cause in the official definition of scientific knowledge in T1; in contrast, T12 does not make any reference to the Necessity Requirement (i.e., Requirement B understood in terms of B2); therefore, T12 must be referring to another conception of scientific knowledge, different from the one found in the *APo* (perhaps developed in a lost treatise etc.).[52] But we should refrain from speculations with no exegetical evidence, especially when a better interpretation is perfectly defensible on the basis of the available evidence. As I said about T10 and T11, Aristotle's emphasis on the notion of *primary* cause in his reference to the notion of scientific knowledge (as defined in T1) is perfectly justified. For Requirement B, understood in terms of B5, only specifies with more exactness what cause is required for having scientific knowledge of each thing. Requirement A only states the condition of knowing that the cause of the explanandum in question is indeed its cause. Requirement B specifies (with more exactness) that scientific knowledge requires that cause which cannot be a different one in relation to the explanandum at stake—and, as Aristotle will cash out in the ensuing discussions in the *APo*, this cause is the cause fully appropriate to explain that explanandum or, in other terms, the *primary* cause. Thus, the progression from Requirement A to Requirement B5, as elements in the definiens stated in T1, is analogous to a progression in which we attempted to characterize

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[52] This style of argument is found in LeBlond 1939. I should emphasise that "*primary* cause" here has the same force as I attributed to it in T11 (*pace* Ross 1924, p. 126). See notes 34 and 50.

human beings by saying this: "a human being is an animal having feet; more precisely, a biped one". As we know, the information that human beings are animals that have feet is contained in the information that human beings are biped animals (cf. *Metaphysics* 1038a22-23). The progression from Requirement A to Requirement B5 is a step from a generic heading ("we need to know the cause") to a specification that takes the generic heading on its most essential point ("we need to know, more precisely, that the explanatory connection between that cause and its explanandum cannot be otherwise"). Therefore, employing the notion of *primary* cause to remind the reader about the definition of scientific knowledge has the same basic effect as employing Requirement B understood in terms of B5. Moreover—as I will explore below—if Requirement A is in a way contained in Requirement B5 (as *having feet* is contained in *biped*), it does not need to be explicitly mentioned, as this explains why sometimes Aristotle relies only on Requirement B5 to present his notion of scientific knowledge.

Another passage from the *Metaphysics* is the following:

> ***T13:*** "in other cases also (even in those of which there is demonstration) we think we know each thing when we know what it is, e.g. what squaring is, viz. that it is the finding of a mean; and similarly in all other cases." (996b18-22, my translation)

This passage should be taken with caution, for several reasons. First, we need caution because the passage is found in Book III of the *Metaphysics*, in a context in which Aristotle is developing *aporiai* concerning the nature and proper task of wisdom taken as the knowledge of the first principles and the highest causes. The development of *aporiai* in *Metaphysics* III sometimes counts with premises that do not correspond to any thesis embraced by Aristotle himself. Sometimes the premises are theses genuinely accepted by Aristotle, but many times they are only the premises needed for the formulation of the dilemma, giving support and some credibility to one of the sides of the difficulty. It would take me too long do discuss which is exactly the situation in T13. Secondly, the example involved in the passage seems to be the geometrical problem of squaring a figure (a circle?)—finding a proof that there is a square the area of which corresponds to the area of a given figure (circle?)—, which is too complex to be satisfactorily discussed within the limits of this paper.[53] Thirdly, T13 suggests that Aristotle has in mind a

[53] For the squaring of a circle, see Mueller 1982, p. 164; Dorion 1995, p. 288; Fait 2007, p. 155; Hasper 2013, p. 314-320. I have dealt with the issue in Angioni 2012b, p. 208-211; Angioni 2016, p. 100.

model of demonstration in which the most relevant explanatory role is played by the essence of the attribute to be explained, such that knowing *why X obtains* (*X* being an attribute) turns out to be equivalent to knowing *what X is*.[54] But, again, the discussion of this point would imply a series of other exegetical issues that would not fit here.

These three reasons ask for caution in the interpretation of T13. Even so, I submit that the fundamental premise involved in this passage does correspond, in fact, to a thesis accepted by Aristotle. At a first glance, the thesis does not seem to have any similarity with Requirements A and B found in the definition of scientific knowledge at T1. However, in Book II of the *APo*, Aristotle explicitly argues for the thesis that "the what-it-is is the same as the why-it-is" (90a14-15) and, further ahead, that "knowing what-it-is is the same as knowing the cause of being something" (93a4).[55] Aristotle proposes an equivalence between knowing the cause why a given subject is of such and such a quality (i.e., has this or that attribute) and knowing what something is (i.e., what the attribute is). This equivalence consists exactly in the core of the model of demonstration in which the most relevant explanatory role is played by the essence of the attribute to be explained.[56] And it is this equivalence that allows us to connect T13 to Aristotle's definition of scientific knowledge in T1. According to T13, having scientific knowledge about the squaring [e.g., of a circle] consists in knowing what that squaring exactly is. Now—if we follow the model presented in the Book II of the *APo* (especially in 90a14-15 and 93a4)—knowing what exactly the squaring of the circle is amounts to knowing what is the cause the makes the area of given circle correspond to the area of a square. This equivalence between knowing the cause and knowing the what-it-is makes it clear that T13 is also relying on the definition of scientific knowledge in T1. Thus, Requirement A requires knowing the cause by which the circle is squared; Requirement B (understood in terms of B5) requires a further specification, namely, that the cause at stake must be exactly that one which cannot be otherwise, namely, the cause that

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[54] To use the terminology found in Bronstein 2016, p. 48-50, it is the "Model 2" of scientific explanation (or, for Ferejohn 2013, p. 153, the "causal model" of demonstration). For discussion, see Angioni 2014a, p. 103-9; Zuppolini 2018b, p. 231-2.

[55] In 93a4, I prefer the reading "αἴτιον τοῦ τί ἐστι" (Bekker), instead of "αἴτιον τοῦ εἰ ἐστι" (Ross). In the expression at stake, "τί εστι" is not the typical question for the essence, given that the "τι" is not interrogative and actually refers to some non-essential attribute, as occurs in 90a3-4.

[56] For discussion, see Charles 2000, p. 198-213; Goldin 1996, p. 108-134; Bronstein 2016, p. 48-50; Angioni 2014b, p. 103-107; Zuppolini 2016, p. 202-203; Zuppolini 2017, p. 47-60; Zuppolini 2018b, p. 231-2, 243-245; Almeida 2017; Ferejohn 2013, p. 134-147.

furnishes the fully appropriate explanation of the squaring by stating what that squaring is and thereby grasping its essence.[57]

There is also a passage from Book VI of the *Metaphysics*, which is very informative:

> ***T14:*** "in general every science which is ratiocinative or at all involves reasoning deals with causes and principles, either more exact or more simplistic; but all these sciences mark off some particular being—some genus, and inquire into this, but not into being simpliciter nor qua being, nor do they offer any explanation of the what-it-is; but starting from the what-it-is—some making it plain to the senses, others assuming it as a hypothesis—they thus demonstrate, either more necessarily or more flexibly, what is attributed *per se* to the genus with which they deal." (1025b5-13, my translation, modified from Ross').

This passage is also full of exegetical issues that cannot be discussed in detail in this paper. I will select some points that are important for my present purposes. First of all, Aristotle refers to Requirement A, but does not seem to refer to Requirement B. Now, one might argue that the word "ἐπιστήμη" in 1025b6 does not refer to the notion of scientific knowledge, but is used with a broader scope. Indeed, it can be argued that the same word seems to be implied in 1025b21, as that to which the adjectives "πρακτική" ("devoted to action") and "ποιητική" ("productive" ou "devoted to craft production") are attached, so that the overall context of T14 must be taken as talking about three kinds of *knowledge* (theoretical, practical and productive) instead of three kinds of *sciences* in the strict sense of scientific knowledge. A similar terminological behaviour seems to be found again in 1026a22. On this picture, one might argue that the lack of reference to Requirement B is fully justified by the fact that "ἐπιστήμη" is being used in a more flexible way. For the Necessity Requirement, understood in terms of B2, does not seem to apply to practical knowledge, nor to the knowledge encoded in technical skills.

It would take me too far to discuss these issues in detail.[58] It is enough for my purposes to remark a few points. First, Aristotle's language in T14 mostly corresponds to the jargon employed in the *APo*—demonstrating the *per se* attributes (75a29-31, b1-2; 76b11-13) of a given *genus*

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[57] I will not discuss the Model 2 of scientific explanation (or demonstration). For discussion, see Zuppolini 2017, p. 181. To be honest, I believe that Model 2 is strictly speaking the only model, found even in Book I of the *APo* (see Angioni 2014a, p. 103-107, Angioni 2016, p. 150-152).

[58] For detailed discussion of the epistemic status of practical philosophy in Aristotle, see Karbowski 2019 and Henry 2015; for detailed discussion of the epistemic status of craft knowledge, see Aimar & Pavese (manuscript).

(74b25, 75a42, 76b12-13), positing *hypotheses* (72a20-24, 76b23-34) etc. The terminological similarity is not superficial. Aristotle seems to be really referring to his notion of demonstrative knowledge, which grasps the causes explaining why, within a determinate domain, a given subject has the attributes that pertain to it in itself. It is not persuasive to claim that T14 is not making reference to the notion of scientific knowledge as defined in T1 and as developed in the *APo* as a whole. After all, Aristotle starts T14 with a clear reference to Requirement A.

Furthermore, we should ask why Requirement B was not explicitly referred to in T14. A reference to Requirement B understood in terms of B2 would suit the passage very well, given that the ultimate aim of the whole chapter consists in presenting the science of being qua being as first philosophy, which deals with eternal beings (cf. 1026a10ff.). Indeed, the science of being qua being deals with objects that are stricly necessary and, thereby, involves propositions that are necessarily true (instead of being true only for the most part)—either if the object of that science is taken as the first mover (cf. 1026a17) or if its object is taken as being qua being in general (cf. 1026a31-32), which has (e.g.) the characteristic of being convertible with one (cf. 1003b22-25) and the property of not being subject to contradiction (cf. 1005a19ff.). On this picture, Requirement B would give Aristotle an extraordinary source from which to characterise the science of being qua being in a very informative way.

One might argue that the reference to Requirement B2 is found at the end of the passage, encoded in the expression "[they demonstrate] either more necessarily or more flexibly". However, this very expression—contrary to the expectations raised by a superficial reading—results in evidence *against* the traditional interpretation. The adjective "ἀναγκαιότερον", in comparative form, refers to something that is *more necessary* (in some sense of the expression), presumably in contrast with something that, being more flexible or resilient, is *less necessary*. However, the comparative form of the adjective does not make any sense if applied to the notion of necessity as understood in B2. I will dwell on this point for the next paragraphs.

Comparative forms are employed in (at least) two cases, each of which relies on a specific presupposition. The first cases relies on the presupposition that the attribute being compared in different subjects is really liable to variation in degree in a proper (non-metaphorical) way—as, for instance, in the case in which we say that "this plate is hotter than this cup". The second case, however, presupposes an attribute which, strictly speaking, does not admit variation in degrees, but works as a standard, in comparison to which the comparative forms of the adjective are

applied to things which, strictly speaking, do not have the attribute in question, but have something that tends to it and can be evaluated in how much it approaches the standard. This is the case in which one might say, for instance, that "parrots are more talkative than cats", or that "bees are more divine than gnats". In this case, there is some connected homonymy between the standard and the things to which the comparative forms are applied.[59]

First of all, it is crystal clear that the first case does not apply to the necessity of a predicative tie. For the necessity in a necessarily true predication is not such that would admit a variation in degree. It does not make sense to say that the proposition "2 + 2 = 4" is *more necessary* than the proposition "3 + 3 = 6", as well as it does not make sense to say that "humans are animals" is more necessary than "horses are animals". Besides—as I will explore below—the same is true for two other kinds of necessity, namely, the logical necessity by which conclusions follow from premises in deductions, and the explanatory necessity that, on my proposal, is the target in T1. Scientific knowledge requires that cause which is *the necessary one* for the most appropriate explanation, and there will be only one such cause for each explanandum. Thus, all three usages of "necessity" are on the same boat: the necessity of predicative ties, the necessity of logical consequence, and the necessity of the explanatory connections presented in a scientific demonstration. Therefore, we are left with the second case, in which the application of comparative forms is somehow metaphorical—it relies on the assumption that a given domain of items, even without having the attribute in question (strictly speaking), involves something similar to that attribute, so that the items in the domain can be mutually compared by taking that attribute as a standard.

In this perspective, one might insist that Aristotle's use of comparative forms, in T14, rests on a loose metaphor involving the necessity of predicative ties, as if he meant something like this: "they demonstrate either necessary propositions, which are true necessarily [= 'the *more necessary*'], or propositions that are true for the most part [= 'the *more flexible* and, thereby, *less necessary*']"—and this would count in favour of option B2* for Requirement B. However, there is a strong reason against taking those comparative expressions as evidence in favour of B2 or B2*. The comparative "ἀναγκαιότερον" has an *adverbial* force and modifies the verb "ἀποδεικνύουσιν",

[59] Thus, strictly speaking, neither parrots nor cats really *talk*, if *talking* is stricly understood as *employing articulate language to convey thoughts* (or something like that). However, parrots do something similar to talking, so that they can be taken as *more talkative* than other animals etc.

"demonstrate"[60]. Thus, what Aristotle is saying in T14 is not that *what is being demonstrated* (e.g., the content encoded in the conclusion) admits variation in the degree of necessity. He is saying, instead, that *the way in which* the demonstration is produced admits variation in degree.

In this case, it is impossible to refer the comparative adverb to the strictly *logical* operation made by the demonstration, for, in any demonstration, the *logical* passage from the premises to the conclusion is a entailment relation that does not admit variation of degree. The conclusion *necessarily* follows from the premises in any valid argument and, *a fortiori*, in any sound deduction, and this relation of logical consequence does not admit variation of degree.[61] Since every demonstration is a sound deduction (even in the biological disciplines that deal with what is true only for the most part), the comparative "ἀναγκαιότερον" in 1025b13 cannot be referring to a supposed variation in degree of the logical entailment of demonstrative conclusions.[62] For there is no such variation.

However, if Requirement B is understood in terms of B5, the comparative "ἀναγκαιότερον" in 1025b13 becomes perfectly intelligible. The explanatory relevance of a cause or explanatory factor is liable to be evaluated in degrees. Variation in degree (even if not precisely measured as in quantities) can be applied to the explanatory success of an explanation, but cannot be applied either to the deductive success of a demonstration or to the necessary truth of predications. If we have two sound deductions, there is no sense in comparing them as to the degree of being successful in entailing their conclusions, in other words, there is no sense in asking which of those conclusions follows *more necessarily* from its premises. Similarly, if we have two apodeictic sound deductions (in the sense in which "apodeictic" is employed in modal syllogistics), there is no sense in comparing them as to the (supposed) degree of necessity that

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[60] Cf. similar expression, with adverbial force, in *Rhetoric* II.6, 1396a33-b1.

[61] This also shows that option B3 cannot be correct as an answer to question Q2.

[62] Perhaps one might think that Aristotle does not take demonstrations in the domain of biology (in which predications are true only for the most part) as valid inferences, and one might insist that this is what he had in mind with "ἀναγκαιότερον etc." in 1025b13: there is *some sort of* variation in degree in the logical passage from premises to conclusions. First of all, if demonstrations with for the most part propositions were *not valid*, there will be no sense in using the comparative forms to compare them with valid deductions: we would be back to the first case of using comparative forms. Secondly, Aristotle's discussion in *APo* I.30 seems to assume that (e.g.) "every sheep has, *for the most part*, four legs" is, indeed, a logical consequence of the premises "every quadruped has, for the most part, four legs" and "every sheep is a quadruped". I will not disentangle the details here. For discussion, see Barnes 1982; Aimar & Pavese (forth.).

would apply to their respective conclusions, in other words, there is no sense in asking which of these predications is *more necessary* than the other.

In contrast, if we have two sound deductions attempting to explain the same explanandum, it makes sense to compare their explanatory success, or, in other words, to ask which pair of premises explains the explanandum with more success. Even when we do not target the same explanandum, or do not presuppose the same domain, it makes sense to compare the explanatory success of different explanatory attempts, for it makes sense to ask which of them explains its respective explanandum with more appropriateness. That comparisons of this kind are at stake is suggested by Aristotle's terminology in the beginning of T14, for he speaks of causes or principles that are "either more exact or more simplistic (or oversimplifying)" (ἢ ἀκριβεστέρας ἢ ἁπλουστέρας, 1025b7).[63] Thus, the explanatory success of demonstrations is liable to variation within a proper range. Demonstrations in general (i.e., demonstrative attempts) can capture either the more exact causes, or causes more generic, or even coarse causes. And this idea seems to be in harmony with the employment of "ἐπιστήμη" in a broader way in the context of T14. For practical knowledge as well as productive knowledge are by definition involved in explaining their objects, as much as possible, even if they are not on the same level as the most successful theoretical sciences.

Against this solution, one might still object the following. Even if the explanatory relevance of causes be liable to an evaluation in degrees, the definition of scientific knowledge in T1, in terms of B5, requires that the cause captured in a demonstration be the most relevant of all, namely, that cause which, being fully appropriate to its explanandum, cannot be otherwise. In other words: the possibility of evaluating the explanatory success of causes by degrees does not imply that the cause to be captured in a scientific demonstration be liable to such a scale. The objection has a correct element: the cause to be grasped in a scientific demonstration must be *the necessary one* for the most appropriate explanation, period. However, my solution does not depend on implying that an evaluation by degrees would apply to the cause that must be the necessary

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[63] It is common to find Aristotle using the adverb "simply" (ἁπλῶς) or cognate expressions to identify a flaw or failure. In *Sophistical Refutations* 176a39, "ἁπλῶς" is used in opposition to "διαιρούμενον": if the subject being discussed is complex and requires distinctions, it is wrong to talk in a *simple* way (if you do that, you are *oversimplifying* a complex subject). Cf. *Generation of Animals* 756b17; *Metaphysics* 987a21; *Ethica Nicomachea* 1104b25 (to refer to a oversimplifier rival theory), 1137b22 (to refer to the failure of the legislator in grasping details). Thus, "ἁπλουστέρας" in 1025b7—which is clearly in opposition to "more exact" or "more accurate"—, can be properly translated as "simplistic" or "oversimplifying".

one. When Aristotle applies the comparative "more necessarily" to demonstrations in T14, he does not abandon the idea that the cause to be captured in a scientific demonstration is not liable to degrees in its explanatory appropriateness: it must be *the necessary one*, period. But this does not prevent Aristotle from applying comparatives forms according to the second case discussed above. Thus, he applies the comparatives "more necessarily" and "more flexibly" to attempted demonstrations which, without bringing the necessary causes, period, are such that have their explanatory success evaluated in degrees—for, even without bringing the necessary causes, they involve the same kind of activity (namely, explaining) that aims at the standard and, therefore, can be evaluated according to the degree in which they approach the standard.

Furthermore, I stress that Aristotle's definition of scientific knowledge in T1 is normative, but not descriptive: Aristotle means that, ultimately and by the highest standard, only counts as scientific knowledge the demonstration that encapsulates the cause which is *the necessary one* for the most appropriate explanation. But Aristotle is aware that this norm is far from being satisfied in every attempt. Passages such as T5 show that Aristotle was perfectly aware of the difficulty in finding, and ascertaining, the exact cause that delivers the most appropriate explanation for each explanandum. While the standard is not yet fulfilled, he can surely describe scientific disciplines in the actual world as presenting demonstrations (i.e., demonstrative attempts) in which the explanandum in question is explained "either more necessarily or more flexibly".[64] And such a description is even more suited to the context of T14, which covers practical and productive disciplines, besides the theoretical ones.

5.b.2) Supposed evidence in favour of the traditional interpretation (*Ethica Nicomachea* VI):

Some passages are usually appealed to as evidence in favour of the traditional interpretation of the definition of scientific knowledge in T1: *Metaphysics* VII.15, 1039b27-1040a5; *Ethica Nicomachea* VI.1, 1139a6-14, VI.3, 1139b18-35. As I said, I will not discuss the *Metaphysics* passage. I will concentrate my discussion on the *Nicomachean Ethics* passages. In the probably most famous of them, we read thus:

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[64] On Aristotle's attitude about the possibility of progress in scientific disciplines, see *De Caelo* 287b28-288a2 (cf. *Metafísica* 993b11-19) and my discussion in Angioni 2010.

> ***T15:*** "What scientific knowledge [*episteme*] is will be clear from the following—if we need to put exact specifications and do not be carried away by similarities. We all think that that of which we have scientific knowledge cannot be otherwise. In contrast, it escapes our notice whether the things which can be otherwise hold or not, when we are not considering them. Therefore, the object of scientific knowledge is from necessity and, therefore, is eternal, for all things that are *simpliciter* from necessity are eternal, and eternal things are not liable to generation and corruption" (1139b18-24, my translation).[65]

The belief that T15 is strong evidence for taking Requirement B in terms of B2 (or, still, B1) is precipitate.[66] The precipitation seems to be favoured by the expressions we normally use in English (or another modern language), such as "object of scientific knowledge". In Greek, we have the verbal adjective "ἐπιστητόν", which is very flexible and vague by itself, as well as the equivalent expression Aristotle has employed before, "that of which we have scientific knowledge" (ὃ ἐπιστάμεθα). This is the crucial question we should ask: after all, what is, exactly, the item of which we have scientific knowledge? For instance, when we acquire scientific knowledge about the lunar eclipse's obtaining due to the interposition of the Earth, what is it, exactly, that we know scientifically?

Three answers are perfectly acceptable *at large*, and none of them by itself exclude the others. First, when we get scientific knowledge about the lunar eclipse's holding due to the interposition of the Earth, we can say that what we know scientifically (or that of which we have scientific knowledge) is the *lunar eclipse*, i.e., a state of affairs with propositional structure. Secondly, according to a different way of using the same expressions ("that of which we have scientific knowledge" [ὃ ἐπιστάμεθα], "the object of scientific knowledge" [ἐπιστητόν]), we can say that the object of our scientific knowledge is *the Moon*. Thirdly, according to another use of the same expressions, we can say that the object of our scientific knowledge is nothing else except the *explanatory connection* between the privation of light in the Moon (which we use to call "lunar eclipse") and the interposition of the Earth.

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[65] This translation is adapted from Angioni 2011b.

[66] But this is a common belief. See Barnes 2014, p. 93; Broadie & Rowe 2002, p. 365; Porchat 2001, p. 272-3. Scholars focused on the exegesis of the ethical treatises do not descry the possibility of a different, more fine-grained interpretation of Requirement B—even when they try to bridge the gap between ethics and science, as Henry 2015, p. 179, n18. For discussion of the gap, see Karbowski 2019, p. 64.

Each of the three answers can be adequate in a given context, and each of them responds to different aspects in which we can consider our knowledge. The first answer seems satisfactory in contexts in which we are concerned with certifying and justifying our cognitive states, or contexts in which we are focused on the propositional content of our knowledge as something different from mere acquaintance with singular objects. After establishing the appropriate cause of the lunar eclipse, we can say that we know, for sure, that the lunar eclipse is the case: for we have a justification that certifies us about the fact. On its turn, the second answer can be taken as satisfactory in contexts where the central concern is to map the subject-matters into their proper disciplines. Thus, saying (or highlighting) that we have scientific knowledge *about the Moon* is important if we wish to stress that that piece of knowledge belongs to the domain of astronomy but not to any other domain (we know something *about the Moon*, not about abstract objects), or if we wish to stress that, within the domain of astronomy, we are targeting the Moon, not any other celestial body. Finally, the third answer seems to be adequate in contexts in which the central concern is the appropriate explanation of a given explanandum. In this case, what we know is, exactly, the explanatory relation—we know *that the appropriate cause of the lunar eclipse is the interposition of the Earth* (following the pattern "we know that *this* is the cause of *that*", found in 71b10-12) or, in other words, we know that *it is because* the Earth is placed between the Sun and the Moon that the Moon undergoes the specific kind of privation of light that we identify as an eclipse (following the pattern "we know that it is because of *this cause* that the predicative tie in the explanandum obtains").

None of the three options by itself exclude the others as an acceptable way of describing the object of our knowledge. The preference for one option over the others can only be determined by contextual factors in each context in which the expression "object of scientific knowledge" or similar ones are employed. I will argue that the correct option for T15 is the third, but, before that, is it important to emphasise that *there is more than one option* to understand the thesis that the object of scientific knowledge is necessary. The traditional interpretation is not the only option—and is far from stemming crystal clear from the text.[67]

[67] The same treatment holds for other relevant occurrences of "ἐπιστητόν" (as in 73a22, 88b30, 982b31-b2, 996b13) or similar expressions (as in 71b15, 74b6). About "ἐπιστητόν" in *APo* I.33, see Angioni 2013a, p. 257-262, 266; Angioni 2019, p. 173-5, 191-5.

One might object that Aristotle's choice of the adjective "eternal" favours the traditional interpretation, for the adjective can only be applied, strictly speaking, to objects and (perhaps) to basic truths expressed in predications, but not to explanations, i.e., to explanatory relations between an explanandum and its explanans. But this objection is fragile. Aristotle's policies in employing expressions might sound strange to us. Some adjectives that might seem only appropriate to objects are equally applied to propositions by Aristotle—as the objection itself acknowledges. Now, once the border between objects and propositions is crossed, we should not be any more surprised by Aristotle's applying "eternal" (and similar expressions) to explanatory relations (or to the complex propositions that encode those relations).

Thus, in 75b22 (at least with some codices), the adjective "eternal" (ἀΐδιον) is applied to "conclusion" (συμπέρασμα).[68] In *Metaphysics* 1025a34 (cf. *Generation of Animals* 742b28), "ἀΐδιον" is applied to the relation between *per se* attributes and their proper subjects—and I stress that those relations are, exactly, taken as explananda in most demonstrations. Futhermore, in 75b27, the adjective "corruptible" (φθαρτή) is applied to "proposition" or "premise" (πρότασις), and it is not seldom that Aristotle refers to a necessarily true proposition with the adjective "ἀκίνητον", which means "not liable to change" (cf. 1052a4-7; 1222b23). Within a picture like this, there is no surprise in the employment of "eternal" to characterise the relation between an explanans and its explanandum—and this employment does not depend on the modal status of the basic predications involved in the explanation. Strictly speaking, the adverb "always" (ἀεί) in 75b34 is directly applied to *demonstrations* in such a way that suggests that, although particular lunar eclipses are phenomena occurring only *many times*, the causal-explanatory relation underlying them is *eternal*—for it holds always.[69] As we know, it is not always that a sheep is born with four legs. Nonetheless, this does not prevent the explanatory connection between *having four legs (for the most part)* and *being a blooded animal of such and such a kind* from being eternal or necessary. Furthermore, Aristotle applies the adjective "eternal" to *causes* in *Metaphysics* 1026a17. At first, he seems to be talking about the First Mover—an "object", at least as this expression is employed as opposed to propositions. But, as Aristotle applies the same adjective in general to *all* causes

[68] See Angioni 2009a, p. 85-86, for discussion of other reading found in the codices.

[69] See Angioni 2009a, p. 75-82.

involved in the context, he seems to have in mind the causes or explanatory connections studied in mathematics and natural sciences too.[70]

There are many other issues about T15, but the passage that immediately follows it is even more important for my purposes. This is what we read:

> ***T16:*** "Furthermore, it is agreed that every scientific knowledge is teachable, and that the object of scientific knowledge is learnable. As we said in the *Analytics*, every learning proceeds from items previously known, sometimes by induction, sometimes on the basis of syllogism. Now, induction too is a principle for universals, whereas syllogisms proceeds from universals. Therefore, there are principles, from which the syllogism proceeds, of which there is no syllogism. Therefore, there is induction for them. Thus, scientific knowledge is a an aptness to demonstrate, and all the things we have additionally stated in the *Analytics*. Indeed, one has scientific knowledge when one has a conviction of a given kind, i.e., when the principles are known to him. For, if the principles were not more known to him than the conclusion, he would only have knowledge on the basis of a concomitant factor." (1139b25-35, my translation).

Just some lines earlier, T15 could have given the impression that Aristotle was relying on a different definition of scientific knowledge, in which Requirement B would take center stage and do all the job, with no reference to Requirement A. However, that is a wrong impression. Now, in T16—which continuously follows after T15—Requirement A recovers its central place and makes it clear that Aristotle resumes his definition of scientific knowledge in T1. I will highlight four points about T16: (i) Aristotle fully acknowledges the superior authoritativeness of the *Analytics* for the subject in question, and his acknowledgement makes it clear that his brief characterisation of scientific knowledge in the *Nicomachean Ethics* only selects some features that are important for his concerns in this context; (ii) the characterisation of scientific knowledge as *teachable* retrieves, even if indirectly, Requirement A; (iii) the harmony with the definition of scientific knowledge in T1 is clear even from some features that are absent in T1 (or in the *Analytics* as a whole) and are highlighted in T16 due to the specific concerns in the *Ethics*; (iv) the

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[70] Besides, the verb "passing-away" (φθείρεσθαι) is applied to "middle term" (μέσον) in 74b34. The argument is obscure and hard to decode (cf. Barnes 1993, p. 127-8), but what concerns me is that the verb is applied exactly to the term that encodes the explanatory factor (cf. 90a5-14, 75a12-14, 35-37, 76a8-9, 78a31ss.). Whatever is the detail of the discussion in 74b32-39, Aristotle is presupposing that, at least on normal conditions, the middle term, which expresses the cause, must be *eternal*, for, if it passed away, there would be no scientific knowledge (presumably of the explanandum in question – πρᾶγμα, 74b33, 36). Aristotle might be talking about the object itself which comes to work as middle term (thus, the object itself must be eternal). But I suggest that Aristotle is talking about that object, not in itself, but exactly as the explanatory factor for a given explanandum: the idea is that *its explanatory role* for that explanandum is eternal (no matter if the object itself is eternal or not).

way in which Requirement A is depicted in T16 confirms that the better interpretation of Requirement B is in terms of B5.

(i) Aristotle's two explicit references to the *Analytics*—"as we said in the *Analytics*" (1139b26-27), "all the things we have additionally stated in the *Analytics*" (1139b32-33)—but, most of all, the latter, make it perfectly clear that, for him, the treatise with more authority over the subject "scientific knowledge" is not the *Nicomachean Ethics*, but the *Analytics*. It is clear that the discussion in the *Ethics* only recalls some features, which turn out to be more important for the its concerns, and refers the reader to the *Analytics* for a more detailed and accurate characterisation of scientific knowledge.[71] Thus, it should strikes us as surprising and unjustified any exegetical strategy that inverts the situation, I mean, any strategy prone to take the characterisation found in the *Ethics* as a decisive criterion to decipher what is said in the *Analytics*. For it is rather the opposite strategy that should be adopted: it is rather the *Analytics* that sheds a light on the brief characterisation of scientific knowledge in the *Ethics*.

(ii) In the beginning ot T16, scientific knowledge is characterised as *teachable*. In order to note that this characterisation retrieves Requirement A from T1, an important connection is T9 (*Sophistical Refutations* 165b1-3). In T9, Aristotle says that "didactic arguments are those which deduce from the principles appropriate to each lesson". Teaching, for Aristotle—or at least in the relevant contexts that concern us here—does not consist in merely transmitting a set of true propositions about a given subject, not even if that set of propositions is articulated on the basis of merely deductive (but not explanatory) relations. Teaching, for Aristotle, consists in explaining the why, "from the principles appropriate to each thing". This concept of teaching does not come as a surprise for the careful reader. The same concept is prominent in *Metaphysic* I.1-2 (982a12-14, 28-30) and other passages (*Rhetorics* 1355a26; also, in some degree, *Sophistical Refutations* 184a1-7).

Besides, the context suggests that, in the sentence "the object of scientific knowledge is learnable"—in Greek, "καὶ τὸ ἐπιστητὸν μαθητόν" (1139b25-26)—the expression "the object of scientific knowledge" refers to the explanatory relation between a cause and its *pragma*. For the most important thing in learning is to grasp the causes, as well as the most important thing in teaching is to show the explanatory relations. Thus, I submit that, in this context, the expression

[71] Something similar occurs in *Ethica Eudemia* 1222b37-41.

"the object of scientific knowledge" could hardly be taken as referring to the object Moon (taking up my previous examples). Indeed, that the Moon exists or that the Moon is the referent of the term "Moon" are not things to be specifically teached and learned through a scientific discipline; instead, they are basic facts with which we are already acquainted in pre-scientific stages of our knowledge. But my point in even simpler than that: it is just that it does not make much sense to say that "I have learned the Moon". Similarly, given that teaching involves, precisely, identifying the causes of phenomena which are already encoded in true propositions, it is a natural step to infer that the the object of scientific knowledge (ἐπιστητόν), i.e., that which one learns (τὸ μαθητόν) when a teacher teaches us a discipline, also involves, importantly, the explanations that identify the causes. What do we learn, after all? We do learn *not only* that it is true that the Moon undergoes the privation of light identified as an eclipse, *but also*, and *more importantly*, that the Moon undergoes that privation of light *due to the interposition of the Earth*. Similarly, when we learn geometry, we learn *not only* that the sentence "every triangle has 2R" is a necessary truth; we *also* learn, and *more importantly*, that every triangle has 2R *because* the essence of the items involved is such and such (74a25-32ff.). The most important item, in what we learn, is the explanatory connection (which, indeed, presupposes and *involves* the basic propositions related in the explanation).

(iii) The characterisation of scientific knowledge in the *Ethics* works with two other features (besides being teachable) that are not prominent in the *Analytics*—first, that scientific knowledge is an aptness (ἕξις), i.e., a capacity or competence, consolidated by appropriate training and practice (or, if we prefer the empty and deflated sense that tradition attributes to "ἕξις", a *state of mind*);[72] secondly, that scientific knowledge requires a greater belief or conviction in the principles on which the conclusions depend. Now, the latter feature is found in the *Analytics* (72a25-b4), but watered down among several others, and the fact that T16 selects this feature instead of others can be understood from the specific concerns in the *Ethics*. For the concern with describing the notion of scientific knowledge in the *Ethics* is subordinated to the major concern of characterising *phronesis* as one of the rational virtues by which we are able to attain the truth (cf. 1139b14-18). In Book II of the *Ethics*, Aristotle has depicted character virtue as an aptness (ἕξις) belonging to the

[72] I defended the interpretation of "*hexis*" (in the *Ethics* context) as a capability or competence, consolidated by appropriate training, in Angioni 2009b, p.6-9, and Angioni 2011a, p. 307, 319.

non-rational part of the soul.[73] In Book VI, Aristotle keeps the same notion of aptness (ἕξις) to characterise the rational virtues.[74] Within such a framework, it is natural for him to say that also scientific knowledge is an aptness (ἕξις)—in this case, a consolidated competence to *demonstrate*,[75] or, in terms of T1, to explain a given explanandum through a causal relation that cannot be otherwise. Furthermore, the emphasis on an epistemological requirement for scientific knowledge —namely, the greater conviction in the principles on which demonstrations depend—is also natural in the *Ethics* context. For, given the main interest in highlighting both differences and similarities between scientific knowledge and *phronesis*, it is convenient to highlight the epistemological attitudes on which the success of both those competences depends—that is, the success of scientific knowledge in demonstrating and the success of *phronesis* in guiding our agency and leading to fully virtuous actions (cf. 1139a17-18ff.).

Moreover, the way in which this epistemological requirement is treated in the *Analytics* refers, again, to Requirement A. For both having a greater conviction in the principles on which depends the conclusion of a demonstration, and having *more* knowledge of them (or knowing them *more*), after all, consist in ascertaining that those principles capture the cause (i.e., the appropriate explanatory factor) of what the conclusion encodes (cf. 72a27-32). It it *because* the principles capture the cause that appropriately explains the conclusion *that* we can say that we have *more* knowledge of them (or know them *more*) and *more* conviction in them.[76]

(iv) Futhermore, the way in which T16 explicitly justifies the epistemological condition just mentioned (namely, having a greater conviction about the principles on which conclusions depend) also confirms the agreement with T1. At the end of T16, Aristotle remarks that "if the principles were not more known to someone than the conclusion, one will have knowledge only on the basis of a concomitant factor [κατὰ συμβεβηκός]" (1139b34-35). As I highlighted in my remarks at (iii), what makes someone have "more knowledge" of the principles of a demonstration is the acknowledgement that these principles capture the appropriate cause of

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[73] In both treatises (for book VI is a common book): *Ethica Nicomachea* 1103b22, 31; 1104b19; 1106a12, 14, 22; b35; *Ethica Eudemia* 1218b38; 1219a6, 12, 18, 31-33; 1220b29; 1222a6.

[74] Cf. 1140a4, 5, 7, 9, 10; 1140b5, 20.

[75] Adjectives attached to *hexis* in 1139a22-23 (cf. 1140a4, 7-10, 20-22; 1140b5, 20-21) refer to the actions and activities *for which* the *hexis* in question is an aptness consolidated by exercise and training. Thus, *hexis apodeiktike* is a capacity or aptness to *demonstrate*, and so on.

[76] I argue for this point in Angioni 2012a, p. 37-42. For discussion of 72a37-b4, see Bronstein 2016, p. 35.

what the conclusion encodes. Thus, if someone fails at having more knowledge of the principles than of the conclusion, it is (according to 72a27-32) because the premises he has selected as principles do not capture the appropriate cause. One who fails at having more knowledge of his principles has selected as cause something which, from the explanatory standpoint, is a mere concomitant factor that "comes together" with the explanandum without explaining it in the most appropriate way. Elsewhere, I have explained in detail that "having knowledge [of a given explanandum] on the basis of a concomitant factor" (ἐπίστασθαι/ ἐπιστήμη κατὰ συμβεβηκός) means, in the appropriate contexts (such as T1, T16 and 76a4-6, connected to T5), explaining a given explanandum on the basis of a given feature that, even being necessarily true of the subject in question (or even being essential to the subject in question), does not capture what is most important to explain the explanandum in the most appropriate way and, from an explanatory standpoint, only "accompanies" or "comes together" with the explanandum.[77] It is precisely this point that is retrieved at the end of T16. Now, attempting to make sense of T16 without a careful understanding of the *Analytics* might lead to wrong interpretations, such as the attempt to understand the expression "κατὰ συμβεβηκός" as if it ranged over the ascription of knowledge to the knowing person. This mistake is made easier by translating "κατὰ συμβεβηκός" as "accidentally". However, in 1139b35—as well as in the relevant occurrences within the *APo*, like 71b9, 28, 74b11-12, 76a2, 4, 99a3— "κατὰ συμβεβηκός" is used with causal-explanatory force and comments over the explanatory attempt *qua* explanatory: first, "κατὰ + accusative" has a causal-explanatory force in these contexts, and, secondly, "συμβεβηκός" refers to items that, from an explanatory standpoint, only come together with (or accompany) the explanandum without capturing the most important factor to explain it in the most appropriate way. For these reasons, what is exactly encoded in the use of "κατὰ συμβεβηκός" in these contexts is much better translated as "on the basis of a concomitant factor" or "on the basis of a concomitant feature".

My next passage is previous to T16 in the order of Aristotle's text, but it will suit me as the last step in my discussion. It reads thus:

> ***T17:*** "Consider that the parts [*sc*. of the soul] that possess reason are two: one is that by which we know the kind of beings *the principles of which* cannot be otherwise; the

[77] See Angioni 2016, p. 91-102; Angioni 2012b, p. 209-213; (Angioni 2007, p. 16).

other part is that by which we know the things that can be otherwise."[78] (1139a6-8, my translation and italics).

The crucial element in this passage consists in the description of the part of the soul to which belongs scientific knowledge: "that by which we know the kind of beings *the principles of which* cannot be otherwise" (1139a6-8). Attention: Aristotle has not said "that by which we know *the kind of beings* that cannot be otherwise". Aristotle's phrasing makes it clear that the point he is concerned with stressing here is, precisely, that *the principles* of those beings cannot be otherwise.

One can say that those principles cannot be otherwise either because they have an eternal and necessary existence (e.g., in the case in which "principles" refers to objects such as god and the celestial spheres, cf. "eternal causes" in 1026a17), or because all propositions serving as principles in scientific knowledge are necessarily true propositions. This is tantamount to taking the Necessity Requirement, in T1 and T17, in terms of B1 and B2 respectively, as the tradition has done. However, there are many troubles with this kind of interpretation. First, as I have been arguing, both options (B1 and B2) are insufficient or even erroneous to characterise scientific knowledge. It would be surprising if Aristotle had selected one of those options—that the propositions are necessary (B2), or that the objects are eternal (B1)—to refer to the notion of scientific knowledge. Indeed, one might know the definition of triangle, and know that it is a necessarily true proposition, while ignoring how it explains the attribute 2R of every triangle.[79] It would be absurd to say that one in such a cognitive state has scientific knowledge of the 2R theorem and know the scientific principles *as* principles. Besides, as I have already argued with a special focus on T4, if Requirement B is taken according to option B2, it delivers a thesis that is not only false but also embarassing.

Furthermore, there is an issue about Aristotle's motivation for having said *exactly* what he has said in T17. Take the domain of geometry, for instance. Within this domain, *all* propositions —including the theorems to be demonstrated—cannot be otherwise, if the expression "cannot be otherwise" is taken in terms of B2, as equivalent to "being a necessarily true proposition". Being

[78] Reading Bekker's text. Further ahead, I comment the conjecture in Irwin 1999.

[79] See Bronstein 2016, p. 39.

so, for what reason would Aristotle select exclusively *the principles* (instead of *all propositions*) as bearer of the predicate "cannot be otherwise"?[80]

It is clear that, within the context of the *Ethics*, the motivation for saying that *the principles* cannot be otherwise is due to the interest in highlighting that the other part of the soul, which controls agency, deals with *things and principles* that can be otherwise (cf. *Ethica Eudemia* 1222b41-42ss.; *Ethica Nicomachea* 1112a21ss.). This point is made clear in Irwin's translation ("with the other we study beings *whose principles* admit of being otherwise"), which conjectures "τὰ ὧν ἐνδέχονται" instead of the options found in the codices in 1139a8 (cf. Irwin 1999, p. 239). But, as I will argue below, the intepretation of T17 in terms of B5 allows us to understand Aristotle's motivation in a more satisfactory and coherent way.

But before developing this point, let me address still another trouble. If T17 is understood according to option B2, it results in a strange anatomy of the rational soul: Aristotle would be saying that, on the one hand, one part of the soul is able to have scientific knowledge of *necessary* truths (which will include—considering the disciplines as a whole—only mathematics, cosmology and theology) but, on the other hand, another part of the soul is able to have knowledge of *non-necessary* truths—and this will lead Aristotle to heap together in the second part of the soul items so diverse as the biological disciplines and our practical knowledge, for both deal with propositions that are true only for the most part. Now, as Irwin remarks about contingent items, "in fact not all these states of affairs are matters of rational calculation and deliberation, as 1112a26-b9 makes clear" (Irwin 1999, p. 239). Thus, the division of the rational soul in T17 seems to result in an implausible butchering. One might be tempted to avoid this trouble with smuggling the 'for-the-most-part' truths to the domain of the first part of the soul. This is what option B2* would do. One might then say that every natural science, strictly speaking, deals with "patterns which in individual cases are necessary-unless-something-interferes".[81]

In contrast, the interpretation I propose avoids both the imprecision Irwin has noted and the smuggling in the anatomy of the rational soul. (It has still other exegetical advantages, as I will highlight further ahead). First of all, let us take for granted that Aristotle's twofold division of

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[80] See Broadie & Rowe 2002, p. 361: "things whose principles are necessary are themselves necessary". True. But why does Aristotle put a stress on the *principles*? Besides: does Aristotle's main concern range over (i) the necessary character of the things themselves which happen to be principles, (ii) or over the explanatory relation between principles and explananda, (iii) or over both?

[81] Broadie & Rowe 2002, p. 361.

the rational soul in T17 seems to be motivated by the concern of spotting the main differences between scientific knowledge and *phronesis* and, more importantly, by the concern of highlighting what is most characteristic of *phronesis*. Now, on options B2 or B2*, the contrast between the two parts of the soul would only highlight the contingency and voluntariness of actions in a too generic way: it is up to a rational agent to do or not to do Φ, etc. Now, I do not deny that reminding us about that feature of rational agency (namely, its contingency due to the openness to contraries) can play an important part in Aristotle's discussion about *phronesis* (in the large context of T17). My point is that the characterisation of *phronesis* as a rational virtue that contributes to the full success of moral action will be stronger and more enlightening, if other features of it come to be highlighted. Now, I submit that the intepretation of Requirement B in terms of B5 will furnish us a picture much more enlightening and coherent about *phronesis*.

Let ϕ be a given action, which is in the power of a given agent to do or not to do. Suppose that ϕ is a virtuous action at least in its external aspects (e.g., an action that an external observer can describe with the sentence "she paid her debts"). In order to characterise *phronesis* and its connection with character virtues, one important issue is that there is a series of different reasons why ϕ can be done: ϕ can be done by shame (and fear of bad reputation); by fear of the penalty imposed by law; from calculation of the material advantages that would ensue its being done; because a friend has recommended ϕ-ing (although the agent has not exactly understood why); because the intrinsec moral value of ϕ has been fully acknowledged, and so on. Now, all these reasons belong to the set of possible answers to the question: "what is the cause that has led agent *A* to do ϕ?" Now, consider that, in such a situation, the following statements are true:

(i) ϕ is contingent, for the agent can indifferently do or not do ϕ.

(i*) the agent's agency itself—as the cause that makes ϕ occur—can be said to be contingent, in the sense that it can be or indifferently not be the cause that makes ϕ occur. (In other words, *A*'s agency counts as a *contingent principle* of the action).

(ii) The specific causes (in the domain of *A*'s agency) by which ϕ can occur are many (i.e., from my previous examples, shame, fear of penalty, respect for a friend's opinion etc.)—in other words, ϕ can be done from a variety of *different principles* of action within the agent.

Now, the interpretation of T17 in terms of B2 (or B2*) captures only the statement (i) and its counterpart (i*). However, statement (ii) seems to have more relevance in the context of T17. It is clear that virtuous actions virtuously done requires the right cause within the agent (cf.

1105a28-33, 1144a13-20). If *phronesis* is a rational virtue that (in some way or another) contributes for virtuous actions being virtuously done, it is clear that it contributes in determining the correct cause in the agent. Thus, in order to highlight the contribution of *phronesis* for this achievement (namely, virtuous actions virtuously done), it is much more enlightening to highlight statement (ii) than statements (i) and (i*). In other words, it is much more enlightening in this context to stress that the principles or causes by which ϕ can be done are *many and multifarious* than to stress that ϕ is contingent and that the agent, consequently, is voluntary. Besides, statements (i) and (i*) seems to follow from statement (ii), but not vice-versa.

It is not my aim to go into details in the controversies about *phronesis* and its role in controlling moral character.[82] However, as some might reject the premise that *phronesis* contributes in determining the correct cause of virtuous actions being virtuously done—i.e., one might say that *phronesis* has nothing to do with responding to the right motivation and rejecting the wrong ones, like shame, material advantages etc.—I can furnish a different option for taking my central point about T17. Let us assume the premise that *phronesis*, which surely involves an excellence in deliberation, contributes to specifying, concretely, what exactly the achievement of a virtuous purpose consists in within a singular circumstance.[83] Let *P* be a given moral purpose, which gives a *general policy* about how the agent must accomplish, virtuously, virtuous actions in each appropriate singular circumstance—for instance, let *P* corresponds to the purpose of enjoying the pleasures of drinking as I should. Now, there is a big gap between, on the one hand, *P* (as a *general* purpose) and, on the other hand, a particular action of the *P*-type that fully accomplishes what was encoded in the purpose *P*. As we know, this gap is due to the indeterminacy of several relevant factors involved in each singular circumstance. Thus, it is possible for the same moral purpose *P* to end up becoming more specified purposes, *P1* and *P2*, which are very different from each other—e.g., in the sense that the "as I should" clause will be fulfilled in very different ways. Suppose, thus, that *P1* recommeds the agent to drink a little bit more than her usual limit, for the sake of a specific circumstance, whereas *P2* recommeds her to drink less than usual, due to different complexities of another circunstances. Given that it is incumbent on *phronesis* to evaluate

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[82] My view on these subjects is found in Angioni 2011a. For recent discussions, see Lorenz 2009, Coope 2012; Moss 2011 and Moss 2014.

[83] The ensuing paragraphs presuppose some theses and discussions that can be tracked in Angioni 2011a. The word "purpose" is my option to translate "προαίρεσις". See Angioni 2011a, p. 310-313.

the moral importance of the particular factors involved in each circunstance, it is clear that *phronesis* will have an important role in settling *P1* and *P2* as more specific purposes suited to particular circumstances—and those specific purposes turn out to be principles or causes (cf. 1139a31) from which concrete actions that satisfatorily instantiate virtuous actions of type ϕ proceed.

Now, on either of the two perspectives depicted above—without going into discussion about which of them (if any, or both) is preferable as an intepretation of *phronesis* and its role in virtuous actions—I stress that the relation between *principle* and *action* (i.e., action taken as that of which the principle is a principle) is not a one-to-one relation. On the contrary. Things are as statement (ii) has them (with a small reformulation):

(ii) The specific causes (in the domain of *A*'s agency) by which ϕ can occur are many (i.e., shame, fear of penalty, respect for a friend's opinion etc.; or, in the second scenario, *P1*, *P2*…*Pn*) —in other words, ϕ can obtain from a variety of *different principles* of action within the agent.

Thus, the principles of action can be otherwise not only in the generic sense that they can occur or not occur etc., but also, and more importantly, in the sense that they include a wide range of options. In the first scenario, Aristotle would be highlighting that an action ϕ is such that its principles can be multifarious, so that it is incumbent on *phronesis* to select (or at least to contribute in selecting) the correct principle that will deliver the goods, namely, a virtuous action virtuously done. In the second scenario, Aristotle would be highlighting that a fully virtuous action of ϕ-type is such that its principle can be different in a different circumstance, for instance, P1 or P2—each of which will turn out to be appropriate in different circumstances.

Thus, Aristotle's motivation to select, specifically, the *principles* as bearer of the predicate "cannot be otherwise" in T17 turns out to be much more coherent and interesting. What is going on in T17 is similar to what is found in T4: the expression "principles", as subject of the predicate "cannot be otherwise", refers to those items that are principles (namely, propositions), but not taken in themselves independently of the explanatory role they play as principles of a given explanandum. On the contrary: "principles", as subject of the predicate "cannot be otherwise" in T17, refers to those items *exactly as they play the role of explanatory principles for a given explanandum*. In this perspective, saying that the principles cannot be otherwise is far from collapsing into the statement that those principles are themselves necessarily true propositions, or necessary beings. Even if those principles are, sometimes, necessarily true propositions (as,

indeed, in mathematics), what Aristotle means to encode in T17 is something different—is the idea that, for each of those principles, the explanatory relation between the principle and its explanandum cannot be otherwise. Thus—employing "*B*" for the cause and "*AC*" for its explanandum with predicative structure—what cannot be otherwise is *B's being the cause of its explanandum AC*, for instance, the interposition of the Earth between the Sun and the Moon (*B*) being the cause of the lunar eclipse (*AC*). Thus, the principle of the explanandum *lunar eclipse* cannot be otherwise: it cannot be a different factor.[84]

In contrast, the other part of the rational soul identified in 1139a8 deals with causal-explanatory relations in which that same description cannot be applied. The principle of an action ϕ can be otherwise: it can be shame, fear etc. The principle of a virtuous action virtuously done of ϕ-type can be otherwise: it can be purpose *P1* or purpose *P2* etc. To be sure, most of the elemental propositions involved in those causal-explanatory relations are not even themselves necessarily true. But this is not the most important point Aristotle highlights in T17. For, in the domain of natural sciences, elemental propositions are themselves true only for the most part (but not necessarily), but, even so, the explanatory relations cannot be otherwise. It is only for the most part true that sheep have four legs. However, this feature of sheep is explained by a more basic property of theirs, such as being a blooded animal with such and such characteristics. This explanatory relation—between having four legs for the most part and being a blooded animal with such and such characteristics—is such that cannot be otherwise. Therefore, the principles on the basis of which sheep have, normally (or for the most part), four legs are such that "they cannot be otherwise" within this explanatory relation. Thus, biological sciences can be lodged in the same part of the soul alongside with mathematics—apart from practical knowledge—, with no need of smuggling them.[85]

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[84] The same holds for the 2R attribute: the principle of the explanandum 2R-belonging-to-its-proper-subject (taken as what it exactly is, cf. 75b38, 76a6) cannot be otherwise.

[85] I am assuming that the kind of cognition properly attributed to the second part of the rational soul (the part that deals with contingent things, the principles of which can be otherwise) is, in the context of T17, pratical knowledge in strict sense: the knowledge that an agent assembles in order to determine what must be done and in order to do it in each concrete circumstance. It is important to stress that there is a difference between this practical knowledge present in each agent and the philosophical enterprise Aristotle develops in his *Ethics.* A significant part of the content of both *Ethics* can perfectly well be taken as belonging to the first part of the rational soul, together with mathematics and natural sciences. At the general level which is enough for the theories developed in the *Ethics*, the explanatory appropriateness of some principles is not so different from what is found in the natural sciences. For discussion, see Karbowski 2019, Henry 2015, p. 177-188.

An action ϕ (i.e., a virtuous action on its external aspects) is something that Aristotle takes to be contingent: ϕ can occur or not occur. Now, ϕ can be done due to a range of different principles or causes: shame, fear of penalty, or deep acknowledgement of its moral value, etc. It is only in this last case that ϕ counts as a full-fledged virtuous action *virtuously done*. But the important point Aristotle makes in T17 is that the relation between ϕ and the principles that can realize ϕ is such that "the principles can be otherwise", and it is incumbent on *phronesis* to select the correct principle. A similar story applies in the second scenario I have suggested. The general purpose on the basis of which the agent acknowledges the intrinsic moral value of actions of ϕ-type can also be multiplied in a variety of more specific purposes, each of them suited to particular circumstances (think of my previous example about specifying the purpose of enjoying drink pleasures as you should). In this way too, the principle of a virtuous action of ϕ-type is such that it can be otherwise: different principles (which have been differently specified, as *P1* and *P2*) can realise an action of ϕ-type in different circumstances.

Discussions about the voluntariness of actions highlight statement (i), relying on the thesis that actions are themselves contingent items in the world. Discussions about *phronesis* also rely on the voluntariness of actions, but remotely, inasmuch as *phronesis* presupposes rational agency in general. Now, specific discussions about *phronesis* as a rational virtue that contributes to virtuous actions being virtuously done—as the discussions found in the broader context of T15-T17—become much more enlightening if focused on statement (ii): the principle of an action ϕ is such that *it can be otherwise* in the sense that the causal-explanatory relation between actions and the principles that realise them is open to a wide range of options, and *phronesis* (in either of the scenarios above offered) is required to select or specify, among the wide range of possible principles, the correct one.

6. Conclusion:

T17 is in perfect harmony with the definition of scientific knowledge in T1 when it emphasises that *the principles* of scientific knowledge cannot be otherwise. The Necessity Requirement in T17 must be understood as B5, in terms of explanatory appropriateness. On this point, T17 is not different from any of the other passages I have considered. For, in all them,

Aristotle's reference to his notion of scientific knowledge proves to be in complete harmony with his definition in T1.

Barnes (1993, p. 92) has suggested that the definition of scientific knowledge in T1 was the result of an unhappy juxtaposition of two disconnected parts.[86] On Barnes's suggestion, Aristotle would have arrived at Requirement A from observing the importance of explanation in natural sciences, and at Requirement B from observing the importance of necessity in mathematics—and would have erroneously lumped them together in a single universal definition for scientific knowledge. Now, from the examination of the passages selected in this paper, I hope to have shown that, on the contrary, the definition of scientific knowledge in T1 is coherent: it starts with the Explanatory Requirement and moves to a more fine-grained specification about the causal-explanatory relation to be captured.[87]

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[86] Barnes 1993, p. 92: "we might surmise that Aristotle, observing the importance of necessity to mathematic sciences and the importance of explanatoriness to the natural sciences, mistakenly concluded that both necessity and explanatoriness must be essential parts of any proper or scientific knowledge". I need not discuss the relation between mathematics and causal explanation (see Barnes 1976, p. 280-281).

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Warning about the translation:

I have decided to translate the original paper into English to reach more readers. I have avoided significant alterations in content. For, although I do believe that the original paper needs many improvements etc., the project of translating it and making it available in English is different from the project of revisiting the same subject and revising my former thoughts (which is something that I will surely do—actually, I'm already doing it).

Although I have restrained myself to avoid significant modifications in the original argument, I have adopted very different phrasings in some cases. Portuguese and English are very different languages, and sometimes what makes sense in a very straightforward way in one language needs to be expanded when translated to the other (or, inversely, what was expressed with more complication in one language can be simplified in the other).

Since this translation has not undergone any professional proof-reading, I ask my reader to be more tolerant with typos and mistakes I have probably left unnoticed.