

Electronic Thesis and Dissertation Repository

11-19-2019 2:30 PM

Modes of Argumentation in Aristotle's Natural Science

Adam W. Woodcox
The University of Western Ontario

Supervisor
Henry, Devin
The University of Western Ontario

Graduate Program in Philosophy
A thesis submitted in partial fulfillment of the requirements for the degree in Doctor of
Philosophy
© Adam W. Woodcox 2019

Follow this and additional works at: <https://ir.lib.uwo.ca/etd>



Part of the [History of Philosophy Commons](#)

Recommended Citation

Woodcox, Adam W., "Modes of Argumentation in Aristotle's Natural Science" (2019). *Electronic Thesis and Dissertation Repository*. 6769.
<https://ir.lib.uwo.ca/etd/6769>

This Dissertation/Thesis is brought to you for free and open access by Scholarship@Western. It has been accepted for inclusion in Electronic Thesis and Dissertation Repository by an authorized administrator of Scholarship@Western. For more information, please contact wlsadmin@uwo.ca.

Abstract

Through a detailed analysis of the various modes of argumentation employed by Aristotle throughout his natural scientific works, I aim to contribute to the growing scholarship on the relation between Aristotle's theory of science and his actual scientific practice. I challenge the standard reading of Aristotle as a methodological empiricist and show that he permits a variety of non-empirical arguments to support controversial theses in properly scientific contexts. Specifically, I examine his use of logical (*logikôs*) argumentation in the discussion of mule sterility in *Generation of Animals* II 8, rational (*kata ton logon*) argumentation in his discussion of cardiocentrism throughout the biological works, and the method of division in *Posterior Analytics* II 13.

Summary for Lay Audiences

The ancient Greek philosopher Aristotle relied on information gained through the senses to guide his scientific theorizing about many subjects, including the motions of the heavenly bodies and the behaviour of animals. Focusing on a few examples drawn from a variety of Aristotle's scientific works, I argue that he also relied on reason. We see perception and reason at play in Aristotle's investigations of reproduction, the role of the heart in animal life, and scientific definitions.

Keywords

Aristotle, natural philosophy, rationalism, empiricism, argumentation, cardiocentrism, scientific method, epistemology, scientific inquiry, Plato

For Mary

Acknowledgements

I would like to thank first and foremost my supervisor, Dr. Devin Henry, for his encouragement and guidance throughout this project. From our early meetings on the *Posterior Analytics* to more recent discussions of the *Metaphysics*, I have always been challenged to think for myself and develop my own views independently of the orthodoxy—so long as those views can be supported by the text. Thanks also to my supervisory committee, Dr. John Thorp and Dr. Lorne Falkenstein. A special thanks is due to Dr. Thorp, whose reading groups and “Greek Gang” meetings were foundational to the community of ancient scholarship during my time at Western.

I am grateful to Dr. Mariska Leunissen, Dr. C. D. C. Reeve, and the Department of Philosophy at UNC–Chapel Hill for hosting me during the Winter of 2018. I received helpful comments on earlier drafts of this material from Dr. Leunissen, Dr. Reeve, Dr. Joseph Karbowski, and audiences at meetings of the Canadian Philosophical Association, the Classical Association of Canada, and the Canadian Colloquium for Ancient Philosophy.

Thanks also to my colleagues and friends for discussions of much of this material: Cecilia Li, Justin Bzovy, Matt Watton, Dan Coren, Mike Korngut, Jamie Shaw, and many others; to my mother Carolyn, my father Bill, and my brother Nathan for their unconditional support and encouragement throughout this process; and to the lovely Joshuelle Solomon for her joyful disposition and enduring optimism.

This project was funded by a fellowship from the Social Sciences and Humanities Research Council of Canada.

Table of Contents

	Abstract	i
	Dedication	ii
	Acknowledgements	iii
0	Introduction	
	0.0 Introduction	1
	0.1 The Dual Knowledge Criterion in the Early Commentators	6
	0.2 Outline	10
1	Two Kinds of Proof in Aristotle’s Natural Science	
	1.0 Introduction	12
	1.1 The Many Senses of Source	16
	1.2 Cardiocentrism in <i>De Inventute</i>	18
	1.2.1 Perceptual Arguments in <i>De Iuv.</i>	20
	1.2.2 Rational Arguments in <i>De Iuv.</i>	23
	1.3 Cardiocentrism in <i>Parts of Animals</i> III 4	31
	1.4 Cardiocentrism in <i>Generation of Animals</i> II 4-5	40
	1.5 Perceptual Argumentation	44
	1.5.1 <i>De Caelo</i> II 14: The Sphericity of the Earth	48
	1.6 Conclusion	51
2	<i>Logikós</i> Argumentation in Aristotle’s Natural Science	
	2.0 Introduction	55
	2.1.1 Introducing the <i>Problémata</i>	60
	2.1.2 Explaining Sterility Generally	63
	2.2 Explaining Sterility in Mules	64
	2.3 Aristotle’s <i>Logikós</i> Demonstration	71
	2.4 Aristotle’s Preferred Explanation	82
	2.5 Positive Uses of <i>Logikós</i> Reasoning	86
	2.6 Conclusion	94
	2.7 Appendix	95
3	The Hunt for Definitions: <i>Posterior Analytics</i> II 13	
	3.0 Introduction	98
	3.1 <i>APo</i> II 5 and the Critique of Division	100
	3.2 The Context of The Hunt	102
	3.3 The Method for Hunting the <i>Infima Species</i>	103
	3.4 Division and Order: 96b26-97a6	105
	3.5 Three Rules for Dividing: 97a23-b6	107
	3.6 The Problem of Homonymy: 97b6-25	109
	3.7 Conclusion	110
4	Conclusion	112

0.0 INTRODUCTION

There has been a longstanding debate about the relation between Aristotle's theory of science and his actual scientific practice. This debate usually centers on the question of how Aristotle's views on the nature of scientific knowledge, as presented in the *Posterior Analytics*, line up with the his natural-scientific works. For instance, scholars raise many issues surrounding the role of demonstration, which is front and centre in Book One of *APo.* but almost absent elsewhere in the corpus. Similar questions are raised about Aristotle's theory of definition, which is presented in Book Two of *APo.* and seems to guide much of his enquiry into nature.

I aim to contribute to the debate surrounding the relation between Aristotle's theory and practice, but I take a less comparative approach than most. On the comparative approach, we take the theory presented in the *Posterior Analytics* to represent Aristotle's *theory* of science, and then see how it applies (or fails to apply) to other parts of the corpus, namely the natural-scientific works wherein we find Aristotle *practicing* science.

Although the comparative approach can be very valuable, it is not the only way to address the question of the relation between Aristotle's theory and practice of science. We often find Aristotle declaring his commitment to certain theoretical standards or ideals in his natural-scientific works, or indeed employing a certain standard without ever explicitly defending it—as we find, for instance, in his use of rational and perceptual argumentation in his defence of cardiocentrism and elsewhere.

Through a detailed analysis of the various modes of argumentation employed by Aristotle throughout his natural scientific works, I aim to contribute to the scholarship on the relation between Aristotle's theory of science and his actual scientific practice.

Specifically, I consider what *kinds* of argumentation are permissible in scientific contexts, focusing especially on his use of, rational (*kata ton logon*) argumentation in his discussion of cardiocentrism throughout the biological works, logical (*logikós*) argumentation in the discussion of mule sterility in *Generation of Animals* II 8, and the method of division in *Posterior Analytics* II 13. I challenge the standard reading of Aristotle as a thoroughgoing methodological empiricist and show that he permits a variety of non-empirical arguments to support controversial theses in properly scientific domains.

Throughout his natural-scientific works, Aristotle repeatedly emphasizes that we should give pride of place to empirical evidence when we are constructing scientific theories. He admonishes the Platonists for relying on arguments in the absence of observation and argues that theories ought to conform to the facts. This attitude is apparent in a number of texts.

For instance, Aristotle begins his investigation in *De Motu Animalium* by invoking the principle that movement requires something at rest. The necessity of something being at rest for movement on a cosmic scale has already been established in the discussion of eternal motion in *Physics* VIII with reference to the Prime Mover. But Aristotle now aims to establish that this principle holds too in the case of animal motion, where the role of the unmoved mover is filled by the joint, so that as the limb moves the joint remains at rest.

[T1] “And we must grasp this not only generally in theory, but also by reference to individuals in the world of sense; for with these in view we seek general theories, and with these we believe that general theories ought to harmonize.” (*De Motu* 1, 698a11-14)¹

δεῖ δὲ τοῦτο μὴ μόνον τῷ λόγῳ λαβεῖν, ἀλλὰ καὶ ἐπὶ τῶν καθ’ ἕκαστα καὶ τῶν αἰσθητῶν, δι’ ἅπερ καὶ τοὺς καθόλου ζητοῦμεν λόγους, καὶ ἐφ’ ὧν ἐφαρμόττειν οἰόμεθα δεῖν αὐτούς.

¹ Trans. A. S. L. Farquharson (1984).

The discussion of the Prime Mover in *Physics* VIII allowed us to grasp the principle in question ‘by reason’ (τῷ λόγῳ). Presumably, Aristotle would identify the argument offered in support of this conclusion as an instance of rational argumentation. Since the investigation in *De Motu* turns to the common cause of all kinds of animal motion (whether flying, swimming, or walking), the same principle is now shown to hold of animal motion via perceptual argumentation (the nature of which will be discussed in Chapter 1). Importantly, Aristotle here claims that we should seek general theories that are in harmony with the perceptual phenomena; we should not allow our antecedent theories to bias our observations, but rather should let the facts lead us to our theories.

He makes a similar claim in his discussion of bee reproduction in the *Generation of Animals*, reiterating the methodological priority of the perceptual phenomena. After laying out his own account of bee reproduction, he offers the following remark.

[T2] “On the basis of reason (*logos*), then, and on the basis of what seem to be the facts about them, matters having to do with generation of bees appear to be this way. The facts, though, have certainly not been sufficiently grasped, but if at some time they are, one should take perception rather than reasonings to be what must carry conviction, and reasonings [only] if what they show agrees with what appears to be the case.” (*GA* III 10, 760b27-32)²

Ἐκ μὲν οὖν τοῦ λόγου τὰ περὶ τὴν γένεσιν τῶν μελιττῶν τοῦτον ἔχειν φαίνεται τὸν τρόπον καὶ ἐκ τῶν συμβαίνειν δοκούντων περὶ αὐτάς· οὐ μὴν εἰληπταί γε τὰ συμβαίνοντα ἰκανῶς, ἀλλ’ ἐάν ποτε ληθῆ ἢ τότε τῇ αἰσθήσει μᾶλλον τῶν λόγων πιστευτέον, καὶ τοῖς λόγοις ἐὰν ὁμολογούμενα δεικνύωσι τοῖς φαινομένοις.

Aristotle sees his own explanation of bee reproduction as one that is based both on reason and on the apparent empirical facts.³ However, he expresses some hesitation because the empirical facts surrounding bee reproduction were at the time very thin. This is likely due in

² Trans. Reeve (forthcoming)

³ For an interesting account of Aristotle’s explanation of bee reproduction and its relation to the divine, see Lehoux (2019).

part to the fact that bee reproduction occurs approximately 25-metres off the ground and so is very difficult to observe directly. As a result of this difficulty, Aristotle assures us that his account is open to revision and that if the empirical facts are sufficiently grasped at some time in the future, they should be given authority over arguments. Accordingly, when an argument contradicts the evidence of observation, we should be convinced by the latter, and should only be convinced by arguments when they are in agreement with the empirical phenomena.

Several other passages throughout the corpus recommend a similar priority to the empirical phenomena.⁴ These texts have encouraged a recent trend in scholarship to read Aristotle as a methodological empiricist. There is an obvious and immediate difficulty with this characterization, however, since the label ‘empiricist’ originates only *after* Aristotle’s death, with the emergence of the Empiricist medical school. Applying this term retrospectively to Aristotle, then, comes with the threat of anachronism.

There are some scholars who argue that Aristotle is an empiricist in the same sense in which members of the Empiricist medical school are empiricists. Lorenz and Morison, for instance, argue that Aristotle’s conception of doxastic knowledge is Empiricist in this sense, specifically in so far as it (i) does not rest on grasping logical relations that hold among relevant propositions and (ii) does not rest on grasping unobservable natures or essences of things.⁵ However, Lorenz and Morison admit that grasping logical relations and intelligible essences are central to Aristotle’s epistemology of *theoretical* understanding; his empiricism extends only so far as his conception of doxastic knowledge.

⁴ See *APr.* I 30, 46a17-21; *Cael.* III 7, 306a5-17; *GC* I 2, 316a4-8; *HA* I 6, 491a7-14; *DA* I 1, 402b21-25; *Metaph.* IX 9, 1051a21-29; *Meteor.* I 7, 334a5-7; and, of course, *APo.* II 19.

⁵ Lorenz and Morison (forthcoming), 1.

Lennox, another recent interpreter of Aristotle as empiricist, defines ‘empiricism’ as “the idea that perceptually grounded experience is the sole source of our knowledge of the world.”⁶ He also suggests elsewhere that Aristotle is engaged in a project similar to that of seventeenth and eighteenth-century empiricists insofar as he asks how we can legitimately abstract and grasp universal knowledge from an experience of sensory particulars.⁷ Lennox’s project, however, goes beyond mere concept acquisition to provide a thoroughly empiricist account of Aristotle’s methodology. He argues that the *Posterior Analytics* provides an erotetic framework—a framework of questions that the scientist must ask—advanced primarily in *APo.* II 1-2 (as *the fact, the reason why, if it is, and what it is*). This erotetic framework is then filled in with the norms of inquiry specific to the different domains of natural science. This explains why the first Book of *Parts of Animals* contains Aristotle’s philosophy of biology. His biological enterprise does not ignore the theory of science developed in the *Posterior Analytics*, but rather adopts and enriches its framework by specifying the various norms of biological inquiry (such as the important role of teleology). Accordingly, Lennox takes a unique kind of comparative approach to the question of the relationship between Aristotle’s scientific theory (as presented in the *Posterior Analytics*) and his actual scientific practice (found in the natural-scientific works). He solves many of the discrepancies noticed by previous scholarship first by reading the theory presented in the *Posterior Analytics* as a global erotetic framework, applicable in some way to all domains of natural science, and second by finding a great deal of local, norm-governed theory in the natural-scientific works themselves.

Lennox’s work has, I think, made for a significant amount of progress in the debate about Aristotle’s theory and practice of science, by allowing room for a great deal of theory

⁶ Lennox (forthcoming) Ch.1 n.9.

⁷ Lennox (2011), 24 n.2.

in what were previously thought to be works of scientific practice. I want to continue this trend by drawing out and investigating some of the theory of science at work in Aristotle's scientific practice. In this way, I hope to show that the characterization of Aristotle as empiricist encounters some difficulty. For he regularly makes use of a family of arguments that might be better characterized as *a priori* or rationalist, in contrast to the empirical arguments for which he is so often praised. In particular, I argue that Aristotle's rationalist bent is most evident in his use of rational argumentation, logical argumentation, and the method of division.

0.1 THE DUAL KNOWLEDGE CRITERION IN THE EARLY COMMENTATORS

Empiricist readings of Aristotle have not always been the norm. Besides the regular occurrence of the distinction between reason and perception in Aristotle's own writings, we have evidence from later sources for the attribution of what has been labelled the dual knowledge criterion thesis.⁸ Diogenes Laertius, for instance, claims that Aristotle distinguished two criteria of truth—sense perception and intellect—and drew a corresponding division between areas in which these criteria operate:

[T3] “[a]s criterion of truth, in the case of things that actually appear he declared it to be sense perception, but in the case of ethics and things concerning the city, the household and the laws, intellect.”
(DL 5.34)⁹

We might find this remark especially odd since Aristotle does not limit his criteria to distinct domains, but often employs rational arguments in natural science and perceptual arguments

⁸ For this label, see Sharples (2010), 106.

⁹ Trans. R. D. Hicks (1925).

in his political works. However, the important point is that Diogenes recognized and assigned equal billing to reason and perception in Aristotle's philosophy.

We find the dual knowledge criterion thesis again upheld by the Peripatetic Aristocles of Messene in his work *On Philosophy*. Aristocles rejected the Epicurean view that we can only apprehend what affects the senses, but he is also critical of the Eleatic view that favours reason over perception. He argues that both perception *and* reason play important roles in knowledge acquisition, so that the dual knowledge criterion thesis must be observed if we are to practice philosophy in the correct manner.

[T4] “But we now say confidently that those philosophize correctly who employ both sensations and reason in order to know things.”
(Aristocles *On Philosophy* F7.9 Chiesara, reported by Eusebius, *Preparation for the Gospel* 14.17.9)¹⁰

In another passage, we find Aristocles employing a hunting metaphor which likens sensation to the tools of the hunter while likening the intellect and reason to the hounds which track down and chase the target.

[T5] “These things being so, we will find, if we are willing to consider, that the stating-points of knowledge are best laid down by those who employ both senses and intellect. Sensation is like the traps and nets and the other hunting implements of this sort; intellect and reason are like the hounds which track down and chase [the prey].”
(F8.6-7 (14.21.6-7))¹¹

Just as the successful hunter must use both hounds and traps to catch his prey, so too the successful philosopher must use both reason and perception. An exclusive reliance on one or the other will lead to failure.

¹⁰ Trans. Sharples (2010).

¹¹ Trans. Sharples (2010).

Sextus Empiricus utilizes a similar metaphor in his discussion of the Peripatetic philosophy in *Against the Professors*, assigning to sensation the role of a tool and to intellect the role of a craftsman.

[T6] “It appears from what has been said that the primary criteria for the knowledge of things are sense perception and intellect, the former having the role of an implement and the latter [that of] a craftsman. For as we cannot conduct an examination of heavy and light things without a balance, or differentiate between straight and crooked things without a rule, so intellect is not naturally able to judge things without sense perception. Well, this is in summary what the Peripatetics are like [in their opinions].” (7.226)¹²

We see from these cases that many of the early commentators on Aristotle’s philosophical method viewed him as a proponent of both empirical and rational methods. By the end of the Early Modern period, interpretations had become more diverse. For instance, in his *Novum Organum* (1620), Francis Bacon identifies three types of false philosopher (1.LXII-LXV): (i) the Sophistic or Rational type, who founds his theory on dialectic and common notions; (ii) the Empirical philosophers, who are said to labour carefully over a few experiments and too quickly generalize to principles of all things; and (iii) the Superstitious philosophers who infuse theology with tradition. For each type, Bacon identifies a corresponding philosopher or group of philosophers who best exhibit these flaws: Plato and the Pythagoreans are given as an example of (iii), in addition to Bacon’s contemporaries who tried to base natural philosophy on the Book of Genesis; William Gilbert, famous for generalizing from his discoveries about magnetism to explain many phenomena in his *De Magnete* (1600), is used as an example of (ii); and finally, Aristotle is listed as Bacon’s prime example of (i), the Sophistic or Rational type. He accuses Aristotle of spoiling natural philosophy with his dialectic and criticizes the construction of the categories, his views about

¹² Trans. Sharples (2010).

the nobility of the human soul, the ‘unilluminating’ distinction between act and potentiality, and natural and constrained motion. Bacon views these ‘common notions’ as universal and relevant to many things, but ultimately weak and superficial. He recognizes the regular appeals to empirical evidence throughout the Aristotelian corpus, but finds this evidence biased by prior assumptions.

[T7] “And no one should be impressed because in his books *On Animals* and in his *Problems* and other treatises there is often discussion of experiments. He had in fact made up his mind beforehand, and did not properly consult experience as the basis of his decisions and axioms; after making his decisions arbitrarily, he parades experience around, distorted to suit his opinions, a captive.”
(*Novum Organum*, 1.63)

Bacon’s critique of Aristotle anticipates some of evaluations that came later in the 21st century, and, to a certain extent, the view defended below (see especially the latter half of Chapter 1). However, we might wonder to what extent Bacon was influenced by Scholastic readings of Aristotle and to what extent his characterization deliberately simplified Aristotle’s method in order to make room for the new method presented in the *Novum Organum*.

More recently, there has been somewhat of a return to the dual knowledge criterion thesis. In a landmark paper on Aristotelian method in natural science, Bolton argues that Aristotle employs “two standards” of inquiry, one properly natural-scientific and one dialectical. In many ways this is similar to the distinction drawn by the early commentators between perception (the natural-scientific standard) and reason (the dialectical standard), although for Bolton the former yields knowledge (*epistémè*) while the latter yields mere opinion. The details of Bolton’s view will be discussed and evaluated hereafter (especially in Chapter Two), but his (re-)introduction of the two standards offered by the dual knowledge criterion thesis—reason and perception—helps set the stage for the arguments of the following chapters.

0.2 OUTLINE

The plan of my dissertation is as follows. In Chapter One I introduce the contrast between the rational and perceptual modes of argumentation. Through a sustained analysis of their use in Aristotle's defense of cardiocentrism, the view that the source of soul is located in the heart, I show that rational arguments can sometimes make use of certain (empirically unfounded) biases that then inform the purported observations used in perceptual arguments for the same thesis. I also examine the nature of perceptual argumentation in Aristotle's natural philosophy and show that it can sometimes involve a degree of inference.

In Chapter Two I turn to the contrast between the logical and physical modes of argumentation. I argue that logical argumentation is essentially general relative to a question, not relative to a science. I develop this interpretation by focusing on the application of logical argumentation to the discussion of mule sterility in *Generation of Animals* II 7-8.

Together, these chapters offer positive evidence against the view that finds a strict distinction between natural scientific and dialectical inquiry. Rational and logical arguments are not essentially dialectical, nor are they necessarily empirical, and both can be used to a positive end in natural science.

Finally, in Chapter Three I consider the role of the method of division in *Posterior Analytics* II 13. I argue that here again we find evidence of a rationalist bent in Aristotelian methodology.

BIBLIOGRAPHY

- Bacon, F. (2000) *The New Organon*. (eds.) L. Jardine and M. Silverthorne. Cambridge.
- Bolton, R. (2009) 'Two Standards for Inquiry in Aristotle's *De Caelo*' in *New Perspectives on Aristotle's De Caelo*, (eds.) A. C. Bowen and C. Wildberg. Leiden: 51-82.
- Farquharson, A. S. L. (1984) (trans.) *Movement of Animals*, in J. Barnes (ed.) *The Complete Works of Aristotle*. Princeton.
- Hicks, R. D. (1925) (trans.) *Diogenes Laertius: Lives of the Eminent Philosophers*. Loeb Classical Library. Harvard.
- Lehoux, D. R. (2019) "Why does Aristotle think bees are divine? Proportion, triplicity and order in the natural world," *The British Journal for the History of Science*: 1-21.
- Lennox, J. (2011) "Aristotle on Norms of Inquiry," *HOPOS: The Journal of the International Society for the History of Philosophy of Science* 1(1): 23-46.
- (forthcoming) *Seeking and Knowing: Aristotle on the Norms of Inquiry*.
- Lorenz, H. and Morison, B. (forthcoming) "Aristotle's Empiricist Theory of Doxastic Knowledge," *Phronesis*.
- Reeve, C. D. C. (forthcoming) *Aristotle's Generation of Animals*. Hackett.
- Sharples, R. (2010) *Peripatetic Philosophy 200 BC to AD 200: An Introduction and Collection of Sources in Translation*. Cambridge.

CHAPTER 1

Rational Argumentation in Aristotle's Natural Science

1.0 INTRODUCTION

The traditional narrative makes Aristotle the empiricist opponent of Plato the rationalist. Barnes, for instance, characterizes Aristotle's view of the acquisition of first principles in *APo.* II 19 as 'whole-heartedly empiricist'.¹³ In his argument against Barnes' characterization, Ferejohn charges empiricist readings of Aristotle with anachronism, but in turn characterizes Plato as a 'clear-cut rationalist'.¹⁴ We might illustrate this narrative with reference to the gesturing in Raphael's *School of Athens*. Plato points up toward the heavens, indicating his commitment to the ideal and immaterial world of Forms. Aristotle stands beside him, motioning down to the earth to reflect a more naturalized philosophy and greater concern for particulars. This interpretation dates back at least to the 19th century and we see it expressed quite clearly in terms of the objective and subjective existence of Ideas in Garrigues' 1879 essay on the philosophical content of the painting.

[T1] "Plato has just proclaimed that Ideas, and Ideas alone, have any existence. Aristotle replies, 'I tell thee, Plato, my master, thou art wrong – radically wrong. Far be it from me to deny the *subjective* existence of Ideas; on the contrary, I consider them the very materials of science. But to give them an *objective* existence, is merely to perpetuate an empty and poetical metaphor.'"¹⁵

Furthermore, this division in ontology is tied up with a complementary division in method.

Plato is an advocate of the method of dialectic, requiring an extensive education in

¹³ Barnes (1994), 270.

¹⁴ Ferejohn (2009), 71.

¹⁵ Garrigues (1879), 415.

mathematics and progressive turning away from the material world. Aristotle, on the other hand, is a friend of induction and constantly engaged with the world of the senses.

But there is an ambiguous character to Aristotelian science. For we find Aristotle regularly employing a distinction between two kinds of proof, showing that what is clear “according to perception” (κατὰ τὴν αἴσθησιν) is also clear “according to reason” (κατὰ τὸν λόγον). Often when Aristotle is trying to establish some controversial scientific thesis he will offer a perceptual argument in its favour, appealing to what is observable and showing that the thesis in question harmonizes with specific empirical data. He will then claim that the same controversial thesis can be established via rational argumentation, showing how it follows necessarily from certain universal principles.

It has been standard to read the distinction between rational and perceptual argumentation as a *prima facie* cause of tension between rational and empirical methods in Aristotle’s science. Bourgey, for instance, identifies this tension in his paper on observation and experiment in Aristotle’s natural philosophy.

[T2] “Aristotle carried out observations, by encouraging passivity and the casual handling of empirical proofs, and at the same time by encouraging the proliferation of arbitrary explanations. Here again we encounter one of the sources of the ambiguous character of Aristotelian science, one which has often been pointed out.”¹⁶

Bourgey finds the distinction between perceptual and rational arguments to be one of the recognized sources of ambiguity in Aristotle’s method, criticizing the philosopher for his use of arbitrary explanations and passive observations. Whether or not we agree with this criticism, Bourgey is surely correct to highlight the distinction as a source of tension and to raise the question of how these distinct kinds of proof relate to one another. If Aristotle

¹⁶ Bourgey (1975), 182/121-2.

holds the metatheoretical principle that scientific theories ought to explain and cohere with empirical data, then we might think that perceptual arguments would be sufficient to establish controversial scientific theses. But then why does he utilize rational arguments in addition? If, on the other hand, Aristotle holds the metatheoretical principle that scientific theses ought to be both necessary and universal, we might think rational arguments are necessary and sufficient for this purpose. But then why does he utilize perceptual arguments? Is the tension between reason and perception simply fundamental to Aristotelian method, or can it be explained in such a way that the use of rational and perceptual argumentation is clear and complementary?

Scholars traditionally adopt the former alternative, viewing the tension between reason and perception as fundamental to Aristotelian science. On one reading, rational argumentation is seen as in some sense *a priori*, proceeding from self-evident general principles.¹⁷ The clear-cut, absolute distinction between understanding and the observation of facts is taken to be characteristic of, and indeed a characteristic *weakness* of, Aristotelian science. On this reading, rational arguments are understood as somewhat arbitrary explanations worked out on a purely abstract level, in contrast to the self-sufficient observation of empirical facts captured in perceptual arguments.

Recently, an alternative reading of the distinction between reason and perception has emerged. Wishing to purge Aristotelianism of the use of abstract proofs of reason,

¹⁷ Bourgey (1975); Lloyd (1979), 137; Hankinson (1998), 172. See also Platt's (1912) translation of *GA I 21* (729b8-9 and 729b21-22) and Frede's (1996) characterization of what is known by deduction from first principles as "*a priori*" knowledge. Leunissen and Falcon (2015) allow that there may be *a priori* arguments developed independently of any empirical evidence (221). However, they count this as a kind of 'loose' dialectical argument, dividing dialectic into (i) arguments that appeal to reputable opinions and (ii) *a priori* arguments. This *a priori* version of the traditional reading might be contrasted with the dialectical version that takes rational arguments to be wholly dialectical, proceeding from reputable opinions or *endoxa*. See Owen (1961) and Bolton (2009). The dialectical version is, I think, successfully refuted by Karbowski (2016), who shows that while some rational arguments might be dialectical, these are ultimately distinct kinds of argument.

commentators attempt to resolve the tension by identifying rational arguments as themselves depending on empirical generalizations based on observation, thus downplaying any rationalist elements in Aristotle's method.¹⁸ On this reading, many rational arguments are themselves ultimately justified by perceptual arguments, so that Aristotle remains a friend of induction and thoroughgoing empiricist.

In this chapter I address the tension between reason and perception in Aristotle's method and the worry that rational argumentation might threaten his thoroughgoing empiricism and, by extension, the traditional narrative represented in the *School of Athens*. Ultimately, I argue in support of the traditional reading that Aristotle often relies on certain assumptions held in light of contrary empirical evidence. In particular, I focus on the assumption that the center of a thing is the best location for its source (*ἀρχή*), but similar lines might be taken regarding his views on locomotion (e.g. the superiority of upward and forward motion), sex (e.g. the superiority of the male to the female), and agency (e.g. the superiority of the agent to the patient), to name only a few. Accordingly, Aristotle makes use of reasoning that is in some sense independent of experience, allowing room for more rationalist features in science. I support this thesis by examining Aristotle's defense of cardiocentrism, the thesis that the source or principle of soul is located in the heart. This chapter thus offers a sustained analysis of Aristotle's defense of cardiocentrism in order to

¹⁸ Karbowski (2016). Karbowski ultimately relaxes his position to allow room for *a priori* arguments in Aristotle. After arguing against an *a priori* reading of the rational argument in *De iuv.* (which we will examine below), Karbowski says "it is most prudent to conclude that the text leaves the existence of *a priori* justificatory arguments indeterminate. But even if some of the justificatory arguments in the natural works do appeal to *a priori* principles, many of them do not; and so we must not construe justification by argument as essentially a form of *a priori* justification" (138). This uncertainty remains, and he concludes that "justificatory arguments sometimes have a *logikos*, dialectical, and (perhaps) *a priori* status" (152). However, I think that Karbowski's initial resistance to *a priori* rational arguments reflects a larger trend in the scholarship that makes Aristotle out to be respectable and thoroughgoing empiricist.

show that he employs proofs in natural science that are not themselves empirical or empirically grounded, but more accurately described as *a priori* or rationalist.

This chapter also aims to get clearer on the nature of the distinction between rational and perceptual argumentation. I argue that rational arguments are given at greater or lesser degrees of abstraction, such that some premises are empirically grounded and specific to a given domain, while others are *a priori* assumptions common to many different areas of investigation.¹⁹ Perceptual arguments, too, admit of a similar imprecision: some are very straightforward and direct observations of empirical phenomena, while others rely on indirect observation and certain theoretical presuppositions.

1.1 THE MANY SENSES OF SOURCE

Before we begin our examination of Aristotle's method, we should get clear on the nature of his cardiocentrism. Specifically, we might wonder what it means for the soul to have its *source* in the heart. Aristotle considers the several senses of the term *arché* in his philosophical lexicon in Book Delta of the *Metaphysics*. Perhaps the sense most relevant to his defence of cardiocentrism is: “[t]hat from which (as an immanent part) a thing first arises, e.g. as the keel of a ship and the foundation of a house, while in animals some suppose the heart, others the brain, others some other part, to be of this nature” (*Met.* V 1, 1013a3-6).²⁰ Aristotle does not here commit himself to a view on which organ is the source in animals, although as we will see he argues in the biological works and the *Parva Naturalia* that the heart (or whatever is analogous) fills this role. This sense of *arché* is immediately contrasted

¹⁹ As we will see, the Optimality Principle is an example of the former, the Centrality and Unity Principles are examples of the latter.

²⁰ Trans. W. D. Ross (1984).

with another similar sense: “[t]hat from which (*not* as an immanent part) a thing first arises, and from which the movement or the change naturally first proceeds, as a child comes from the father and the mother, and a fight from abusive language” (*Met.* V 1, 1013a6-9).²¹ It is essential to the first sense of *archê*, then, that it is an immanent rather than external part. The cardiocentric thesis holds that the heart is that from which (as an immanent part) the animal first arises.

However, this cannot be the only sense in which the heart is an *archê*. Aristotle offers another sense that seems relevant: “[t]hat by whose choice that which is moved is moved and that which changes changes, e.g. the magistracies in cities, and oligarchies and monarchies and tyrannies, are called origins, and so are the arts, and of these especially the architectonic arts” (*Met.* V 1, 1013a9-13).²² This sense seems relevant, not because the heart makes any sort of choice, but because Aristotle elsewhere draws a close analogy between the organism and the state. On this analogy, the soul resides in a kind of *archê* of the body, just as the monarch sits alone and governs over the entire commonwealth. Aristotle makes this analogy most explicit in Chapter 10 of the *De Motu* following his explanation of the initiation of animal motion through thrusting and pulling.

[T3] And the animal organism must be conceived after the similitude of a well-governed commonwealth. When order is once established in a city there is no more need of a separate monarch to preside over each several task. The individuals each play their assigned part as it is ordered, and one thing follows another because of habit. So in animals the same thing happens because of nature, each part naturally doing its own work as nature has composed it. There is no need then of a soul in each part, but it resides in a kind of origin of the body, and the remaining parts live by being naturally connected, and play their parts because of their nature.”
(De Motu 10, 703a29-703b1)²³

²¹ Trans. W. D. Ross (1984).

²² Trans. W. D. Ross.

²³ Trans. A. S. L. Farquharson.

ὑποληπτέον δὲ συνεστάναι τὸ ζῶον ὡς περ πόλιν εὐνομουμένην.
 ἔν τε γὰρ τῇ πόλει ὅταν ἅπαξ συστήῃ ἡ τάξις, οὐδὲν δεῖ
 κεχωρισμένου μονάρχου, ὃν δεῖ παρῆναι παρ' ἕκαστον τῶν
 γινομένων, ἀλλ' αὐτὸς ἕκαστος ποιεῖ τὰ αὐτοῦ ὡς τέτακται, καὶ
 γίνεται τόδε μετὰ τόδε διὰ τὸ ἔθος· ἔν τε τοῖς ζώοις τὸ αὐτὸ τοῦτο
 διὰ τὴν φύσιν γίνεται καὶ τῷ πεφυκέναι ἕκαστον οὕτω συστάντων
 ποιεῖν τὸ αὐτοῦ ἔργον, ὥστε μηδὲν δεῖν ἐν ἐκάστῳ εἶναι ψυχὴν,
 ἀλλ' ἐν τινι ἀρχῇ τοῦ σώματος οὔσης τᾶλλα ζῆν μὲν τῷ
 προσπεφυκέναι, ποιεῖν δὲ τὸ ἔργον τὸ αὐτῶν διὰ τὴν φύσιν.

The heart is a source of soul as an immanent, rather than external, part from which the animal is generated and from which movement and change originate (in a way analogous to the magistrate in the city).²⁴ So much by way of introduction. The sense and nuance of Aristotle's use of *arché* will become more evident through our investigation of his defence of cardiocentrism by way of perceptual and rational argumentation.

1.2 CARDIOCENTRISM IN *DE IUVENTUTE*

The first instance of the distinction in method I want to examine occurs in *De iuventute*, a short treatise in the *Parva Naturalia* that investigates the causes of aging and death. Aristotle opens the work by asking in what part of the body the source of soul is located, noting that it must be a part that possesses control over the other members. The location of the source of soul will be important if we are trying to understand the phenomena of life and death, since being alive and being ensouled are coextensive. As Aristotle says in *De Anima*, “what has soul in it differs from what has not in that the former displays life” (*DA* II 2, 413a22-3).²⁵ At the time, there were two competing views on the question of where in the body the

²⁴ See also *GA* II 6, 742b33-743a1, where Aristotle distinguishes *arché* in the sense of essence (*to ti estin*) for immovable and unchanging things from *arché* in the sense of the principle of movement for things that are subject to generation and destruction, identifying the latter with the heart in blooded animals (and its analogue in bloodless).

²⁵ Trans. J. A. Smith.

source of soul is located: the more prominent and in some ways contemporary cephalocentrists argued that the source of soul is located in the head, or more specifically in the brain; the cardiocentrists, on the other hand, argued that the source of soul is located in the heart. As we will see, Aristotle counts himself among the latter.

The first four chapters of *De imm.* Purport to establish that the source of soul is located in the middle of the organism, identifying the heart as the specific organ of control. The discussion is meant to establish the location of the source of both nutritive and the sensitive soul, although it is unclear whether this is also meant to apply to the rational soul, since Aristotle elsewhere seems to leave open the question of whether the rational soul is separable in space as well as in definition.²⁶ Before locating the source of soul specifically in the heart, Aristotle establishes its place in the middle of the body. To this end, he first claims that all perfectly formed animals (τελεία τῶν ζώων) are divided into three parts: (i) that part by which food is taken in and nutrition received (i.e. the head and mouth), (ii) that part by which nutrition is prepared and waste discharged (i.e. the fundament), and (iii) the region intermediate between these (i.e. the chest) (*De imm.* 2, 468a14-17). Although these parts are defined by their functional roles, namely receiving food and discharging waste, the distinction is in part established empirically as the mid-section is said to be more distinctly marked off in some animals than in others (468a18). Compare, for instance, the body of an ant to that of a snake: the former has three clear divisions that the latter appears to lack. Indeed, the Greek ἔντομον (“being cut in pieces”), Aristotle’s neologism for the kind to which ants belong and from which our term ‘insect’ derives, makes reference to their visibly notched bodies.

²⁶ See *DA* III 4.

1.2.1 PERCEPTUAL ARGUMENTS IN *DE IUUV*.

After making this division of the body into three parts, Aristotle invokes the methodological distinction between perceptual and rational argumentation.

[T4] Now it is evident (φαίνεται) both by perception (κατὰ τὴν αἴσθησιν) and by reason (κατὰ τὸν λόγον) that the source (ἀρχὴ) of the nutritive soul is in the middle of the three parts. For many animals, when either part—the head or the receptacle of the food—is cut off, retain life in that member to which the middle remains attached. This can be seen to occur in many insects, e.g. wasps and bees, and many animals also besides insects can, though divided, continue to live by means of the part connected with nutrition. (*De iuv.* 2, 468a20-28)²⁷

ἀλλ' ἢ γε τῆς θρεπτικῆς ἀρχῆς ψυχῆς ἐν τῷ μέσῳ τῶν τριῶν μορίων καὶ κατὰ τὴν αἴσθησιν οὕσα φαίνεται καὶ κατὰ τὸν λόγον· πολλὰ γὰρ τῶν ζώων ἀφαιρουμένου ἑκατέρου τῶν μορίων, τῆς τε καλουμένης κεφαλῆς καὶ τοῦ δεκτικοῦ τῆς τροφῆς, ζῆ μεθ' οὐπερ ἂν ἦ τὸ μέσον. Δῆλον δ' ἐπὶ τῶν ἐντόμων, οἷον σφηκῶν τε καὶ μελιττῶν, τοῦτο συμβαῖνον· καὶ τῶν μὴ ἐντόμων δὲ πολλὰ διαιρούμενα δύναται ζῆν διὰ τὸ θρεπτικόν.

Chapters 2 and 3 carry out the perceptual arguments, drawing on observable data gathered from the empirical study of animals and plants. First, as we see in T4, Aristotle observes that many animals continue to live following decapitation or the removal of the fundament. Since life and nutrition are co-extensive, the source of the nutritive soul must be located in that part which continues to live (i.e. the mid-section, plus any part still attached). If it were located in the head or the fundament, their removal would result in death. Next, Aristotle turns to the source of generation in plants, observing that both root and stem emerge from

²⁷ Trans. G. R. T. Ross.

the mid-point of the seed (468b18ff).²⁸ His studies of the early stages of development in eggs led Aristotle to a similar conclusion with regard to blooded animals (468b27ff). He claims that we see that the heart is the first organ to develop, that the veins issue from the heart, and again that the heart is located in the mid-section of the organism. Just as the root and stem grow out of the middle of the seed, the upper and lower parts of the (blooded) animal grow out of the heart (and whatever is analogous in the case of bloodless animals). Since the nutritive soul is responsible for growth, then, it must be the case that its source is located in the part from which all others grow, which in the plant is the seed and in blooded animals is the heart.

It is clear in these chapters that Aristotle's reasoning is empirically informed. He begins with the presupposition that the source of soul is localizable and, although this assumption might not itself be empirically informed, it is an assumption that Aristotle appears to share with his contemporaries and so can be dismissed as relatively unproblematic from a methodological point of view. He draws his conclusions from close engagement with a variety of different organisms and observations of the early stages of development of plants and animals. Each proof is more or less ostensive, as Aristotle highlights some phenomenon that is taken to support the cardiocentrist thesis. In this way, he makes it clear by perceptual argument that the source of soul is located in the mid-section of the organism.

Before turning to the use of rational argumentation that follows, we should note that Aristotle's claim that the heart is the first organ to develop is factually incorrect in an interesting way. Modern biologists have discovered that the primitive nervous system is in fact the first part of the embryo to form in the early stages of development, but due to its

²⁸ Ross (1955, 299) suggests that Aristotle was led to the mistaken belief that all seeds are bivalvular by the examination of leguminous plants (see *GA* 752a21-23). It was not until the seventeenth century that the division of plants into dicotyledons, monocotyledons, and acotyledons was made by John Ray.

initial transparency it is very difficult, if not impossible, to see with the naked eye. And although the heart forms after the primitive nervous system, it is the first organ visible to the naked eye. The obvious lesson, then, is that perceptual arguments are limited by our perceptual abilities, and for Aristotle limited to naked eye perception.

If we maintain the traditional distinction between reason and perception and reject recent attempts to find an empirical grounding for Aristotle's rational arguments, we might then wonder how rational and perceptual arguments are related to one another. Does Aristotle prioritize perceptual arguments over their rational counterparts? Does he think that perception already establishes what he then tries to support by other rational arguments, perhaps in an *ad hoc* manner? Or alternatively, is Aristotle committed to cardiocentrism on *a priori* grounds, and this commitment then biases the kinds of empirical proofs he chooses to focus on? He provides empirical reasons and presents them as being foundational (although not necessarily prior to rational considerations). But we might wonder whether his non-empirical presuppositions bias the kinds of evidence he selects and what sorts of empirical data he privileges in his arguments.

As we will see, Aristotle is not averse to *ad hoc* justification (specifically with regard to the fact that the heart in human beings inclines more to the left than the center or right, as his theory would lead us to expect—but more on this below). However, I do not think we can simply reduce all his rational arguments for cardiocentrism to *ad hoc* supplementary proofs. Aristotle's rational arguments often employ principles that are central not only to his thought in the biological realm, but to his political philosophy and metaphysics more generally. But to see the truth of this statement, we must now turn to investigate the particular rational arguments that Aristotle gives in support of the cardiocentric thesis.

1.2.2 RATIONAL ARGUMENTS IN *DE IUV.*

So much for Aristotle's perceptual arguments in Chapters 2 and 3. *De iuv.* 4 provides additional support for cardiocentrism by switching modes and offering two rational arguments for the thesis that the source of soul is located in the center of the animal. The second rational argument runs from 469b1–6 and appeals to the practices of craftsmen to justify the claim that “that which employs an instrument and the instrument it employs must be distinct both in capacity and, if possible, in location” (469b1-3).²⁹ From this principle, Aristotle argues that the sensitive soul viewed as instrument must be in a distinct location, which is identified as the heart. This argument appears to rely more clearly upon induction to support the major premise, since it is a generalization from the crafts, and so it does not appear to threaten Aristotle's empiricism. The rational argument that precedes this, however, might be more of a threat. It is introduced as follows.

[T5] Thus if, on the one hand, we look to the observed facts (*κατὰ τὰ φαινόμενα*), what we have said makes it clear that the source (*ἀρχή*) of the sensitive soul, together with that connected with growth and nutrition, is situated in this organ and in the central one of the three divisions of the body. But it follows by reason (*κατὰ τὸν λόγον*) also, for we see (*ὁρῶμεν*) that in every case nature does that which is best from among the possibilities: the two parts of the body (that which prepares the ultimate nutriment and that which receives it)³⁰ would each accomplish its proper function most if each source was in the middle of the substance; for then the soul will be close to both parts, and the central position of such a capacity will be in a position of control (*ἄρχοντος χώρα*).

²⁹ Trans. G. R. T. Ross.

³⁰ There is a minor controversy over the reference of *τό δεκτικόν* (a32). Ogle supposes that Aristotle divides the body “into two departments: one, the heart in which the food is elaborated, and, the other, that part to which the food, thus elaborated, is distributed, that is to say, all the body excepting the heart.” He takes *τό δεκτικόν* to be “not the stomach, which is the receptacle of the *undigested* food, but the mass of the body, other than the heart, which is the recipient of the *elaborated* food.” Against this, Ross argues that Aristotle is maintaining the tripartite division of head, fundament, and middle region. See Ross 1955, 301.

(*De inv.* 4, 469a23-b1)³¹

κατὰ μὲν οὖν τὰ φαινόμενα δῆλον ἐκ τῶν εἰρημένων ὅτι ἐν τούτῳ
τε καὶ ἐν τῷ μέσῳ τοῦ σώματος τῶν τριῶν μορίων ἢ τε τῆς
αἰσθητικῆς ψυχῆς ἀρχὴ ἐστὶ καὶ ἡ τῆς ἀντικειμένης καὶ θεραπευτικῆς·
κατὰ δὲ τὸν λόγον, ὅτι τὴν φύσιν ὁρῶμεν ἐν πᾶσιν ἐκ τῶν
δυνατῶν ποιοῦσαν τὸ κάλλιστον· ἐν τῷ μέσῳ δὲ τῆς οὐσίας τῆς
ἀρχῆς οὐσίας ἐκατέρας μάλιστα ἂν ἀποτελοῖ τῶν μορίων ἐκάτερον
τὸ αὐτοῦ ἔργον, τό τε κατεργαζόμενον τὴν ἐσχάτην τροφήν καὶ τὸ
δεκτικόν· πρὸς ἐκατέρῳ γὰρ αὐτῶν οὕτως ἐστὶ, καὶ ἔστιν ἡ τοῦ
τοιούτου μέσου χώρα ἄρχοντος χώρα.

Here we find Aristotle turning away from the perceptual phenomena to offer a more abstract argument for the location of the source of soul. The argument begins with Aristotle's Optimality Principle, the teleological principle that "nature does nothing in vain but always what is best from among the possibilities." The second premise is a particular claim about the best location for the source, namely that the best location for the source of soul is in the middle of the substance or organism. We might call this Aristotle's Centrality Principle. Assuming that it is *possible* for the source of soul to be located in the mid-section, it then follows from these two principles that the source *must* be so located. Moreover, since Aristotle has already identified the heart as the organ occupying the middle, it follows that the source of soul will be located specifically in the heart. The question I now want to address is whether this argument is at odds with the thoroughgoing empiricism that scholars often attribute to Aristotle. Is there a tension between this rational argument and the mode of perceptual argumentation we saw employed in T4, or are the two modes complementary and grounded in (apparent) empirical phenomena?

On one reading, the rational argument in T5 is simply an extension of Aristotle's empiricism and the premises are themselves supported by empirical induction.³² This reading

³¹ Trans. G. R. T. Ross.

³² Karbowski (2016), 132.

attempts to resolve the tension between reason and perception by identifying the principles used in Aristotle's rational argument as themselves empirical generalizations based on observation, thus downplaying any rationalist elements in his methodology (if not eliminating them entirely). To determine whether this is a plausible reading of the text, we must consider the status of each premise in turn and decide whether each is supported empirically or more plausibly understood as a mere assumption justified independently of any experience. Again, the premises in question are:

The Optimality Principle (OP) – Nature always does what is best from among the possibilities.

The Centrality Principle (CP) – It is best if the source is located in the middle of the substance.

We should note, however, that Aristotle's Centrality Principle in turn seems to depend on a Unity Principle, that it is best if there is one source rather than many. There is evidence external to the argument of *De iuv.* That supports the attribution of such a principle to Aristotle, especially in biological and political sciences. For instance, in his discussion of the heart as the source of the blood vessels in *Parts of Animals*, Aristotle says that the vessels "must necessarily have one primary part. For it is preferable that there shall be one such [primary source], when possible, rather than several" (*PA* III 4, 665b14-15).³³ The same principle is evident in Aristotle's discussion of certain kinds of insect that are capable of surviving after being cut up into pieces. He says in *De iuv.* That the nutritive soul and the principle of sensation are both single in actuality but plural in potentiality, since the segments of divisible animals continue to live and perceive after being divided up (*De iuv.* 2, 468b2-9).³⁴ This leads Aristotle to the strange statement that "[d]ivisible animals are like a number of

³³ Trans. W. Ogle.

³⁴ The segments cannot be preserved, however, since they lack the organs on which the maintenance of life depends, i.e. organs for seizing and receiving food. (468b8-9).

animals grown together, but animals of superior construction behave differently because their constitution is a unity of the highest possible kind” (468b10-13).³⁵ Similarly, he says in *Parts of Animals* IV 5 that “the aim of nature is to give to each animal only one such dominant part [i.e. the seat of sensation]; and when she can, she makes it a unity; when she cannot, a plurality” (Βούλεται μὲν γὰρ ἡ φύσις ἐν πᾶσι μόνον ἔν ποιεῖν τὸ τοιοῦτον, οὐ δυναμένη δ’ ἐνεργεῖα ποιεῖ μόνον ἔν, δυνάμει δὲ πλείω·) (*PA* IV 5, 682a6-8).³⁶ It is clear that Aristotle thinks this principle is operative in biological contexts, working in conjunction with the Optimality Principle, so that most animals have a single source of soul because it is better, and nature always does what is best from among the possibilities. Of course, there are exceptions to the rule, but in such cases there is something preventing nature from assigning a single source. This Unity Principle can be seen at work again in Aristotle’s *Metaphysics*, where he associates the plurality of principles with bad government, citing the *Iliad*: “The rule of many is not good, one ruler let there be” (*Met.* XII 2, 1076a4). Accordingly, we might add the following premise to the argument of *De iuv.* 4.

The Unity Principle (UP) – It is best of there is a single source for each substance.

If we are correct to suppose a hidden Unity Principle at work in T4, the argument as a whole will run as follows.

- P1. Nature always does what is best from among the possibilities. (OP)
(P2. It is best if there is a single source. (UP))
 (C1. There is a single source. (P1, P2))
- P3. It is best if this source is in the middle. (CP)
 C2. The source is in the middle (P1, C1, P3)

³⁵ Trans. W. Ogle.

³⁶ Trans. W. Ogle.

To determine whether this argument is at odds or in tension with the perceptual mode of argumentation, we must first determine the epistemic status of these principles. Are they themselves empirical generalizations based on observation, or are they more accurately described as *a priori* assumptions?

First, let us consider the status of the Optimality Principle, that “Nature always does what is best from among the possibilities.” When Aristotle introduces this principle in the context of T5, he says “we *see* (ὁρῶμεν) that in every case nature does what is best from the possibilities” (469a26). Karbowski suggests that this “seeing” is perceptual rather than intuitive, as the verb ὁρᾶν is typically used by Aristotle in his scientific works to report *perceptual* observations.³⁷ I am skeptical that this is the same sense of “seeing” that we encounter in the perceptual arguments discussed above. Surely we do not see nature acting for the best in the same way we see that insects continue to live following decapitation, or that the heart is the first organ to develop in the egg, or that the veins issue from the heart. But perhaps Aristotle is here using ὁρᾶν in a perceptual but indirect sense, so that we see nature acting for the best in the same way that we see the lunar eclipse caused by the interposition of the Earth.

In her commentary on the *Prior Analytics*, Striker offers an interesting and relevant take on Aristotle’s claim that experience must provide the starting-points about each subject (*Apr.* I 30, 46a17-27). She claims that the application of this method can “at best hold for the limited field of sciences in which it might be possible to start from a fairly complete set of observed facts for which one then seeks scientific explanations and demonstrations.”³⁸ An example of such a field is astronomy, since a great deal of data had been collected and

³⁷ Karbowski (2016), 132-6. See also Henry (2013), 247n39.

³⁸ Striker (2009), 207.

passed down from Egyptian and Babylonian astronomers to the Greeks. However, Striker also notes that “Aristotle’s own example of astronomy offers a counterexample to the claim that all the facts can be collected in advance of scientific treatment, for the assumption that the planets move in circles, as the astronomers of Aristotle’s time believed, is indeed based on observations, but is not itself an observable fact.”³⁹ Similarly, we might say that the Optimality Principle for Aristotle is based on observation but is not itself an observable fact, and in this sense ὁρθῶν might be used in a perceptual but *indirect* sense.⁴⁰

Before moving on, we should briefly note that Karbowski also identifies the rational argument of T5 as a physical (*phusikós*) argument, since it employs the Optimality Principle, which is a “supposition” (ὑπόθεσις) of natural science and therefore a proper or peculiar principle of that science.⁴¹ But to count this as a physical argument we should also have to establish the appropriateness to natural science of the Unity and Centrality Principles—a task which appears more difficult given their apparent use in political and metaphysical discussions.⁴²

Assuming that Karbowski is right about the empirical grounding of the Optimality Principle, we might still ask about the epistemic status of the second and third premises, the Unity Principle and the Centrality Principle. Looking back at T5, we see that Aristotle offers a sub-argument in support of the Centrality Principle. He says that “the two parts of the body (that which prepares the ultimate nutriment and that which receives it) would each accomplish its proper function most if each source was in the middle of the substance; for then the soul will be close to both parts, and the central position of such a capacity will be in

³⁹ Striker (2009), 207.

⁴⁰ For a similar argument regarding Aristotle’s treatment of the sphericity of the Earth, see my treatment of the nature of perceptual argumentation below.

⁴¹ Karbowski (2016), 133.

⁴² *Phusikós* argumentation and its relation to *logikós* argumentation will be considered in detail in Chapter 2.

a position of control (ἄρχοντος χώρα)” (*De imm.* 4, 469a27-b1).⁴³ Accordingly, nature places the source of soul in the center of the organism *because* the parts that prepare and receive nutriment (i.e. the head and the fundament) will best perform their appropriate functions.⁴⁴ Moreover, Aristotle suggests that each part will be better able to perform its function because the source of soul will be equidistant from both parts, occupying a “position of control” (ἄρχοντος χώρα). If the source of soul were located in the head, it would impede the function of the fundament; if it were located in the fundament, it would impede the function of the head. So, Aristotle claims, it must be located in the center of the organism.

What are we to make of this justification? Why does Aristotle think the center is the position of power and its equidistance from the head and fundament functionally superior to an alternative placement? This seems to presuppose the Unity Principle, since we could instead posit multiple principles, such that one occupies each of the three sections of the organism, so that the functions of the head and fundament remain unimpeded. Indeed, the view that attributes multiple distinctly located sources of soul to the body is not obviously problematic and Aristotle would have been familiar with something like this view from Plato’s *Timaeus*. In his discussion of the constitution of the human body, Plato locates the different kinds (or parts) of soul in different organs: the rational soul (or the “immortal origin of the soul” (ἀρχὴν ψυχῆς ἀθάνατον), 69c5) is said to reside in the brain, while the different parts of the mortal soul—the spirited and the appetitive—are located in the heart and the stomach respectively (*Timaeus* 69c-71e). So Aristotle’s assumption that the center is a

⁴³ Trans. G. R. T. Ross.

⁴⁴ It is necessary that animals get nutriment from an external source, and that it is converted into the ultimate nutriment (i.e. blood) which is then distributed to the various parts (*PA* 4.4, 678a6ff.). Ross notes that, although Aristotle regarded the heart as the supreme organ which exercises control over the process of digestion, he recognized that other organs also do their part in this: the blood is converted in the mammary organs into milk (*GA* 4.8, 776b31-34), in the generative organs into semen (*GA* 1.11, 719a35-b4), and in all parts of the body into fat (*PA* 652a6-10). See Ross (1955), 302.

functionally superior location for the source is at odds with Plato's mature view of the matter. Similarly, his assumption that there can only be one source is at odds with Plato, unless each part has its own single source. The justification of the Centrality Principle with reference to the improved functionality of the head and fundament cannot be wholly empirical, then, since there are other models that seem to allow the head and fundament to complete their functions equally well. The difference is that Aristotle assumes principles of Unity and Centrality, whereas Plato allows for multiple sources located throughout the body.⁴⁵

We have now seen how Aristotle employs perceptual and rational argumentation in support of the cardiocentrist thesis in *De iuv.* Moreover, we have seen that his rational proof depends on principles about optimality, centrality, and unity, and although the Optimality Principle might be justified empirically (though not in a direct sense), the text of *De iuv.* Seems to leave the status of the Centrality and Unity Principles underdetermined. Aristotle says that nature acts for the best by placing the source of soul in the center of the organism because this allows for the improved functionality of the upper and lower parts, but we have seen that this in turn depends on the Unity Principle and the assumption that a single source is better than many. In the next section, I turn to Aristotle's use of these principles in the *Parts of Animals* and elsewhere for further insight into his justification for the claim that the middle of a thing is the best location for its source, and that a single source is better than

⁴⁵ Karbowski makes little of Aristotle's point about the improved functionality of the head and fundament. On Karbowski's reading, Aristotle is silent on the status and justification of the Centrality Principle and offers no defense of this presupposition, but Karbowski thinks we should not take this silence as evidence in support of an *a priori* reading. The principle might be taken as self-evident, but Aristotle might also think it derives its obviousness from our ordinary experience with systems that have a single origin or source (in which case the proof will be ultimately empirical), or from common opinion (in which case it will be dialectical). Accordingly, the epistemic status of the Centrality Principle is textually underdetermined between the *a priori*, empirical, and dialectical readings. See Karbowski (2016), 137n51.

many. Moreover, I argue that these principles are not empirically grounded, but are better understood as *a priori* assumptions that bias Aristotle's observations.

1.3 CARDIOCENTRISM IN *PARTS OF ANIMALS* III 4

In *Parts of Animals* III 4 we find Aristotle again employing the distinction between perceptual and rational argumentation in defense of the thesis that the source of soul is located in the heart. However, in *PA* this distinction in method comes in the context of a larger argument defending the view that the heart is also the source of the blood vessels, and indeed of the blood itself. Aristotle is here arguing in response to those who identify the brain with the source, contrasting his own cardiocentrism with the more popular cephalocentrism of Plato and the Hippocratics.⁴⁶ As in *De imm.*, he makes use of the evidence provided by observation and dissection which suggests that the heart is the first part to be formed, and that it straightaway (εὐθέως) contains blood.⁴⁷ From here, Aristotle moves to his defense of the thesis that the heart is the source of sensation.⁴⁸

[T6] And this is in accordance with our account (κατὰ τὸν λόγον). [1] For the source (ἀρχὴν) must, whenever possible, be one; and, of all places, the best suited for a source is the center. For the center is one, and is equally or almost equally within reach of every part. [2] Again (Ἐτι δ'), as neither the blood itself, nor yet any part which is bloodless, is endowed with sensation, it is plain that that part which first has blood, and which holds it as it were in a receptacle, must be the primary source. And that this part is the heart is not only a rational inference (κατὰ τὸν λόγον), but it is also evident to the

⁴⁶ See *HA* III 3, 513a10-15. Aristotle notes that the investigation of the subject is "one fraught with difficulties."

⁴⁷ *PA* 3.4, 666a10ff. See also *GA* 2.1, 734a21-5; 5, 741b15-24; *HA* 6.3, 561a4-562a21. Lennox (2002) finds this argument incomplete and "presumably the missing premiss is that the blood could not originate elsewhere, since there is no organ prior to the heart in development" (257).

⁴⁸ In his discussion of hearing in *Generation of Animals*, Aristotle says that "the passages of all the sense-organs, as has been said in the treatise on sensation, run to the heart, or to its analogue in creatures that have no heart. The passage of the hearing, then, since this sense-organ is of air, ends at the place where the innate breath causes in some animals the pulsation and in others respiration" (*GA* V 2, 781a20-25; trans. A. Platt).

senses (κατὰ τὴν αἴσθησιν).⁴⁹ [3] For no sooner is the embryo formed, than its heart is seen in motion as though it were a living creature (καθάπερ εἰ ζῶον), and this before any of the other parts, it being, as thus shown, that starting-point of their nature (ἀρχὴ τῆς φύσεως) in all animals that have blood. (PA III 4, 666a13-22)⁵⁰

Οὕτω δ' ἔχει καὶ κατὰ τὸν λόγον· ἀρχὴν γὰρ εἶναι δεῖ μίαν ὅπου ἐνδέχεται. Εὐφυέστατος δὲ τῶν τόπων ὁ μέσος· ἐν γὰρ τὸ μέσον καὶ ἐπὶ πᾶν ἐφικτὸν ὁμοίως ἢ παραπλησίως. Ἔτι δ' ἐπεὶ οὔτε τῶν ἀναίμων οὐθὲν αἰσθητικὸν οὔτε τὸ αἷμα, δῆλον ὡς τὸ πρῶτον ἔχον ὡς ἐν ἀγγείῳ δ' ἔχον ἀναγκαῖον εἶναι τὴν ἀρχὴν. Οὐ μόνον δὲ κατὰ τὸν λόγον οὕτως ἔχει φαίνεται, ἀλλὰ καὶ κατὰ τὴν αἴσθησιν· ἐν γὰρ τοῖς ἐμβρύοις εὐθέως ἢ καρδία φαίνεται κινουμένη τῶν μορίων καθάπερ εἰ ζῶον, ὡς ἀρχὴ τῆς φύσεως τοῖς ἐναίμοις οὔσα.

We might helpfully divide this passage into three sections. Sections [1] and [2] offer two distinct rational arguments, while section [3] offers a rather straightforward perceptual argument. Lennox takes τὸν λόγον at 666a13 to refer to the account given earlier at 665b14-23 and reiterated here: “that there should be one source where possible and that it should be in the middle of the body.”⁵¹ In other words, on Lennox’s reading Aristotle’s rational argument employs the Unity and Centrality Principles in tandem to show that the (single) source of soul should be located in the center of the organism. However, given Aristotle’s use of the κατὰ τὸν λόγον designation elsewhere, and the contrast with the proof κατὰ τὴν αἴσθησιν at 666a20, we are better off taking this as a regular occurrence of the mode of rational argumentation meaning something closer to “by reason” and not referring to a specific “account” present in the text.

⁴⁹ “Notice that this is not the stronger claim that these observations provide additional *evidence* for this claim, only that they are consistent with it” (Lennox (2002), 258) But again the question remains, if the rational argument is not contributing additional support to Aristotle’s thesis, then what is it doing?

⁵⁰ Trans. W. Ogle.

⁵¹ Lennox (2002), 257.

According to the perceptual argument [3] in T6, observation shows that the heart is the first part of the embryo in motion.⁵² This argument appears to rely on the assumption that the first part in motion will be the source, but given Aristotle’s definition of nature as “a principle or cause of being moved and of being at rest in that to which it belongs primarily, in virtue of itself and not accidentally,” the assumption seems fair.⁵³ We also have two rational arguments for the conclusion that the source of sensation—or indeed the source of *nature* (ἀρχὴ τῆς φύσεως)—in blooded animals is the heart (and in bloodless animals, whatever is analogous to the heart). The argument [2] in T6 depends in part on the thesis that the heart is the source of the blood. For the blood is not itself able to perceive (666a16), but it conveys the data of perception so the primary vessel of the blood (i.e. the heart) must be the origin of perception (666a13).⁵⁴ The other rational argument [1] in T6 more closely resembles that put forward in *De iuv.* For the same conclusion. It depends in part on the Unity and Centrality Principles: the source must be *one* and located in the middle of a thing, since this is equally accessible in all directions. In his commentary on this passage, Lennox notes that Aristotle does not explain why one source is better than many and makes the following suggestion: “Perhaps his chief concern is unity: In order that an organism act in a co-ordinated manner, a single origin for the blood—which he had already claimed as the source of perception, locomotion, and nutrition—is preferable.”⁵⁵ Surely Aristotle is concerned with the unity of the organism, but the question remains whether the Unity and

⁵² Cf. *GA* 2.1, 734a21-5; 2.4, 740a5ff.; 2.5, 741b15-24; *HA* 5.3, 513a13-15; 6.3, 561a4-562a21.

⁵³ *Pb.* II 1, 192b20-22 (trans. R. P. Hardie and R. K. Gaye).

⁵⁴ Lennox rightly points out that the argument in *PA* III 4 relies upon the unstated premise that the blood conveys the data of perception and directs us to *PA* II 3, 650b2-8 for more on the inability of blood to perceive (2002, 257).

⁵⁵ Lennox (2001), 56.

Centrality Principles are themselves empirically grounded, or whether they are *a priori* assumptions that bias Aristotle's observations.

The prominence of the Unity and Centrality Principles in Aristotle's defense of cardiocentrism is obvious throughout *PA* III 4. When he introduces us to the cephalocentrists at 665b27, Aristotle gives a number of reasons why they are wrong to think the vessels commence in the head. The most interesting for our purposes is the first: "For in the first place, according to their representation, there would be many sources (πολλὰς ἀρχὰς) for the vessels, and these scattered (διεσπαρμένας ποιοῦσιν)" (*PA* III 4, 665b27).⁵⁶ Cephalocentrism violates the Unity Principle by assigning the vessels multiple sources, and the Centrality by locating these sources in different parts of the body rather than the center. Again, at 666a26-28 Aristotle rules out the liver as the primary organ because its position is not central and the organ is counterbalanced by the spleen.

[I7] It is true that sanguineous animals also invariably have a liver.⁵⁷ But no one could ever deem the liver to be the primary organ either of the whole body or of the blood. For the position in which it is placed is far from being that of a primary part (κεῖται γὰρ οὐδαμῶς πρὸς ἀρχοειδῆ θέσιν); and, moreover, in the most perfectly finished animals there is another part, the spleen, which as it were counterbalances it. (*PA* III 4, 666a24-28)⁵⁸

Ἐπάρχει δὲ καὶ τὸ ἥπαρ πᾶσι τοῖς ἐναίμοις· ἀλλ' οὐθεὶς ἂν ἀξιόσειεν αὐτὸ ἀρχὴν εἶναι οὔτε τοῦ ὅλου σώματος οὔτε τοῦ αἵματος· κεῖται γὰρ οὐδαμῶς πρὸς ἀρχοειδῆ θέσιν, ἔχει δ' ὥσπερ ἀντίζυγον ἐν τοῖς μάλιστα ἀπηκριβωμένοις τὸν σπλῆνα.

So again we must wonder: how does Aristotle think these principles are justified? As we have seen with respect to the Centrality Principle, Karbowski suggests that this might be a

⁵⁶ Trans. W. Ogle.

⁵⁷ In *Generation of Animals* IV 4, Aristotle confronts the fact that some animals lack certain internal parts or possess them in a mutilated condition. However, he claims that no (blooded) animal has ever been born without both a heart and a liver, although there have been cases where the liver is 'incomplete' (771a3-5).

⁵⁸ Trans. W. Ogle.

generalization from our experience with systems that have a single origin, and in this way, we might resolve the tension and find a consistent empiricism in Aristotle’s method.⁵⁹ But just prior to Aristotle’s use of perceptual and rational argumentation in *PA* III 4, Aristotle makes the following point about the heart’s location:

[T8] Moreover, it [the heart] is situated in an originative place (ἀρχικὴν χώραν). For nature, when no other more important purpose stands in her way, places the more honourable part in the more honourable position (ἐν τοῖς γὰρ τιμιωτέροις τὸ τιμιώτερον καθίδρυκεν ἢ φύσις); and the heart is near the middle (περὶ μέσον), but more above than below, and more in front than behind. (*PA* III 4, 665b18-22)⁶⁰

Ἔχει δὲ καὶ ἡ θέσις αὐτῆς ἀρχικὴν χώραν· περὶ μέσον γάρ, μᾶλλον δ’ ἐν τῷ ἄνω ἢ κάτω καὶ ἔμπροσθεν ἢ ὀπίσθεν· ἐν τοῖς γὰρ τιμιωτέροις τὸ τιμιώτερον καθίδρυκεν ἢ φύσις, οὐ μὴ τι κωλύει μεῖζον.

Those familiar with Aristotle’s biology know that he will occasionally rely on the natural superiority or “honourability” of certain directions in explaining the placement of certain parts of the body. As we see here, above is more honourable than below and the front more honourable than the rear. But Aristotle will usually include the superiority of right over left in addition. So a little earlier in *PA*, he makes the following point about the location of ‘what is better’.

[T9] And generally, where nothing greater impedes, what is better and more honourable is always, in the case of above and below, present more in things that are above; in the case of front and rear, more in things front; and in the case of right and left, more in things on the right. (*PA* III 3, 665a22-26)⁶¹

Ὅπως δ’ αἰεὶ τὸ βέλτιον καὶ τιμιώτερον, ὅπου μὴ τι μεῖζον ἕτερον ἐμποδίζει, τοῦ μὲν ἄνω καὶ κάτω ἐν τοῖς μᾶλλον ἔστιν ἄνω, τοῦ δ’

⁵⁹ To be fair, Karbowski also admits that the Centrality Principle might be *a priori* or dialectical and finds the texts of *De inv.* to be underdetermined between these options and the empirical reading. However, the inclination to argue for the possibility of an empirical reading indicates the desire to eliminate the rationalist elements from Aristotle’s methodology.

⁶⁰ Trans. W. Ogle.

⁶¹ Trans. W. Ogle.

ἔμπροσθεν καὶ ὀπίσθεν ἐν τοῖς ἔμπροσθεν, τοῦ δεξιοῦ δὲ καὶ ἄριστεροῦ ἐν τοῖς δεξιοῖς.

As we saw in T8, Aristotle admits that the heart (and therefore the source of the soul) is not, strictly speaking, in the middle and equally accessible in all directions, contrary to what he asserts in his rational arguments in both *De iuv.* And *PA*. Instead, it is more above and in front—and this is in accordance with the sentiment expressed in T9. But interestingly, Aristotle does not think the heart is on the right, even though by his own doctrine the right is more honourable than the left. This is because he was confronted by the obvious *empirical* difficulty that in human beings the heart is not more on the right, or even in the center—it is more on the left. And Aristotle explicitly recognizes this fact in the *History of Animals*

[T10] With all animals that are furnished with these parts, the parts are similarly situated, and with the exception of man, the heart is in the middle; in man, however, as has been observed, the heart is placed a little to the left-hand side. (*HA* II 17, 506b32-507a2)⁶²

Τῇ δὲ θέσει, ὅσα ἔχει ταῦτα τὰ μόρια, ὁμοίως κείμενα ἔχει, τὴν τε καρδίαν περὶ τὸ μέσον, πλὴν ἐν ἀνθρώπῳ· οὗτος δ' ἐν τῷ ἄριστερῷ μᾶλλον μέρει, καθάπερ ἐλέχθη πρότερον.

This is particularly problematic, since in man alone “the natural parts hold the natural position” (*PA* II 10, 656a13).⁶³ Aristotle begins his investigation into the parts of animals by looking at the parts of the human being, not only because our interactions with the human body (at least externally) are much easier and more frequent than with other organisms, but also because human beings are “natural in a higher degree” than other animals (*LA* 706a19).

Faced with this difficulty, we might expect Aristotle to abandon the view that the right is more honourable than the left. But instead, he doubles down and makes the *ad hoc*

⁶² Trans. d'A. W. Thompson.

⁶³ See also *De iuv.* 1, 468a5: “To men in particular among the animals, on account of his erect nature, belongs the characteristic of having his upper parts pointing upwards in the sense in which that applies to the universe, while in the others these are in an intermediate position” (trans. G. R. T. Ross). Cf. *LA* 4, 705a30-1.

and *empirically false* claim that the left side is naturally cooler than the right, so that the heart (which contains the “vital heat”) must be on the left to counterbalance the natural chill of the left side of the body.

[T11] But while the heart in the other animals is in the middle of the chest, in human beings it inclines slightly to the left, in order to balance the cooling of things on the left; for much more than the other animals, in mankind the parts on the left are cold. (*PA* III 4, 666b6-10)⁶⁴

Ἔστι δ' ἡ καρδία τοῖς μὲν ἄλλοις ζώοις κατὰ μέσον τοῦ στήθικοῦ τόπου, τοῖς δ' ἀνθρώποις μικρὸν εἰς τὰ εὐώνυμα παρεγκλίνουσα πρὸς τὸ ἀνισοῦν τὴν κατάψυχιν τῶν ἀριστερῶν· μάλιστα γὰρ τῶν ἄλλων ζώων ἄνθρωπος ἔχει κατεψυγμένα τὰ ἀριστερά.

Surely the claim that the left side is naturally cooler than the right has no empirical basis.

Indeed, it is unclear how we could ever determine empirically that the left side is cooler since the heat of the heart is supposed to counterbalance the chill, making both sides the same temperature.⁶⁵ This is rightly observed by Lloyd, who says “[o]n this occasion, when he encounters an obvious and important fact which apparently runs counter to his doctrine of the superiority and greater nobility of the right-hand side, he does not abandon that doctrine, but refers to a second arbitrary assumption, the purely imaginary distinction between the temperature of the two sides of the body.”⁶⁶ The fact that the heart is on the left side in human beings, however, runs counter not only to Aristotle’s doctrine of the superiority of the right, but also to the Centrality Principle, which places the source in the centre. Aristotle admits that, in most animals, the heart is in the centre. If it were to incline to either side,

⁶⁴ Trans. W. Ogle.

⁶⁵ One might object that we can in fact establish the natural chill of the left side by discovering the relative contributions of the heart to the right and left sides of the body. But this is not what Aristotle does (or even claims to do). One might also contest the claim that Aristotle is thinking of heat in the literal temperate sense, but I think this is clear from his claim elsewhere that “an animal is by nature human and warm, and to live is to be of such a constitution, while old age is dry and cold, and so is a corpse” (*De Long.* 5, 466a18-20).

⁶⁶ Lloyd (1966), 53.

given the doctrine of the superiority of the right, we should expect it to incline to the right side. But it inclines to the left instead.

Lennox, in his commentary on the *Parts of Animals*, brings against Lloyd a charge of confusion on this point. He argues: “As it [the heart] is never thought of by Aristotle as on the right, *PA* 666b6 cannot be considered a special argument to show why it is not on the right in man, as Lloyd suggests. The right side is more honorable, because the more honorable is whichever side originated motion—but this normative claim can only be used to explain facts having to do with motion.”⁶⁷ Lennox seems to object to Lloyd’s reading on the basis that the doctrine of the superiority of the right is a wholly normative doctrine that explains facts of motion. And indeed, we see the doctrine put to such use in Aristotle’s *De Incessu Animalium*. On Lennox’s view, Aristotle’s biological concepts of direction are defined by function, not by cosmic orientation: upper and lower are defined by the reception of food and expulsion of waste (*Juv.* 468a2-4; *LA* 705a30-b6; *PA* 686b35); backward and forward are defined by the orientation of the sense organs (*Juv.* 467b31-34, *LA* 705b10-13); right and left are defined by the location of the origin of locomotion (*LA* 705b17-18). According to Lennox, Aristotle predicates ‘honourable’ of the front *because* that is the direction of locomotion and perception. Thus, the principle that the front is more honourable “is not a basic principle of biology; it is to be explained by principles having to do with basic organic activities.”⁶⁸ On Lennox’s view, then, honourability is predicated of whatever is the origin of organic activity; and since the origins of organic activity belong to certain positions more than others, honourability is predicated more of certain positions (i.e. the front, upper, and right).⁶⁹

⁶⁷ Lennox (2001a), 278n39.

⁶⁸ Lennox (2001b), 269.

⁶⁹ Lennox (2001b), 269.

Although Lennox offers a very thorough and convincing account of Aristotle's doctrine of the biological concepts of direction, I think he misses the point of Lloyd's observation. The location of the heart on the left side of human beings does not only run counter to what we would anticipate, given Aristotle's doctrine of the superiority of the right side over the left. It also runs counter to his doctrine, made explicit in *De iuv.* And *PA*, that the source of soul is located in the center of the organism because this is equally accessible in all directions. This discrepancy cannot be so easily dismissed with a charge of confusion over the normativity of Aristotle's doctrine of biological direction. For, the discrepancy extends beyond this doctrine to more general and foundational commitments about Centrality and Unity—commitments which are not likely reducible to normative doctrine. Lennox's view also seems problematic because Aristotle often proclaims that the heart is the origin of organic activity (including growth, nutrition, and perception), and guided by the Centrality Principle, he thinks that the heart, as the origin of organic activity, belongs to the center more than these other direction.⁷⁰ So, on Lennox's reconstruction, the center, rather than the right or front, ought to be the most honourable position.

We have now seen Aristotle's use of perceptual and rational arguments in support of the cardiocentric thesis in *PA* III 4. As in *De iuv.*, he here appeals to the Unity and Centrality Principles to argue that the heart—not the brain or liver—is the source of soul in all blooded animals (and what is analogous in the bloodless). We have also seen how these principles might conflict with Aristotle's doctrine of the superiority or greater honourability of certain directions over others. Moreover, we have seen how, when confronted with the difficulty of the placement of the heart in human beings, Aristotle makes the *ad hoc* and empirically false

⁷⁰ Aristotle normally locates the heart in the centre of the organism, at least close to the centre, since Aristotle admits that the heart inclines slightly up and to the front).

claim that the left side is cooler than the right. Let us now turn to Aristotle's defence of cardiocentrism in the *Generation of Animals* to consider another series of perceptual and rational arguments that speak against the thoroughgoing empiricist readings of this distinction.

1.4 CARDIOCENTRISM IN *GENERATION OF ANIMALS* II 4–5

We have seen Aristotle's defence of cardiocentrism throughout *De iuv.* 2–4 and *PA* III 4. He uses perceptual and rational argumentation to prove that the heart is the location of the source of soul in all blooded animals. Moreover, I have shown that Aristotle's rational arguments often rely upon *a priori* assumptions, such as the Unity Principle (that every organism has a single source) and the Centrality Principle (that the source is located in the center). Aristotle's defence of cardiocentrism continues in Book II of his *Generation of Animals* where again he invokes the distinction between rational and perceptual argumentation. To provide some context to the discussion: Aristotle is defending the claim that male animals that do not emit semen nonetheless exert the same formative power on the material provided by the female by a movement within themselves in that part from which the semen is secreted. He claims that this region is near the diaphragm in all animals that have one, for “the heart or its analogue is the first principle of a natural body, while the lower part is a mere addition for the sake of it” (ἀρχὴ γὰρ τῆς φύσεως ἡ καρδία καὶ τὸ ἀνάλογον, τὸ δὲ κάτω προσθήκη καὶ τούτου χάριν.) (*GA* II 4, 738b16-18).⁷¹

⁷¹ Trans. A. Platt.

From here, Aristotle continues with his discussion of the early stages of development, arguing for the thesis that the heart is the first part differentiated in actuality. To begin, he compares the embryo (τὸ κήμα) to the seeds of plants: the seed contains “the first principle of growth” in itself (ἡ μὲν γὰρ ἀρχὴ καὶ ἐν τοῖς σπέρμασιν ἐν αὐτοῖς ἐστὶν ἡ πρώτη, 739b35); at first, this exists only potentially, but when it becomes differentiated and actualized, the shoot and root are then sent off from it. In the same way, all the parts exist potentially in the embryo, but “the first principle is furthest on the road to realization” (ἀρχὴ πρὸ ὁδοῦ μάλιστα ἐνυπάρχει, 740a3). At this point, Aristotle introduces his familiar distinction.

[T12] Therefore the heart is first differentiated in actuality. This is clear not only to the senses (for it is so) but also on theoretical grounds. For whenever the young animal has been separated from both parents it must be able to manage itself, like a son who has set up house away from his father. Hence it must have a first principle from which comes the ordering of the body at a later stage also, for if it is to come in from outside at a later period to dwell in it, not only may the question be asked at what time it is to do so, but also we may object that, when each of the parts is separating from the rest, it is necessary that this principle should exist first from which comes growth and movement to the other parts. (That is why all who say, as did Democritus, that the external parts of animals are first differentiated and the internal later, are much mistaken; it is as if they were talking of animals of stone or wood. For such as these have no principle of growth at all, but all animals have, and have it within themselves.) Therefore it is that the heart appears first distinctly marked off in all the sanguinea, for this is the first principle of both homogeneous and heterogeneous parts, since from the moment that the animal or organism needs nourishment, from that moment does this deserve to be called its principle. For that which exists grows, and the nutriment, in its final stage, of an animal is the blood or its analogue, and of this the blood-vessels are the receptacle, and that is why the heart is the principle of these also. (This is clear from the *Histories* [*HA* III 3] and the *Anatomies*.) (*GA* II 4, 740a4-23)⁷²

⁷² Trans. A. Platt.

διὸ ἀποκρίνεται πρῶτον ἡ καρδία ἐνεργείᾳ. Καὶ τοῦτο οὐ μόνον ἐπὶ τῆς αἰσθήσεως δῆλον (συμβαίνει γὰρ οὕτως) ἀλλὰ καὶ ἐπὶ τοῦ λόγου· ὅταν γὰρ ἀπ' ἀμφοῖν ἀποκριθῆ δεῖ αὐτὸ αὐτὸ διοικεῖν τὸ γενόμενον καθάπερ ἀποικισθὲν τέκνον ἀπὸ πατρός. ὥστε δεῖ ἀρχὴν ἔχειν ἀφ' ἧς καὶ ὕστερον ἡ διακόσμησις τοῦ σώματος γίνεταί τοις ζώοις. Εἰ γὰρ ἔξωθεν ποτ' ἔσται καὶ ὕστερον ἐνεσομένη οὐ μόνον διαπορήσειεν ἂν τις τὸ πότε, ἀλλ' ὅτι ἀνάγκη, ὅταν ἕκαστον χωρίζεται τῶν μορίων, ταύτην ὑπάρχειν πρῶτον ἐξ ἧς καὶ ἡ αὔξησις ὑπάρχει καὶ ἡ κίνησις τοῖς ἄλλοις μορίοις. Διόπερ ὅσοι λέγουσιν, ὥσπερ Δημόκριτος, τὰ ἔξω πρῶτον διακρίνεσθαι τῶν ζώων, ὕστερον δὲ τὰ ἐντός, οὐκ ὀρθῶς λέγουσιν, ὥσπερ ξυλίνων ἢ λιθίνων ζώων· τὰ μὲν γὰρ τοιαῦτ' οὐκ ἔχει ἀρχὴν ὅλως, τὰ δὲ ζῶα πάντ' ἔχει καὶ ἐντός ἔχει. Διὸ πρῶτον ἡ καρδία φαίνεται διωρισμένη πᾶσι τοῖς ἐναίμοις· ἀρχὴ γὰρ αὕτη καὶ τῶν ὁμοιομερῶν καὶ τῶν ἀνομοιομερῶν. ἤδη γὰρ ἀρχὴν ταύτην ἄξιον ἀκοῦσαι τοῦ ζώου καὶ τοῦ συστήματος ὅταν δέηται τροφῆς· τὸ γὰρ δὴ ὄν αὐξάνεται. Τροφή δὲ ζώου ἢ ἐσχάτη αἷμα καὶ τὸ ἀνάλογον, τούτων δ' ἀγγεῖον αἱ φλέβες· διὸ ἡ καρδία καὶ τούτων ἀρχή. Δῆλον δὲ τοῦτο ἐκ τῶν ἱστοριῶν καὶ τῶν ἀνατομῶν.

Aristotle takes himself to have established cardiocentrism, or at least the thesis that the heart is first differentiated in actuality, on perceptual grounds. He now moves to show that the same conclusion holds on the basis of rational argumentation. His rational argument begins with the assumption that the embryo separated off from its parents must be able to manage itself. To support this claim, Aristotle draws an analogy between the embryo and the young man who moved out on his own for the first time. Just as the young man must be able to manage his household on his own without the aid of his parents, so too the newly formed embryo must be able to manage its growth and development without the aid of its parents. From this, it follows that the embryo must have a first principle or source responsible for the ordering of the body throughout the later stages of development. This source, Aristotle thinks, is located in the heart. Thus, the heart is the first organ, containing the source of soul, which is then responsible for the growth of all other parts in the course of development (and, ultimately, for sensation, reproduction, etc.).

One might object that the source responsible for the ordering of the body at the later stages comes from outside at those later stages. However, Aristotle anticipates and responds to this objection asking first at what time the source enters. Moreover, he claims that during the initial stages of development, when individual organs are separating off from one another, there must necessarily be an initial source from which comes the growth and movement to the other parts. Aristotle takes this as additional support for the view that the internal organs are the first to develop, in opposition to the Democritean view that the external parts are first differentiated.

Bourgey, who back in T2 so clearly formulates the tension between reason and perception in Aristotle's thought, offers the following summary of the argument in T12:

[T13] "Since the heart of an animal supplies the basis of its development as a living being, when the embryo starts to take shape on its own, it must necessarily possess the organ which forms this basis, as all parts of the animal derive their existence and growth from it."⁷³

If this is a correct reformulation of Aristotle's reasoning, we should wonder what he thinks is the status of the first premise, namely that the heart supplies the basis of the organisms' development. On Bourgey's reading, Aristotle does not set out to prove the thesis that identifies the heart as the source of soul. Rather, he assumes this thesis and argues that the heart, since it is the source of soul, must be the first organ generated and from which the rest of the animal comes to be.

An alternative reading of the rational argument in T12 has been offered by Hankinson, who thinks that Aristotle assumes only that *some* organ must be first in the process of development, and that this organ will be the location of the source of soul.

[T14] 'It is clear a priori that some organ must develop first, which is subsequently responsible for the creature's further development: its own internal principle of change and growth must appear as soon as

⁷³ Bourgey (1975), 182/121.

the semen has induced its distinctive form-producing motions into the menstrual fluid, for only thus can the animal function independently. But that this first directing principle is the heart is learned from observation; and in general theory must answer to the empirical data.' (Hankinson 1998, 172)

Note that on Hankinson's reading, even though the cardiocentric thesis that locates the source of soul in the heart is itself determined empirically, presumably through the various perceptual arguments offered by Aristotle elsewhere, the rational argument of T12 still involves the use of an *a priori* assumption that itself has no empirical justification. Aristotle assumes that the interaction of sperm and menstrual fluid, when successful, must give rise to a *single* organ to house the organisms' source of soul. So here again we find the Unity Principle at work in Aristotle's defence of cardiocentrism.

We have now seen several instances of Aristotle employing the distinction between rational and perceptual argumentation in his defence of cardiocentrism. I have argued that rational arguments seem to be given at greater or lesser degrees of abstraction. In some cases, they employ premises that are empirically grounded and specific to a given domain. But in many cases, Aristotle's rational arguments depend on principles, such as the Centrality and Unity Principles, that are better understood as *a priori* assumptions common to many different areas of investigation. Before we return to consider the question of how this squares with the traditional narrative of Aristotle as the empiricist opponent of Plato the rationalist, let us first further investigate the nature of perceptual argumentation. In the next section, I will argue that perceptual arguments, too, admit of a similar imprecision: some are very straightforward and direct observations of empirical phenomena, while others rely on indirect observation and certain theoretical presuppositions.

1.5 PERCEPTUAL ARGUMENTATION

We find the distinction between perceptual and rational argumentation employed throughout Aristotle's corpus to support a number of controversial scientific theses. We have seen how Aristotle utilizes this distinction to establish his own cardiocentrism—the thesis that the heart is the location of the source of the soul. Moreover, after evaluating a few instances of these kinds of proof, I have suggested that in the case of rational argumentation, while some premises may be empirically grounded (such as the Optimality Principle), others are more plausibly read as *a priori* assumptions that occasionally bias Aristotle's observations of the phenomena. Specifically, I have tried to make the case for reading the Unity and Centrality Principles as *a priori* assumptions held by Aristotle in light of contrary empirical evidence.

Although we have focused primarily on his defence of cardiocentrism, Aristotle employs rational arguments in conjunction with perceptual arguments in order to support a variety of controversial scientific theses. And while some rational arguments proceed from principles that are themselves empirically grounded, we have seen that some proceed instead from principles that are more accurately described as *a priori*. We turn now to examine in further detail the nature and use of perceptual arguments in Aristotle's natural science.

The importance of perceptual argumentation for our understanding of Aristotle's philosophical outlook cannot be understated. He is, after all, taken by many to be a champion of empiricism in the ancient world. In contrast to Plato, who is supposed to have practiced the "armchair" style of philosophy for which the discipline is often criticized, Aristotle went out into the world and engaged in scientific research informed by observation. In what follows I attempt to draw out the nature and role of perceptual argumentation in

Aristotle's natural science and show in what sense the label of empiricist might rightly be applied.

In this section, I analyze and develop a more accurate and qualified characterization of perceptual argumentation in Aristotle's natural science. I argue that, like many other scientists throughout history, he fell victim to the theory ladenness of observation.⁷⁴ In particular, *De Caelo* II 14 offers a clear example of the distinction between rational and perceptual arguments that can help to further enlighten us on their nature and use. This text has been neglected in the scholarship and, I argue, offers a more nuanced picture of perceptual argumentation.

On one reading, perceptual argumentation operates by simply putting forward some empirical datum gathered through sense perception or "read off the world" in order to support some otherwise controversial scientific thesis. Rational arguments, by contrast, involve some degree of inference, showing how the conclusion follows necessarily from certain universal principles. In his study of optimality reasoning in Aristotle's natural science, Henry makes a first (albeit brief) pass at characterizing perceptual arguments as those which establish their conclusions "inductively by appealing to what is observable."⁷⁵ On this view, the status of the premises of a rational argument is irrelevant to its being cast as a case of rational argumentation. Even if a rational argument uses empirically-grounded principles, the *reasoning* Aristotle uses to establish the conclusion is not empirical, but rather depends on making a rational inference. The truth of the conclusion in a rational argument depends on

⁷⁴ The theory ladenness of observation is a view held in various forms by Kuhn (1962, 123-124), Hanson (1958) and Feyerabend (1959). It posits that "[d]ata production (including experimental design and execution) is heavily influenced by investigator's background assumptions. Sometimes these include theoretical commitments that lead experimentalists to produce non-illuminating or misleading evidence. In other cases they may lead experimentalists to ignore, or even fail to produce useful evidence" (Bogen (2017)).

⁷⁵ Henry (2013) 252.

the logical connections between the premises, whereas in a perceptual argument the conclusion is just a matter of fact and does not require an act of inference to be established.

Although this reading contrasts nicely with the understanding of rational argumentation as discursive reasoning from universal principles, Henry's characterization is problematic for at least two reasons.⁷⁶ First, induction (*epagōgē*) is itself a large and thorny issue in Aristotelian scholarship and it is notoriously difficult to get clear on what it means to establish a thesis inductively for Aristotle.⁷⁷ Second, as I will argue below, the observations to which Aristotle appeals are often determined by certain theoretical presuppositions to which he is committed. This is not a problem with Henry's characterization *per se*, but rather an important qualification. A similar point can be made about Karbowski's characterization of perceptual arguments as those which show that a thesis "harmonizes with specific empirical data about the subject of investigation."⁷⁸ Again, this view must be qualified, since what Aristotle counts as "empirical data" is often determined by his theoretical commitments.⁷⁹

If we look more closely at Aristotle's use of perceptual arguments, we see that this cannot be the full story. Even when perceptual arguments are put forward in conjunction with rational arguments, the former might still involve some degree of rational inference. In other words, sensory arguments are not always perceptually given, although we might think that Aristotle intends them to be in some instances, especially when we consider the

⁷⁶ Since Henry's focus is on Aristotle's use of optimality reasoning in *De Iuv.* 4, he leaves the nature of perceptual argumentation underdeveloped. What follows is thus a critique of what one might read into his characterization of perceptual argumentation rather than a critique of the characterization itself.

⁷⁷ See, for instance, Groarke (2009).

⁷⁸ Karbowski (2016), 124.

⁷⁹ Karbowski is careful, however, to distinguish between direct and indirect perceptual arguments. The former show that "a thesis best explains some recalcitrant empirical datum," while the latter "show that a thesis is directly verified by empirical data" (2016, 124). He cites as examples of indirect perceptual arguments *De Caelo* II 14, 297b23-30 and *De iuv.* 2, 468a20-8; and as examples of direct perceptual arguments *Meteor.* II 5, 362b19-27; *PA* II 8, 653b30-6; and *PA* III 4, 666a13018. "Nonetheless, all perceptual arguments proceed by revealing the fidelity of a thesis to specific empirical data about the subject under investigation" (124).

arguments he gives in support of cardiocentrism (e.g. we see the heart develop first in eggs; we see that life remains when the head and fundament are removed; we see that all blooded animals have a heart; we see that blood vessels terminate in the heart; etc.).

I consider below an example perceptual argumentation that involves (i) some background assumptions about the nature of its object and (ii) some degree of inference involving these background assumptions. Briefly, *De Caelo* II 14 shows that in order to establish the sphericity of the earth we must rely on our understanding of a lunar eclipse as the interposition of the earth between the sun and moon.

1.5.1 *DE CAELO* II 14: THE SPHERICITY OF THE EARTH

The instance of perceptual argumentation to be examined comes in Aristotle's *De Caelo* II 14. Following a series of arguments about the position and motion of the earth, he turns at 297a8 to consider its shape. He argues that it must necessarily be spherical since (i) every body that has weight moves towards the centre, and (ii) if an equal amount is added on every side the mass will be equidistant from its centre. This argument is counterfactual, however, since for Aristotle the earth is eternal and so ungenerated. Thus he says at 297a13-15 that "[t]he process should be conceived by supposing (*noêsai*) the earth to come into being in the way that some of the natural philosophers describe."⁸⁰ If the earth was generated, it would have been generated in this way; "and if it is ungenerated and has remained so always, its character must be that which the initial generation, if it had occurred, would have given it" (297b15-17).⁸¹ Note that Aristotle does not explicitly identify this as a rational argument with

⁸⁰ Trans. J. L. Stocks (1984).

⁸¹ Trans. J. L. Stocks (1984).

the usual ‘according to reason’ designation. However, following this counterfactual argument, he puts forward a number of perceptual arguments for the thesis that the earth is spherical. These arguments are introduced with the usual phrase: “The evidence of the senses further corroborates this” (Ἐτι δὲ καὶ διὰ τῶν φαινομένων κατὰ τὴν αἴσθησιν) (297b23-24).⁸² For this reason, I think, we can read the former argument as an instance of rational argumentation after all.

Turning, then, to the perceptual mode of argumentation, Aristotle first appeals to the lunar eclipse as evidence for the sphericity of the earth. He notes that throughout the lunar cycle we see a variety of shapes on the moon’s surface (e.g. straight, gibbous, or concave), but during a lunar eclipse we always see a curved figure. This curved figure taken on its own, however, is not enough for us to draw any conclusions about the shape of the earth. Aristotle must employ a further premise connecting the shape of the earth to the lunar eclipse: “and, since (ἐπεὶπερ) it is the interposition of the earth that makes the eclipse, the form of this line will be caused by the form of the earth’s surface, which is therefore spherical (ἢ τῆς γῆς ἂν εἴη περιφέρεια τοῦ σχήματος αἰτία σφαιροειδῆς οὖσα)” (297b28-30).⁸³

We thus have here a perceptual argument that appeals to evidence that is directly observable (i.e. the shape on the moon’s surface), but also explicitly employs an additional *causal* premise from which the ultimate conclusion is drawn. Moreover, this premise is not itself the result of direct observation; we do not *see* that a lunar eclipse is *caused by* the interposition of the earth between the sun and moon. Aristotle elsewhere (*APo.* II 8-10; cf. *Met.* VII, 1014a15) uses the example of the eclipse to illustrate important features of his

⁸² Trans. J. L. Stocks (1984).

⁸³ Trans. J. L. Stocks (1984).

theory of demonstration and its relation to definition. Setting the details aside, it is clear from Aristotle's discussion that the interposition of the earth is only one possible explanation of the lunar eclipse. We first determine whether the eclipse exists by "grasping something of the object itself" (II 8, 93a22), for instance, "that it is a sort of privation of light" (93a23).⁸⁴ Once this is established (i.e. that a sort of privation of light belongs to the moon), we then seek the reason why or explanation, which will act as the middle term of the demonstration. Thus Aristotle says: "When it is plain that A holds of C, then to seek why it holds is to seek what B is—whether screening or rotation of the moon or extinction" (93b4).⁸⁵ He does not here commit himself to any explanation of the eclipse, since this is beyond the scope of the *Analytics*, but instead offers three alternatives. It is clear from this discussion that the first perceptual argument of *De Caelo* II 14 relies on an inference from a (non-perceptual) causal premise.

Following the appeal to the curved figure during a lunar eclipse, Aristotle offers a second perceptual argument that is said to establish not only the sphericity of the earth, but also its relatively small size. He notes that we see that a small change in our position north or south, so a trip from Athens to Macedonia, for instance, brings about a noticeable change on the horizon, and that some stars are always visible in the north but appear to rise and set in the south (and vice versa) (297b30-298a9). Again, this argument seems to require a level of inference that shows it is not simply 'read off' the world; we infer from the change on the horizon that the change in position was a change on a spherical surface.

Next, Aristotle notes that the presence of elephants in both India and Africa can be explained by their geographic continuity (298a9-11). Is this still an instance of perceptual

⁸⁴ Trans. J. Barnes (1984).

⁸⁵ Trans. J. Barnes (1984).

argumentation? Perhaps, if we *see* the continuity in certain kinds of animals, such as the elephant, we can infer from this the continuity of the land. But this case is less clear. Finally, Aristotle offers the evidence of mathematical calculations of the earth's circumference, which ancient astronomers put at around 400,000 stades (or roughly 10,000 miles) (298a14-19).⁸⁶ Is this still an instance of perceptual argumentation? This seems more difficult to maintain. However, the point is introduced by "also" (*kai*), and there is no other indication that Aristotle has switched out of the perceptual mode of argumentation.⁸⁷

1.6 CONCLUSION

We have seen Aristotle's use of rational argumentation in his defence of geocentrism and his use of perceptual argumentation in his defence of the sphericity of the Earth. In both cases, I have argued that the arguments admit of degrees of abstraction. Rational arguments are given at greater or lesser degrees of abstraction. Sometimes the premises are empirically grounded; sometimes they are *a priori* assumptions common to many different areas of investigation. Perceptual arguments, too, admit of a similar imprecision: some are very straightforward and direct observations of empirical phenomena, while others rely on indirect observation and certain theoretical presuppositions.

How, then, are we to resolve the tension between Aristotle's methodological empiricism, more clearly displayed in his perceptual arguments, and his willingness to employ rational arguments that depend on *a priori* assumptions? Perhaps the best way to state the result of our investigation is this. The traditional narrative represented in Raphael's

⁸⁶ The circumference of the Earth is actually more than double, standing at 24,901 miles.

⁸⁷ Aristotle rejects the view that the Earth is flat at *De Caelo* II 13, 293b32-294a10, arguing that those who defend this position fail to take into account the immense size and distance of the bodies.

School of Athens is accurate, but only to a certain point. It might be a helpful pedagogical tool to paint Aristotle as the empiricist opponent of Plato the rationalist, allowing the instructor to emphasize the differences and downplay the similarities between the two. And insofar as Aristotle reflects on the methods of natural science, he might be fairly characterized as an empiricist, since he often says that the perceptual phenomena should be taken as the standard that to which our theories ought to conform. However, insofar as Aristotle practices natural science and utilizes abstract rational arguments with *a priori* premises, he has more of a rationalist bend. So perhaps the tension between perception and reason cannot be totally resolved, and Aristotelian science ultimately remains methodologically ambiguous.

BIBLIOGRAPHY

- Barnes, J. (1994) *Aristotle: "Posterior Analytics," 2nd edn.* Oxford.
- Bogen, J. (2017) "Theory and Observation in Science," *The Stanford Encyclopedia of Philosophy*. E. N. Zalta (ed.), URL = <https://plato.stanford.edu/archives/sum2017/entries/science-theory-observation/>.
- Bolton, R. (2009) "Two Standards for Inquiry in Aristotle's *De Caelo*" in *New Perspectives on Aristotle's De Caelo*, (eds.) A. C. Bowen and C. Wildberg. Leiden: 51-82.
- Bourgey, L. (1975) 'Observation and Experiment in Analogical Explanation' in *Articles on Aristotle: Science*, (eds.) J. Barnes, M. Schofield, and R. Sorabji. London: 175-182.
- Falcon, A. and Leunissen, M. (2015) 'The Scientific Role of *Eulogos* in Aristotle's *Cael* II 12' in *Theory and Practice in Aristotle's Natural Science*, (ed.) D. Ebrey. Cambridge: 217-240.
- Ferejohn, M. (2009) 'Empiricism and the First Principles of Aristotelian Science' in *A Companion to Aristotle*, (ed.) G. Anagnostopoulos: 66-80. Blackwell.
- Feyerabend, P. K. (1959) "An Attempt at a Realistic Interpretation of Experience," in *Realism, Rationalism, and Scientific Method* (Philosophical Papers I). Cambridge: 17-36.
- Frampton, M. F. (1991) 'Aristotle's Cardiocentric Model of Animal Locomotion' *Journal of the History of Biology* 24(2): 291-330.
- Frede, M. (1996) 'Aristotle's Rationalism' in *Rationality in Greek Thought*, 157-74 at 158.
- Garrigues, G. (1879) 'Raphael's "School of Athens"' *The Journal of Speculative Philosophy* 13(4): 406-420.
- Groarke, L. (2009) *An Aristotelian Account of Induction: Creating Something from Nothing*. McGill-Queen's UP.
- Hankinson, R. J. (1998) *Cause and Explanation in Ancient Greek Thought*. Oxford.
- Hanson, N. R. (1958) *Patterns of Discovery*. Cambridge.
- Henry, D. (2013) 'Optimality Reasoning in Aristotle's Natural Teleology', *Oxford Studies in Ancient Philosophy* 45: 225-263.
- Hardie R. P. and Gaye, R. K. (1984) (trans.) *Physics*, in J. Barnes (ed.) *The Complete Works of Aristotle*. Princeton.
- Karbowsky, J. (2016) 'Justification "by Argument" in Aristotle's Natural Science', *Oxford Studies in Ancient Philosophy* 51: 119-160.

- Kuhn, T. S. (1962) *The Structure of Scientific Revolutions*. Chicago.
- Lennox, J. (2001a) (trans. And comm.) *Aristotle: On the Parts of Animals I-IV*. Oxford.
- (2001b) *Aristotle's Philosophy of Biology: Studies in the Origins of Life Science*. Cambridge.
- Leunissen, M. and Falcon, A. (2015) 'Eulogos in Natural Scientific Inquiry', in D. Ebrey (ed.), *Theory and Practice in Aristotle's Natural Philosophy*. Cambridge: 217-240.
- Lloyd, G. E. R. (1979) *Magic, Reason and Experience: Studies in the Origin and Development of Greek Science*. Cambridge. (137-8)
- Ogle, W. (1984) (trans.) *Parts of Animals*, in J. Barnes (ed.) *The Complete Works of Aristotle*. Princeton.
- Owen, G. E. L. (1961) "Tithenai ta Phainomena" in *Aristote et les problèmes de méthode*, (ed.) S. Mansion. Louvain: Symposium Aristotelicum, 83-103.
- Platt, A. (1984) (trans.) *Generation of Animals*, in J. Barnes (ed.) *The Complete Works of Aristotle*. Princeton.
- Ross, G. R. T. (1984) (trans.) *On Youth, Old Age, Life and Death, and Respiration*, in J. Barnes (ed.) *The Complete Works of Aristotle*. Princeton.
- Ross, W. D. (1984) (trans.) *Metaphysics*, in J. Barnes (ed.) *The Complete Works of Aristotle*. Princeton.
- Stocks, J. L. (1984) (trans.) *On the Heavens*, in J. Barnes (ed.) *The Complete Works of Aristotle*. Princeton.
- Striker, G. (2009) (trans. And comm.) *Aristotle: Prior Analytics Book I*. Oxford.
- Thompson, d'A. W. (1984) (trans.) *History of Animals*, in J. Barnes (ed.) *The Complete Works of Aristotle*. Princeton.

CHAPTER 2
Logical Argumentation in Aristotle's Natural Science

2.0 INTRODUCTION

Aristotle makes use of several different modes of reasoning in his works on natural science. Traditionally, scholars reduced these modes to two, finding a strict distinction between the natural-scientific and dialectical modes of investigation.⁸⁸ Although both modes might be used within a single treatise, they are understood to have different structures and ends; dialectical inquiry relies on *endoxa* and proceeds according to opinion (*κατὰ δόξαν*), while scientific inquiry relies on causal first principles and proceeds according to truth (*κατ' ἀλήθειαν*) (*Top.* VIII 13, 162b30-33). This reductive reading has been challenged in recent years, as scholarship turned to investigate in detail the particular features of the different modes of reasoning at work in Aristotle's scientific works, giving rise to a much more complex and dynamic picture of Aristotelian method.⁸⁹ There are certainly advantages to this alternative picture, not the least of which is a more faithful reading of the primary text. But due to the complexity of Aristotle's method there are also many features of these modes of reasoning in need of clarification. This chapter aims to contribute to the larger discussion of the modes of reasoning in Aristotle's natural science by focusing on the role of *logikós* reasoning, with special attention to its application in the discussion of mule sterility in *Generation of Animals* II 8.⁹⁰ In line with the traditional reductive reading, most scholars think

⁸⁸ Bolton (2009), for instance, reduces all *kata tén aisthésin*, *phusikós*, and *analutikós* argumentation to 'scientific' and all *eulogon*, *kata ton logon*, *katholon*, and *logikós* argumentation to 'dialectical' (2009, 65). Cf. Bolton (1987).

⁸⁹ For discussions of *eulogós* argumentation see Karbowski (2014) and Falcon and Leunissen (2015). For a discussion of justification *kata ton logon* see Karbowski (2016). For a discussion of the relations between *phusikós*, *logikós*, and *analutikós* argumentation see Zingano (2017).

⁹⁰ The term *logikós* (and its grammatical variants) occurs 29 times in the *Corpus Aristotelicum*. Of these occurrences, 10 come in the *Organon* (6 in *APo*, 4 in *Top.*), 7 in the *Metaphysics*, and 5 in the ethical works (3 in *EE*, 1 in *EN*, 1 in *Rhetoric*). Only 7 occurrences – less than a fourth of the total – come in the works on natural

that *logikós* reasoning is a kind of dialectical reasoning that essentially relies on principles drawn from outside the domain of natural science in order to impart conviction. This reading dates back to the early commentators and some version is found in both Alexander of Aphrodisias and Simplicius.⁹¹ It is represented particularly clearly in Ross, who says that “[*logikós* suggests plausibility rather than truth, dialectic or sophistic as opposed to science, a reference to abstract considerations (*logoi*) rather than to the precise nature of the facts in question... It probably always refers to linguistic inquiries or considerations...” (1924, 168; cf. 171). Similarly, in his commentary on Aristotle’s *Physics*, Hussey says that “The fact that the problem is called ‘formal’ (*logikê*) indicates that the arguments used are of a very general kind and do not appeal to facts or principles peculiar to any particular science” (1983, 66). Barnes adopts the same reading in his commentary on the *Posterior Analytics*, claiming that *logikós* is “used by Aristotle to designate an argument not employing notions or principles proper to any given science (thus it is more or less synonymous with *dialektikos*)” (1994, 173).⁹² Karbowski rejects the dialectical reading, but maintains that the *logikós* mode of reasoning essentially relies on principles drawn from outside of natural science. Thus, he says that “*logikós* arguments rely upon general claims that are not proper or peculiar to the science in question” (2016, 125). Due to its abstract nature, *logikós* reasoning is often disparaged by Aristotle as an “empty” Platonic method of investigation, in contrast to the *phusikós* manner

philosophy, and these are quite spread out (3 in the *Physics*, 1 in *De Caelo*, 1 in *GC*, 2 in *GA*). Sometimes it is used as an adverb to qualify a particular way of proceeding, sometimes as an adjective to qualify a particular kind of syllogism, excellence, or demonstration.

⁹¹ Alexander of Aphrodisias (*In Metaph.* 167.1-3, 210.20-1, 218.12 Hayduck; *In Top.* 30.9-27 Wallies); Simplicius (*In De Caelo* 236, 10 Mueller).

⁹² Reeve identifies *logikós* reasoning with a kind of dialectical reasoning, but thinks that dialectic plays an important role in the discovery of principles in natural science (2016), 441-44.

of investigation more appropriate to the natural scientist which uses empirically grounded principles specific to physical domains.⁹³

In this paper, I argue that *logikós* reasoning can in some cases rely on principles that are proper to the domain of natural science, although these principles remain general relative to the specific question under investigation. My preliminary interpretation is developed and illustrated with a close textual analysis of Aristotle's explanation of mule sterility in *Generation of Animals* II 8. To be sure, *logikós* reasoning may in some cases rely on principles that are not appropriate to a particular science. But this cannot be the essential or defining feature, as many scholars assume. For in *GA* II 8 we find a *logikós* argument that relies exclusively on principles that fall within the relevant domain of inquiry (i.e. biological principles in biology).

It is evident that the standard view takes *logikós* reasoning to be general relative to the science, but this view, like any other, has not found universal acceptance. Burnyeat, in his very helpful guide to Aristotle's *Metaphysics* Zeta, recognizes that there are exceptions. So, he says "a 'logical' approach need not start from outside the science altogether. It may start from a more general level within the science." (2001, 21). He refers to the passage with which we will be concerned, *GA* II 8, as an instance of logical proof operating within a science, albeit at too general a level.⁹⁴ This paper defends a similar thesis, but whereas Burnyeat makes this point in a brief and somewhat tangential manner with no argument or analysis—which is fair, given his focus on the argument of the *Metaphysics*—I take *GA* II 8 as

⁹³ *Logikós* reasoning is associated with Platonism at *Metaph.* XII 1, 1069a27-28; *EE* I 8, 1217b19; and *GCI* 2, 316a10-11; cf. *GA* II 8, 748a7.

⁹⁴ A similar point was made in a recent paper by Steinkrüger, who sees the argument of *GA* II 8 as a violation of the kind-crossing prohibition of *APo.* I 7. However, his paper focuses on developing and defending a reading of Aristotle's kind-crossing prohibition according to which kind-crossing refers to the kind with which the demonstration deals rather than the kind with which the science deals. See Steinkrüger 2018, 119-124, for his discussion of the *logikós* demonstration of *GA* II 8.

my focus and develop a sustained argument for this alternative reading of *logikós* argumentation.

With this interpretation in place, I turn to the question of whether *logikós* reasoning might play a positive role in natural science. In *GA* II 8 and elsewhere, Aristotle offers a negative evaluation of *logikós* reasoning and seems to prohibit it entirely from natural-scientific investigation. Whether it might have another positive use in metaphysics (due to its general nature) or whether it is in all cases merely verbal and empty, scholars assume that *logikós* reasoning has no positive role in natural science. My second goal is to show that Aristotle allows for a positive role of *logikós* reasoning in natural science and prohibits its use only when it is *excessively* general and therefore neglects the relevant empirical phenomena.⁹⁵

A third goal is to gain insight through a close reading of *GA* II 8 into the relation between Aristotle's theory and practise of science, and especially his theory of demonstration (τὴν ἀπόδειξιν). Aristotle refers to each candidate explanation of mule sterility as a demonstration (reoccurring at 747b23 and b27). Demonstration is one of the main subjects of the *Posterior Analytics* (especially Book One), in which it is defined as 'a scientific deduction... in virtue of which, by having it, we understand something' (*APo.* I 2, 71b17-18).⁹⁶ A TLG search of 'ἀπόδειξ-' yielded 334 results. The vast majority occur in the *Organon* and especially the *Analytics*. In the natural scientific works the root appears in *Physics* (4), *De Caelo* (3), *Generation and Corruption* (1), *History of Animals* (1), *Parts of Animals* (2), and *De Anima* (5). Somewhat surprisingly, *Generation of Animals* leads the list with 7 occurrences, 3 of which are in II 8. Most of the references to demonstration in the natural scientific works refer, not

⁹⁵ That *logikós* argumentation might be put to a positive end is, admittedly, less controversial than the thesis that takes it to be general relative to a question (rather than a science). It has been recognized that there are exceptions to what can otherwise sound like a prohibition on *logikós* reasoning (see Bolton 2009), but this remains an important point for a complete account of Aristotle's use of *logikós* argumentation.

⁹⁶ See also *Topics* I 1, 100a24-28.

to purported demonstrations in the text, but to features of demonstration established in the *Posterior Analytics*. Due to the scarcity with which this technical terminology is used in Aristotle's biological works, and his scientific works more generally, its presence in *GA II 8* speaks to the importance of the chapter for insight into Aristotle's methodology and the link between his scientific theory and practise.

My argument will proceed as follows. I begin with an examination of Aristotle's formulation of the question of mule sterility in contrast to the more general question of sterility in all species. After a brief consideration of his answer to the latter question, I outline Aristotle's discussion of the explanations of mule sterility offered by his predecessors Democritus and Empedocles and draw some intermediate conclusions about empirical adequacy and generality in argument. Although some scholars identify these as instances of *phusikós* argumentation, in contrast to the *logikós* argument that follows, I argue for a new reading of *GA II 8* that sees the three explanations operating at progressive levels of generality relative to the question of mule sterility. Next, I turn to Aristotle's *logikós* demonstration and show that it is neither dialectical nor generality relative to the science of nature, but instead general relative to the particular question about mule sterility. This is followed by an examination of Aristotle's preferred explanation, which I argue is appropriately general relative to the question and thus succeeds where the previous explanations failed. Finally, I close with some remarks on Aristotle's use of *logikós* and *phusikós* argumentation to show that there cannot be a body infinite in magnitude. It follows from this discussion that *logikós* argumentation is not always empty and to be prohibited from natural science. Indeed, it is often used by Aristotle in conjunction with *phusikós* argumentation to establish controversial scientific theses.

2.1.1 INTRODUCING THE *PROBLÉMATA*

One of the most interesting uses of *logikós* reasoning in Aristotle's natural science comes in the second book of his *Generation of Animals*, where Aristotle addresses the problems associated with cross-species reproduction and hybrid offspring. Most cases of reproduction occur naturally between animals that are the same in kind, but we also find that in some cases animals different in kind are able to reproduce with one another, giving birth to hybrid offspring. This phenomenon is an obvious explanandum for any complete theory of animal generation and Aristotle recognized it as such. His investigation proceeds in the usual scientific manner by first establishing the fact that cross-species reproduction occurs.

To begin, Aristotle notes that we cannot produce hybrid offspring from any random pairing of male with female (*GA* II 7, 746a29-32). Crossbreeding requires that the male and female share a similar nature, being of approximately the same size with equal durations of gestation. Aristotle also suggests that conception must take place around the same season for both species, since it will turn out that environmental factors play a large role in the success or failure of a pregnancy (*GA* II 4, 738b27). Although he does not spell out what it means for two animals to share a similar nature, the claim that they must be 'not especially different in species' (οὐκ ἀδιαφόροις δὲ τῷ εἶδει, 746a31) suggests that there are many common or overlapping differentiae, so that the species will be located close together on a branching division. For instance, the dog and fox have many differentiae in common (both are blooded viviparous quadrupeds, etc.) and so will fall close to one another in division, while the dog and octopus have few features in common and rather distinct formal natures. As a result, the dog is able to reproduce with the fox but not the octopus.

As a result of these conditions cases of crossbreeding are rather rare, but even among the Greeks the phenomenon was observed among certain viviparous animals (e.g. dogs, foxes, wolves and jackals), salacious birds (e.g. partridges and hens), and certain species of hawk (746a33-746b4).⁹⁷ Aristotle says that among aquatic animals the so-called rhinobates are thought to be produced from the crossbreeding of the rhine and the batus, although he emphasizes the difficulty and lack of observation in such cases (746b5-7). He also cites as evidence the proverb that ‘Libya is always producing something new’, which is said to have originated from animals crossbreeding at Libyan water springs (746b8-12). We see Aristotle appealing to different sources of evidence – observation and *endoxa* – in order to establish the fact that cross-species reproduction occurs.

Next, Aristotle turns to perhaps the most familiar hybrids – mules, the product of crossbreeding between horse and ass – and notes a peculiar feature of their reproduction. He claims that, with the exception of the mule, hybrids are for the most part fertile and able to produce both male and female offspring. The mule, however, is sterile (*ἄγονος*) and unable to reproduce both with other mules and with other animals that share a similar nature, size, and gestation period. Accordingly, Aristotle separates the investigation of sterility generally from the investigation of sterility in mules.

[T1] It is a general problem (*πρόβλημα καθόλου*) on account of what cause (*διὰ τίν’ αἰτίαν*) any individual, whether male or female, is sterile. For women and men are sterile, and so are other animals in each kind that comes-to-be, e.g. horses and sheep. But this kind as a whole (*τοῦτο τὸ γένος ὅλον*) is sterile, namely that of mules.

⁹⁷ Aristotle differentiates the various subspecies of hawk at *HA IX 39*, 620a16ff. Some species of hawk are said to differ greatly in size from one another and so may be unable to crossbreed, in accordance with the conditions outlined above. For instance, when Aristotle coordinates having crooked talons with being carnivorous, he refers to two species of hawks, the dove-hawk and the sparrow-hawk (*ὁ τε φαβοτύπος καὶ ὁ σπιζίας*), which are said to "differ greatly in size from one another" (*διαφέρουσι δ' οὗτοι τὸ μέγεθος πολὺ ἀλλήλων*) (*HA VIII 3*, 592b1-3). Cf. *HA VI 7*, 563b24-25; *HA IX 12*, 615b7. For an alternative reading of these conditions, see Groisard (2017).

(GA II 7, 746b16-20)⁹⁸

ἔστι δὲ τὸ πρόβλημα καθόλου μὲν διὰ τίν' αἰτίαν ἄγονον ἢ ἄρρεν
ἢ θῆλυ ἐστίν· εἰσὶ γὰρ καὶ γυναῖκες καὶ ἄνδρες ἄγονοι καὶ τῶν
ἄλλων ζώων ἐν τοῖς γένεσιν ἐκάστοις, οἷον ἵπποις καὶ προβάτοις.
ἀλλὰ τοῦτο τὸ γένος ὅλον ἄγονόν ἐστι, τὸ τῶν ἡμιόνων.

In this passage we find Aristotle carefully formulating two distinct questions that must be answered in the course of the investigation into animal generation. These questions are referred to as *problēmata*, a technical term in Aristotle's scientific vocabulary defined loosely as 'the subjects on which deductions take place' (*Top.* I 4, 101b14-15).⁹⁹ On one hand, we are confronted by the general (*katholou*) problem which asks on account of what cause any individual animal, whether male or female, is sterile. This question is general in so far as it applies to members of all species that reproduce, from humans to horses to sheep, but does not apply to all members of these species since most members will be fertile. On the other hand, we are confronted by the particular problem which asks on account of what cause mules are sterile. This problem is particular in so far as it applies only to members of one kind, i.e. mules, but applies to all members of this kind. We might find it surprising that Aristotle labels the mule a kind (*genos*), especially given what he says elsewhere about dualizers, but the mule does not simply share the dual nature of horse and ass.¹⁰⁰ Rather, it has a distinctive nature of its own.¹⁰¹ This characterization seems to imply that it will be something about its nature that explains sterility.

⁹⁸ Aristotle distinguishes these two questions again at *GA* II 8, 747a23-25. All translations in this chapter are my own, unless otherwise specified.

⁹⁹ See *Top.* I 4, 101b15-36; 11, 104b1-5. *Posterior Analytics* II 14-15 purport to show how to grasp (ἔχειν) problems (98a1). See Lennox (2001) and (2015).

¹⁰⁰ Dualizers are those animals that share two distinct natures. Among these, Aristotle includes the Libyan ostrich (*PA* IV 14, 697b13-28), apes (*HA* II 8-9, 503a16-24; *PA* IV 10, 689b32-4), seals and bats (*PA* IV 13, 697b1-12).

¹⁰¹ Aristotle recognizes two natures – material and formal (*Phys.* II 2, 194a12-15; see Lennox 1995). My argument does not turn on which is responsible for sterility in mules, since demonstrations can use any of the four causes as middle term (See *APo.* II 11). My point is simply that sterility is not an accidental feature of mules.

An answer to the former question must explain sterility with reference to some accidental features (such as illness or problems in development and nutrition), while an answer to the latter must explain sterility with reference to the kind itself. In other words, the explanation of sterility in mules (being a phenomenon coextensive with the species) must in some way fall out of the mule's essence. This difference allows us to make sense of Aristotle's characterization of the various explanations as *demonstrations* (but more on this below).

2.1.2 EXPLAINING STERILITY GENERALLY

We have seen how Aristotle's discussion of crossbreeding leads him to raise the particular question of why the offspring of the most common case of crossbreeding, the mule, is *as a kind* sterile. Moreover, we have seen how this question is carefully distinguished from the universal question of why certain members of other species are sterile. Aristotle addresses this latter question first, postponing the particular question of mule sterility to II 8. As stated in T1, the universal question asks about the cause of sterility generally, but Aristotle quickly specifies that there are in fact a plurality of causes.¹⁰² Importantly, his explanation of sterility is here offered at a higher level of generality than the explanation of mule sterility in *GA* II 8, since the problem at hand is itself more general. The various causes of sterility include imperfect development of the reproductive organs, the body being too well-nourished and illness.¹⁰³ Each cause makes reference to something gone wrong for the individual, so that

¹⁰² "The causes of sterility in other animals are several (τὰ δ' αἴτια τῆς ἀγονίας ἐπὶ μὲν τῶν ἄλλων πλείω συμβαίνει)". (*GA* II 7, 746b21)

¹⁰³ When deformity occurs in the early stages of development, Aristotle says the result will be 'masculine women' and 'feminine men' (γυναῖκές τε ἀρρενωποὶ καὶ ἄνδρες θηλυκοί), where the former lack catamenial fluid and the latter possess thin and cold sperm (747a1-3).

sterility occurs when there is some issue in the individual's development, nutrition, or health. All cases result either in problems with the quality or quantity of reproductive fluid (thin and cold semen or a deficient volume of catamenial fluid) or damage to the parts associated with reproduction.

It is important from a methodological perspective that this explanation enables Aristotle to claim that his account is in harmony with the Greek practices of fertility testing, which purported to determine the quality of semen (whether cold and thin or well-concocted and hot) and the condition of the passages in females through which the catamenial fluid is secreted.¹⁰⁴ These tests cohere with Aristotle's explanation of sterility because they presuppose that sterility is somehow connected with the quality of semen in males and the untampered secretion of catamenial fluid in females.

2.2 EXPLAINING STERILITY IN MULES

GA II 8 begins by reiterating the contrast, drawn in T1, between the general problem of sterility that occurs in individuals of all species and the peculiar problem of sterility in mules as a kind. Having dealt with the former, Aristotle now turns to investigate the latter. In usual Aristotelian fashion, he first canvases the views of his predecessors on the subject. As he states elsewhere, Aristotle's motivation to begin an inquiry with an investigation of other theories is twofold. First, he claims that the demonstrations (αἱ ἀποδείξεις) of one theory are puzzles (ἀπορίαι) for another (*De Caelo* I 10, 279b6-7). So, before he is able to offer his own explanation of mule sterility, Aristotle must first tell us what is wrong with the explanations

¹⁰⁴ This is an instance of Aristotle utilizing *eulogós* argumentation. See Karbowski (2014) and Leunissen and Falcon (2015).

offered by his predecessors. He is also motivated to canvas other explanations due to the worry that otherwise he might leave himself open to the charge of ‘procuring judgment by default’ (*De Caelo* I 10, b8-10). If Aristotle were to simply offer his explanation of mule sterility without first considering and rejecting the alternatives, we might be less likely to accept his account, presumably on the suspicion that there is a more satisfactory explanation being concealed.

For these reasons, then, Aristotle begins his investigation of mule sterility by examining the views on the subject held by his predecessors, specifically the explanations put forward by Democritus and Empedocles, which he introduces in the following manner.

[T2] Empedocles and Democritus did not speak well (οὐ καλῶς) about the cause [of mule sterility] – the former speaks unclearly (οὐ σαφῶς), but Democritus speaks more intelligibly (γνωρίμως μᾶλλον). For they give the same demonstration (ὁμοίως τὴν ἀπόδειξιν) for all animals that join contrary to their kind. (*GA* II 8, 747a25-29)

περὶ δὲ τῆς αἰτίας, ὡς μὲν λέγουσιν Ἐμπεδοκλῆς καὶ Δημόκριτος – λέγων ὁ μὲν οὐ σαφῶς Δημόκριτος δὲ γνωρίμως μᾶλλον – οὐ καλῶς εἰρήκασιν. Λέγουσι γὰρ ἐπὶ πάντων ὁμοίως τὴν ἀπόδειξιν τῶν παρὰ τὴν συγγένειαν συνδυαζομένων.

We find Aristotle again utilizing the technical scientific language of the *Posterior Analytics* in his initial remarks on the failures of his predecessors. Democritus’ explanation is said to be more intelligible or familiar (γνωρίμως μᾶλλον) than Empedocles’, although both ultimately fail because they are excessively general and apply to all cases of cross-species reproduction. The distinction between things being more familiar to us and more familiar by nature is a leitmotif of the Aristotelian corpus; things are said to be more familiar to us when they are nearer to perception, but more familiar by nature when they are further away from

perception, that is, universal.¹⁰⁵ As we shall see below, Aristotle praises Democritus for keeping his explanation in harmony with the perceptual phenomena.

Following this initial remark, Aristotle proceeds to introduce and reject each candidate demonstration in turn, beginning with the ‘more familiar’ explanation offered by Democritus. According to Democritus, the reproductive organs of mules are damaged *in utero* because they are not generated from parents of the same kind, but instead have a mixed origin. As we have seen, Aristotle suggests in II 7 that sterility in certain members of other species is occasionally caused by imperfection or deformity in the reproductive organs. However, Democritus’ explanation is problematic because he attributes the cause of damage to the fact that the parents are different in kind.¹⁰⁶ This explanation faces a number of counterexamples, since there are many other animals generated from parents of different kinds whose reproductive organs nonetheless remain intact. Indeed, the mule alone is wholly sterile, whereas other hybrids are for the most part capable of reproduction. Democritus’ explanation thus fails because the phenomenon it describes (namely, generation from a mixed origin) happens in all other cases of cross-species reproduction and yet the offspring in these cases are still able to reproduce. In other words, the proposed cause (parents different in kind) is not co-extensive with the effect (damaged reproductive organs). Aristotle rejects this as a candidate demonstration because it is too general relative to the question of mule sterility, since it purports (and ultimately fails) to explain sterility in all hybrids.

¹⁰⁵ See *Posterior Analytics* I 2, 71b33-72a4. Learning and inquiry proceed from what is more intelligible to us to what is more intelligible by nature. Cf. *Physics* I 1, 184a16-17; *Metaphysics* I 9, 992b30-4; VII 3, 1029a33-b12.

¹⁰⁶ We might dress Democritus’ demonstration in syllogistic garb as follows:

Sterility belongs to offspring of parents different in kind.

Offspring of parents different in kind belongs to mules.

Sterility belongs to mules.

The middle term—parents different in kind—identifies the cause of sterility belonging to the kind mules.

Empedocles takes a different approach and assigns the cause of mule sterility to the mixture of the parent's seeds. On Empedocles' account, horse and ass both contribute soft seminal fluid which, when mixed, form a hard and dense substance as the hollow parts of each are filled with the dense parts of the other.¹⁰⁷ This explanation is said to work on analogy with copper and tin which, when mixed together, yield the much denser bronze.

Aristotle criticizes Empedocles' explanation on several fronts. First, he rejects the force of the analogy with bronze, denying that the "filling in" of hollow parts with dense is the correct explanation in the case of copper and tin (747b3-4). Next, he charges Empedocles with failing to posit his principles from what is knowable (ἐκ γνωρίμων, 747b6). It quickly becomes clear that this charge is grounded on a lack of empirical evidence, as Aristotle asks:

[T3] For how do the hollows and solids fit into one another to make the mixture, e.g. wine and water? This saying is beyond us; for how it is necessary to grasp the hollows of wine and water is too far beyond our perception (λίαν ἐστὶ παρὰ τὴν αἴσθησιν). (GA II 8, 747b6-10)

τὰ γὰρ κοῖλα καὶ τὰ στερεὰ ἀρμόττοντα ἀλλήλοις πῶς ποιεῖ τὴν μίξιν οἶνον οἴνου καὶ ὕδατος; τοῦτο γὰρ ὑπὲρ ἡμᾶς ἐστὶ τὸ λεγόμενον· πῶς γὰρ δεῖ λαβεῖν τὰ κοῖλα τοῦ οἴνου καὶ τοῦ ὕδατος λίαν ἐστὶ παρὰ τὴν αἴσθησιν.

The example of wine and water is telling. It cannot be meant to replace the analogy with tin and copper, since unlike bronze the resulting mixture would be thinner than one of its component parts (i.e. wine). It is given instead as an ordinary case with which the Greeks would have had a great deal of experience. Aristotle assumes that a satisfactory explanation of mule sterility ought to be grounded in or at least minimally supported by a mechanism

¹⁰⁷ Empedocles' demonstration, too, might be represented syllogistically:

Sterility belongs to animals with dense reproductive fluid.

Dense reproductive fluid belongs to mules.

Sterility belongs to mules.

that can be detected by perception, but even in the ordinary case of mixing water and wine we are unable to perceive the hollow parts being filled in by the dense. And we must be able to perceive this process, Aristotle thinks, in order to understand *how* the hollows and solids fit together and the mixing occurs. Even in cases where the mechanism itself is not perceptible, it will have to be established empirically in some analogous phenomenon. For example, the mechanism responsible for fertilization is not immediately open to observation, so Aristotle instead appeals to the analogy with coagulation where the semen is the analogue of the rennet and the menstrual blood the analogue of the milk (*GA* I 20, 729a9-13; II 4, 738b20-6). We can observe that rennet is the coagulating agent because of its heat (Aristotle thinks), even though we cannot observe this in the case of fertilization.

The reason for Aristotle's initial appreciation of the superior intelligibility of Democritus' explanation should now be clear. For even though Democritus goes wrong in making his explanation too general, the elements of his explanation are at least supported by and testable against empirical evidence.¹⁰⁸ We can see and indeed test for deformities in the reproductive organs and we know *ex hypothesi* that mules are generated from horse and ass, which are different in kind from the mule and from one another. Empedocles' explanation, however, posits hollow and dense elements in liquids for which we have no evidence and so does not even meet this minimal standard.

Aristotle also objects to the generality of Empedocles' explanation. Even if we assume that mule sterility can be sufficiently explained with reference to the mixing of reproductive fluid from the horse and ass, we might ask why the horse-foal, being the offspring of stallion and mare, is not equally sterile since the reproductive fluids will be soft in this case as well (and similarly with the ass-foal, being the offspring of jack and jenny). If

¹⁰⁸ Aristotle often praises Democritus for his method. Cf. *GC* 315a33-b6; 316a5-14.

the mixing of soft reproductive fluids produces something solid, causing sterility in the offspring, then the offspring of horses mixing with horses or asses with asses should also be sterile. Since the offspring in these cases are not sterile, the mixture of soft fluids cannot be the cause of sterility in the case of mules.¹⁰⁹ Aristotle objects, moreover, that Empedocles' explanation purports to apply in the same way to male and female mules even though the facts are different in each case. Specifically, Empedocles says nothing about why the female mule is able to conceive without bringing the pregnancy to completion or why the male mule is able to reproduce after seven years.¹¹⁰

Putting concerns about empirical adequacy aside, Aristotle rejects the candidate demonstrations offered by Democritus and Empedocles because both are excessively general relative to the question of mule sterility. Democritus' explanation ranges over all animals that are the product of cross-species reproduction, while Empedocles extends the range of his explanation even further to cover cases of reproduction between animals of the same kind.

In a recent paper, Marco Zingano argues that these explanations are cases of *phusikôs* argumentation, in contrast to the *logikôs* proof we will see in the next section.¹¹¹ On this reading, Aristotle considers and rejects the *phusikôs* arguments of Democritus and Empedocles before moving on to offer his own preferred *logikôs* explanation of mule

¹⁰⁹ Lloyd (1996) says that Aristotle criticizes Empedocles and Democritus for attempting "too global an *apodeixis* of the sterility of mules, one that covers all cases of copulation between animals of different kinds" (26). This is surely the case for Democritus, as we have seen, but not for Empedocles, whose explanation applies only to animals with soft seed.

¹¹⁰ Note that infertility is still a problem for male mules, since they are infertile for at least the first seven years of their lives and after this point reproduction only occurs in some cases, where this is not simply a fact of development (as it is in human beings, having not progressed beyond puberty at that age). Moreover, in such cases the offspring is deformed (*GA* II 8, 749a1ff.) It is unclear why Aristotle is not equally critical of Democritus for failing to account for these facts.

¹¹¹ Zingano (2017), 21.

sterility. This *logikós* explanation is then rejected in turn as Aristotle reverts to the use of *phusikós* reasoning to develop a more appropriate explanation of the phenomenon.

Before progressing, we might stop to consider what evidence we have for thinking that the explanations offered by Democritus and Empedocles are *phusikós*. Aristotle does not label them as such. He calls them both demonstrations, but this cannot indicate their *phusikós* status since he will go on to call the *logikós* argument in II 8 a demonstration as well. We might think that Democritus' and Empedocles' explanations are *phusikós* because they use principles appropriate to biology, whereas the *logikós* argument we will see in the next section uses principles that are too general and therefore external to natural science.¹¹² The principles of Democritus' explanation might be appropriate in this sense – something like 'the reproductive organs of hybrids are damaged *in utero*' – but the principles of Empedocles' explanation seem quite clearly to extend beyond the biological realm to all cases of chemical mixture (e.g. tin and copper, water and wine).¹¹³ Further, we shall see below that the principles of Aristotle's *logikós* argument, though false, are appropriate to biology. Perhaps, then, Democritus' and Empedocles' explanations are *phusikós* because they are empirically grounded and cohere with the relevant perceptual phenomena. But in that case Empedocles' explanation again will not qualify as *phusikós* since Aristotle says that it lacks empirical support. So it seems the status of the premises (whether internal to biology or empirically adequate) cannot be our grounds for classifying Democritus' and Empedocles' explanations as *phusikós*.

¹¹² For Aristotle, of course, there is no science of biology strictly speaking, but only a science of nature, of which the study of living things is a part. See Falcon (2005) and Lennox (2010).

¹¹³ The general character of Aristotle's work on mixture is indicated at *De Sensu* III, 440a31-b4, where he says that mixing by juxtaposition of minimal parts and by wholly blending have both been discussed in his treatise on mixture (*περὶ μίξεως*, presumably *Generation and Corruption*) 'in a general manner and with respect to every case' (*καθόλου περὶ πάντων*).

From these considerations, and to anticipate the argument of the next section, we should not read the structure of Aristotle's investigation of mule sterility as beginning with two *phusikós* explanations which are then followed by a preferable *logikós* explanation. Although Aristotle often contrasts the *logikós* and *phusikós* modes of inquiry, this is not a contrast he draws (explicitly or implicitly) in *GA* II 8. Rather, the investigation begins with three arguments that are progressively more general, before Aristotle arrives at his preferred explanation made at the appropriate level of generality, which also turns out to be the *least* general. We have already seen in what sense Empedocles' explanation is more general than Democritus'. It will be the goal of the next section to show that the *logikós* demonstration that follows attempts to provide an explanation at an even higher level of generality.

2.3 ARISTOTLE'S LOGICAL DEMONSTRATION

I have suggested that Democritus and Empedocles both go wrong (whether knowingly or unknowingly) in extending the range of their explanations to cover cases of reproduction that they ought not cover and so make them too general relative to the question of mule sterility. Democritus' explanation ranges over all animals that are the product of crossbreeding, while Empedocles' ranges over cases of reproduction between animals of the same kind. For this reason, both explanations are open to counterexamples and as a result are rejected as candidate demonstrations.

Before turning to his own preferred explanation of mule sterility, Aristotle introduces a third candidate:

[T4] Perhaps a logical¹¹⁴ demonstration might seem to be more plausible than the things we have said (Ἴσως δὲ μᾶλλον ἂν δόξειεν ἀπόδειξις εἶναι πιθανὴ τῶν εἰρημένων λογικῆ) – I call it logical (λογικῆν) because that which is more general (καθόλου μᾶλλον) is further removed from the appropriate principles (τῶν οικείων ἀρχῶν).
(GA II 8, 747b27-30)

Ἴσως δὲ μᾶλλον ἂν δόξειεν ἀπόδειξις εἶναι πιθανὴ τῶν εἰρημένων λογικῆ – λέγω δὲ λογικῆν διὰ τοῦτο ὅτι ὅσῳ καθόλου μᾶλλον πορρωτέρω τῶν οικείων ἐστὶν ἀρχῶν.

As we saw above, it is common for scholars to read Aristotle’s *logikós* demonstration as a preferable alternative to the Democritean and Empedoclean *phusikós* explanations. I have shown why we should be wary of attributing a *phusikós* status to the earlier explanations, but we should be equally wary of reading the *logikós* argument that follows as in any way preferable to the rejected alternatives. Note the tentative language that Aristotle uses when introducing this explanation: he begins with Ἴσως and follows this with ἂν plus the optative δόξειεν, which suggests that Aristotle is simply entertaining an alternative explanation that might *appear* more plausible. Nothing he says suggests that he endorses this explanation any more than the alternatives just considered.

Bolton argues that this *logikós* proof is dialectical, noting Aristotle’s use of the verb *doxein* at 748a9 and 748a11 (2009, 74). On this reading, for an argument to qualify as *logikós* it must not only rely on some generalization or other, but the generalization must be *endoxon* and so hold a certain level of acceptability or plausibility. The fact that the *logikós* proof is general does not explain why Aristotle thinks that it might seem to be more plausible than an alternative mode of proof. On Bolton’s reading, Aristotle is making the point that most

¹¹⁴ Groisard (2017) suggests that Aristotle’s use of *logikós* “here can mean either a “logical” or “notional” demonstration, since it gives an explanation of mules’ sterility not based on any physiological reasons but on the sole notion of what a mule is and is not” (160).

people neglect the relevant particular facts and instead rely on overgeneralizations, so that an argument that generalizes is more likely to be persuasive.

First, we should note that Aristotle is not contrasting the potential persuasiveness of the *logikós* proof with the persuasiveness of an alternative mode of proof (e.g. *phusikós*). He says in T5 that the *logikós* argument might be held to be more persuasive ‘than the things we have said’ (τῶν εἰρημένων). In context, it is clear that τῶν εἰρημένων refers to the explanations of Democritus and Empedocles, so that Aristotle contrasts the potential persuasiveness of the *logikós* argument with the less persuasive arguments of his predecessors. Bolton’s point will only stand if we assume (with Zingano) that the rejected candidate demonstrations are themselves distinct modes of reasoning from the *logikós* argument. But we have seen that there are good reasons to reject this assumption. It might be that the *logikós* demonstration in *GA* II 8 is dialectical after all, but being dialectical is not an essential or defining feature of *logikós* arguments.

Indeed, the very fact that Aristotle refers to this as a demonstration seems to rule out the possibility that it is dialectical. In the first chapter of the *Topics*, Aristotle defines a deduction (συλλογισμὸς) as “an argument (λόγος) in which, certain things being laid down, something other than these necessarily comes about through them” (*Top.* I 1, 100a24-25). If the principles of a deduction are true and primitive, or are such that our knowledge of them comes through principles which are true and primitive, then it will be a demonstration (ἀπόδειξις) (100a26-27).¹¹⁵ If, however, the deduction reasons from ‘reputable opinions’ (ἐξ ἐνδόξων), which are those accepted by everyone or by the majority or by the wise (either all of them or the majority or the most reputable), then it will be a *dialectical* deduction

¹¹⁵ These conditions on the premisses of demonstration are elaborated and added to in *Posterior Analytics* I 2.

(διαλεκτικὸς δὲ συλλογισμὸς) (100a28-30; 100b20-24). It should be clear from this distinction that the notion of a *dialectical* demonstration is, for Aristotle, a *contradictio in terminis*.

Aristotle follows the introduction of the *logikḗs* demonstration in T4 with a somewhat dense and difficult *reductio ad absurdum* argument, which runs as follows. First, he sets out two relatively straightforward reproductive principles (747b29-32).

- RP1 If parents are the same in species (ὁμοειδὲς), they will generate an offspring of the same species. ($S_1 \& S_1 \rightarrow S_1$)
- RP2 If parents are different in species (ἐτέρων τῶ εἶδει), they will generate an offspring of a different species. ($S_1 \& S_2 \rightarrow S_3$)

He illustrates these principles with the following examples (747b32-748a1).

- (RP1) The offspring of a male dog and a female dog is itself a dog.
- (RP2) The offspring of a male dog and a female lion, or a male lion and a female dog, will be something different in kind from both dog and lion.¹¹⁶

With these principles in place, he puts forward the following argument (748a1-8). We know that the mule is the offspring of parents that are different in kind from one another, namely horse and ass. So, by RP2, the mule will be distinct in species from both. Indeed, this is consistent with what Aristotle said earlier, labelling the mule its own *genos* (see T1). Now, if we assume that mules reproduce, we might ask: according to what principle does their reproduction occur? It will not occur according to RP2, since we are assuming that the parents are not different in species from one another (since both are mules). However, it will not occur according to RP1, since the offspring would then itself be a mule. But we have already established that mules are born in accordance with RP2, being the offspring of horse

¹¹⁶ Note that Aristotle's example of RP2 is an impossible offspring and violates the conditions given in *GA* II 7 (i.e. size, duration of gestation, and similarity in kind).

and ass. So, assuming that all reproduction must occur according to either RP1 or RP2, since mules cannot reproduce according to either principle, they must necessarily be sterile.¹¹⁷

An important question to address going forward is why Aristotle considers this *logikós* explanation before moving on to his own favored explanation. The standard reading has a readily available answer, namely that this explanation is superior to the previous *phsikós* explanations offered by Democritus and Empedocles.¹¹⁸ But this reading is of course faced with the difficulty of accounting for Aristotle's rejection of the *logikós* demonstration and the claim that it is "too general and empty" and the problems with Aristotle's introduction of the explanation outlined above. We also need to determine what makes this proof more general, since it might seem at first glance to be less general than Empedocles' explanation. For the latter uses principles that apply to all cases of chemical combination, whereas the principles used in the *logikós* explanation are specific to biological reproduction.

My hypothesis is that, as with the previous cases, the range of explanation expands to cover even more cases of reproduction. The *logikós* explanation covers all cases of crossbreeding (like Democritus) and certain cases of reproduction between animals of the same kind (like Empedocles), but it is even more general in so far as it covers all other cases of reproduction. Accordingly, Aristotle uses this *logikós* argument to further illustrate the mistake made by his predecessors of extending the generality of the scope of their explanations beyond the peculiar question of mule sterility.

So much for the mechanics of the *logikós* argument. What follows is a very insightful account of the problem with this explanation and the conditions for correct proof in natural science.

¹¹⁷ This argument does not rule out the possibility that a mule might reproduce with an animal of a different species and so generate some third kind, in accordance with RP2.

¹¹⁸ See Zingano 2017, 22.

[T5] This account (λόγος), then, is too general and empty (καθόλου λίαν καὶ κενός). For all accounts not based on appropriate principles are empty (οἱ γὰρ μὴ ἐκ τῶν οἰκείων ἀρχῶν λόγοι κενοί), but they appear to be connected with the facts without being so. For geometrical arguments must start from geometrical principles, and similarly in other cases; the empty argument (τὸ κενὸν) might seem to be something, but it is nothing. This account is not true, for many animals that are not produced from the same species are fertile, as was said earlier. We must not inquire into questions of natural science (περὶ τῶν φυσικῶν) in this manner any more than any other questions; one would better grasp the cause (μᾶλλον λάβοι τὴν αἰτίαν) by considering the facts peculiar to the kinds (ἐκ δὲ τῶν ὑπαρχόντων τῷ γένει... θεωρῶν) horse and ass. (*GA* II 8, 748a7-16)

οὗτος μὲν οὖν ὁ λόγος καθόλου λίαν καὶ κενός· οἱ γὰρ μὴ ἐκ τῶν οἰκείων ἀρχῶν λόγοι κενοί, ἀλλὰ δοκοῦσιν εἶναι τῶν πραγμάτων οὐκ ὄντες. Οἱ γὰρ ἐκ τῶν ἀρχῶν τῶν γεωμετρικῶν γεωμετρικοί, ὁμοίως δὲ καὶ ἐπὶ τῶν ἄλλων· τὸ δὲ κενὸν δοκεῖ μὲν εἶναι τι, ἔστι δ' οὐθέν. Οὐκ ἀληθές δέ, ὅτι πολλὰ τῶν μὴ <ἐξ> ὁμοειδῶν γενομένων γίνεται γόνιμα καθάπερ ἐλέχθη πρότερον. Τοῦτον μὲν οὖν τὸν τρόπον οὔτε περὶ τῶν ἄλλων δεῖ ζητεῖν οὔτε περὶ τῶν φυσικῶν· ἐκ δὲ τῶν ὑπαρχόντων τῷ γένει τῷ τῶν ἵπων καὶ τῷ τῶν ὄνων θεωρῶν ἂν τις μᾶλλον λάβοι τὴν αἰτίαν, ὅτι πρῶτον μὲν ἐκάτερον αὐτῶν ἐστὶ μονοτόκον ἐκ τῶν συγγενῶν ζώων, ἔπειτ' οὐ συλληπτικὰ τὰ θήλεα ἐκ τῶν ἀρρένων αἰεὶ, διόπερ τοὺς ἵππους διαλείποντες ὀχεύουσι [διὰ τὸ μὴ δύνασθαι συνεχῶς φέρειν].

One might be tempted to read this as a prohibition on the use of *logikós* reasoning in natural science. I will return to the question of the role of *logikós* reasoning in natural science. For now, let us consider what this passage tells us about the structure of such reasoning. The principles of the *logikós* argument are inappropriate, to be sure, but not in the sense that they belong to another science. They are straightforward (but admittedly false) principles of biology relating to generation and the conditions for inheritance of species.¹¹⁹ The

¹¹⁹ The biological force behind these principles speaks against Mosquera's reading, who maintains that *logikós* argumentation is dialectical in so far as it proceeds from principles that are proper to metaphysics, i.e. the science of being (1998, 43-51). This also suggests a negative answer to Karbowski's suggestion that '[i]t would be worth examining whether all of the general principles invoked in *logikós* arguments in the corpus can plausibly be claimed to be proper principles of first philosophy' (2016, 126n18). It is hard to imagine how RP1 and RP2 might be read as principles of first philosophy, rather than straightforward principles of biological reproduction.

inappropriateness stems rather from the lack of consideration given to the empirical phenomena relevant to the question of mule sterility.¹²⁰ Aristotle is clear in labelling an empty *logos* one that not only fails to conform with the facts, but appears to do so. It's not just that they're erroneous but deceptively plausible.¹²¹ So, he says an empty *logos* appears to be connected to the facts and seems to be something. In line with the relative generality of Democritus' and Empedocles' explanations, the *logikós* argument fails to limit its premises to the facts about the kinds relevant to the problem (i.e. horse, ass, and mule). Just as Democritus expanded the scope of his explanation to all cases of cross-breeding, and Empedocles extended it even to cases of regular species-specific breeding (horse-horse and ass-ass, or all cases in which both parents have thin seed), Aristotle's *logikós* proof extends the scope of explanation even further to *all cases of generation*, whether the parents are the same in kind or different. So we see Aristotle rejecting this explanation for the same reason he rejects those given by Democritus and Empedocles: it is too general and so subject to a number of counterexamples.

On Bolton's reading of T5, Aristotle is criticizing the assumption that every type of animal is produced in just one way.¹²² He argues that it is this assumption that is said to be 'exceedingly general' (*katholou lian*), as it overgeneralizes from common cases and neglects other relevant cases where animals are produced in more than one way. Presumably the 'common cases' are all cases of reproduction according to nature (where two species of the same kind generate an offspring of the same kind) and cases of hybrid offspring like the

¹²⁰ This speaks against Nussbaum's reading. She references *GA* 748a7ff. as a passage that "criticizes for being outside the proper genus principles that appear to belong—though they are in fact false—to the science in question, narrowly conceived" (1978, 110).

¹²¹ See *Topics* VIII 12, 162b27, where Aristotle says "if an argument depends on false but reputable beliefs, it is *logikós*."

¹²² Bolton (2009), 73.

mule (where two species of different kinds generate an offspring of a different kind from both, but this offspring is sterile). The neglected relevant cases, then, are all other cases of cross-species reproduction, where the offspring is different in species from both parents but also able to generate offspring of the same kind as itself. Aristotle's criticism cannot target the fact that the proof is abstract or that it draws on a generalization that is too wide in scope, according to Bolton, because he uses a generalization of the same scope in his own explanation of why mules are sterile (namely, that 'all animals are sometimes produced in two ways').

It would be very odd, however, if Aristotle were referring to the particular hidden assumption that every type of animal is produced in just one way as καθόλου λίσαν. Although the term λόγος is notoriously versatile, in this context it seems to refer unambiguously to the whole of the preceding argument (in Platt's trans. 'this theory'). Moreover, Aristotle pairs λόγος with the demonstrative pronoun οὗτος ('this account'), which requires or at least implies a reference to something explicit in the text. But the argument runs from 747b29 to 748a7 and Aristotle nowhere makes explicit the assumption that every type of animal is produced in just one way. He states the two principles (RP1 and RP2 above), illustrates them with examples, and shows that neither can apply to the mule. The fact that the overgeneralized assumption is not made explicit, paired with the reference to "this account," seems to rule out Bolton's reading of the text. If we accept that Aristotle is objecting to the generality of the scope of the *logikós* argument as a whole (rather than any particular assumption), then there is no problem with him using the assumption that animals are sometimes produced in two ways in his own explanation of sterility in mules. Moreover, although Aristotle would surely agree with this assumption, it is not clear that it plays any role (whether explicit or implicit) in his own explanation of why mules are sterile.

The problem of mule sterility is, as we saw above, peculiar insofar as it applies to all and only members of the species. For this reason, Aristotle is able to contrast it with the general (*katholou*) problem of sterility in all other animals. It turns out that the latter problem does not admit of a single explanation, but requires us to state several distinct causes (development, nutrition, and illness), which ultimately reduce to deficiencies in seminal fluid or damage to reproductive organs. So it was clear from the beginning that we should not seek a general account of why mules are sterile, since this is not a general problem.

In light of these considerations, I suggest that we ought to understand the explanations offered by Democritus and Empedocles as no more *phusikós* than *logikós*. Even if they draw on principles that are proper to natural science and are in this sense natural-scientific, both use principles that are too general for the inquiry into mule sterility.¹²³ Moreover, it is clear that for Aristotle both kinds of argumentation admit of degrees. So in T4 he says that the argument which is ‘more general’ (*καθόλου μᾶλλον*) is further removed from appropriate principles and in T5 he rejects the *logikós* demonstration for being ‘too general’ (*καθόλου λίαν*). Moreover, as we will see below, Aristotle employs the comparative *logikóteron* at *De Caelo* I 7, 247a23 and turns to arguments identified as ‘more physical’ (*phusikós mallon*) at *Physics* III 5, 204b10. It is surprising, given these texts, that no one has commented on the comparative nature of *logikós* and *phusikós* argumentation. So we see that an explanation might be more or less general relative to the question or inquiry at hand and, I think, we should understand the three candidate demonstrations as proceeding at different and progressively general levels, each expanding the range of the kinds to which it applies. Accordingly, the *logikós* argument is most general, Democritus’ is least general

¹²³ We have considered above the extent to which Empedocles’ explanation falls outside of the domain of biological inquiry, but in so far as his explanation draws on principles of chemical combination, it falls within the domain of natural science.

(although still too general relative to the question), and Empedocles' sits somewhere in between.

Consider again Zingano's reading of *GA* II 8. He argues that *logikós* arguments hold a positive place in physical discussions and are occasionally given precedence over the more empirically-informed *phusikós* arguments.¹²⁴ To this end, he says that the *logikós* explanation in *GA* II 8 is "evaluated as better off than the physical proofs provided by Democritus and Empedocles."¹²⁵ We have already considered above why we should not characterize Democritus' and Empedocles' explanations as *phusikós* rather than *logikós*, but we are now in a position to see what is wrong with the suggestion that Aristotle's *logikós* proof is superior or better off. For it goes wrong in the same way that the former explanations go wrong and in fact does so to an even greater degree by expanding its scope to all cases of animal generation. Aristotle does not endorse the argument or offer a positive evaluation, but introduces it (in T4) with very tentative language and concludes (in T5) by dismissing it as empty and false.

Perhaps a discerning reader sympathetic to the standard view might think we moved a little too hastily. After all, Aristotle says in T5 that the *logikós* argument fails because it is not based on the appropriate principles (μη ἐκ τῶν οἰκείων ἀρχῶν), adding that "geometrical arguments must start from geometrical principles, and similarly in other cases." Surely, one might think, this speaks in favor of the standard reading and the identification of *logikós* arguments with those that use premises external to the domain of inquiry. Further

¹²⁴ Zingano (2017), 21.

¹²⁵ Zingano (2017), 22. See also Karbowski (2016, 127n20), who cites *GA* II 8 as an instance of Aristotle's positive use of *logikós* argumentation.

support for this claim might be sought in the following important methodological passage from *On Generation and Corruption*.¹²⁶

[T6] The cause of being less able to see comprehensively the facts agreed upon is inexperience. Therefore as many as have been dwelling more among natural things (έν τοῖς φυσικοῖς) are more capable of positing such principles which are possible to bring together more: those who on the basis of many arguments (έκ τῶν πολλῶν λόγων) are unobservant of the things that are, having looked at [only] few things, easily make assertions. One could see also from these things how much those who investigate naturally differ from those who investigate logically (Ἴδοι δ' ἄν τις καί εκ τούτων ὅσον διαφέρουσιν οἱ φυσικῶς καί λογικῶς σκοποῦντες): for about the existence of atomic magnitudes, some say that otherwise the triangle itself would be many, whereas Democritus would appear to be convinced by *logoi* that are more appropriate and natural (Δημόκριτος δ' ἄν φανεῖη οικείους καί φυσικοῖς λόγοις πεπεισθαι). (GC I 2, 316a4-13)

Αἴτιον δὲ τοῦ ἐπ' ἔλαττον δύνασθαι τὰ ὁμολογούμενα συνορᾶν ἢ ἀπειρία. Διὸ ὅσοι ἐνφκῆκασι μᾶλλον ἐν τοῖς φυσικοῖς μᾶλλον δύνανται ὑποτίθεσθαι τοιαύτας ἀρχὰς αἱ ἐπὶ πολὺ δύνανται συνείρειν· οἱ δ' ἐκ τῶν πολλῶν λόγων ἀθεώρητοι τῶν ὑπαρχόντων ὄντες, πρὸς ὀλίγα βλέψαντες, ἀποφαίνονται ῥᾶον. Ἴδοι δ' ἄν τις καί εκ τούτων ὅσον διαφέρουσιν οἱ φυσικῶς καί λογικῶς σκοποῦντες· περὶ γὰρ τοῦ ἄτομα εἶναι μεγέθη οἱ μὲν φασιν ὅτι τὸ αὐτοτρίγωνον πολλὰ ἔσται, Δημόκριτος δ' ἄν φανεῖη οικείους καί φυσικοῖς λόγοις πεπεισθαι. Δῆλον δ' ἔσται ὃ λέγομεν προιοῦσιν.

Here we find Aristotle distinguishing, and offering criteria for distinguishing, between *phusikós* and *logikós* modes of inquiry. Some philosophers (i.e. Platonists) employ the latter, reasoning from principles of geometry and being unobservant to the relevant empirical data. Democritus, on the other hand, seems to employ the *phusikós* mode of reasoning, having been persuaded by *οικείους καί φυσικοῖς λόγοις*. Joachim takes the *καί* at 316a14 epexegetically, translating the phrase ‘arguments appropriate to the subject, i.e. drawn from the science of nature’, so that *καί* functions to explain and add clarity to the sense of

¹²⁶ See Bolton (2009, 52); Karbowski (2016, 117).

οἰκείοις. This is then read back into *GA* II 8 and used as evidence to support the standard reading. Accordingly, when Aristotle says in T5 that *logikōs* arguments are empty and not based on appropriate principles, ‘appropriate’ is taken in Joachim’s sense to mean ‘appropriate to the subject, i.e. drawn from the science of nature’.

However, we need not take the phrase in T6 this way. The καὶ at 316a14 might be taken in its usual conjunctive sense, so that a more literal (and accurate) translation might be: “Democritus would appear to have been persuaded by appropriate arguments and arguments drawn from the science of nature.” This translation preserves the distinction I have been attempting to draw between arguments that employ principles of physics and those that are made at the correct level of generality.

2.4 ARISTOTLE’S PREFERRED EXPLANATION

If we are right about the flaw common to all three candidate demonstrations, then we should expect Aristotle to limit the scope of his preferred explanation to the particular facts about the kinds horse, ass, and mule. And this is exactly what he does, claiming that this limiting of scope will better allow us to grasp the cause (748a14-15; see [T5]). We must not consider the general facts that are supposed to apply to all cases of generation from male and female (as in the *logikōs* demonstration), or to some cases of cross-breeding and other cases of species-specific breeding (as in Empedocles’ demonstration), or even the facts thought to apply only to cases of cross-breeding (as Democritus’ demonstration). Rather, we will put ourselves in a better position to determine the cause by utilizing principles that are *appropriately general* and pertain to the kinds targeted by the problem, which in this case is the level of particular species (or particular sexes of particular species, namely horse, ass, and mule).

And indeed, we see that Aristotle's preferred explanation is given at just this level. He explains the problem about the whole *genos* of mule with reference to several facts about horse, ass and mule. The ass is of a cold nature (748a24) with cold seed (a31-b3) and although the horse is of a hotter nature, allowing the pregnancy to be preserved, both are said to "naturally tend towards sterility" (748b8). So, even when mated with its own kind, each bears only a single young (748a16) and does so only in a warm climate and during the summer (748a24-30). Mare and she-ass are deficient in catamenial fluid (the former having less than any other quadruped (748a21)) and in mules the nutriment that would otherwise be used to nourish the embryo until birth is discharged with excrement and used up to increase the size of the body (748b20-31). For all these reasons, then, the mule will be sterile, and will be so *from necessity* (ἐξ ἀνάγκης) (748b19). Many of these claims are either themselves empirical or supported by empirical evidence, as Aristotle makes reference to the practices of breeders (748a19-20), the absence of mules born in colder regions (i.e. Scythia and among the Celts) (748a25-26), and the fact that if a female is impregnated by a horse and then mounted by an ass, the pregnancy is destroyed (whereas the pregnancy persists in the converse case) (748a33-748b1).¹²⁷ Taking all these peculiar facts into consideration, Aristotle is able to develop an explanation at the correct level of generality relative to the question.

Let us stop now to consider a potential objection to this account. Does Aristotle's preferred explanation itself rely on principles that are general relative to the question of mule sterility? He refers to a number of facts peculiar to the relevant kinds, to be sure, but he also seems to employ principles that apply more generally. For instance, he says:

[I7] "Now when either hot is added to cold or cold to hot so as to mix, the result is that the embryo itself arising from these is preserved and thus these animals are fertile when crossed with one another,

¹²⁷ He refers to the latter as a proof or sign (*sêmeion*, 748a32) the cold nature of the mule's seed (*spermatos*) (748a35).

but the animal produced by them is no longer fertile but unable to produce perfect offspring.”¹²⁸ (*GA* II 8, 748b4-6)

ὅταν δὲ μιχθῆ ἢ θερμὸν ἐπὶ ψυχρὸν ἢ ψυχρὸν ἐπὶ θερμὸν
συμβαίνει αὐτὸ μὲν τὸ ἐκ τούτων κύημα γενόμενον σώζεσθαι καὶ
ταῦτ’ ἐξ ἀλλήλων εἶναι γόνιμα, τὸ δ’ ἐκ τούτων μηκέτι γόνιμον
ἀλλ’ ἄγονον εἰς τελειογονίαν.

Here we find Aristotle employing the (general) principle that the mixture of hot and cold preserves the embryo together with the additional (and more peculiar) principle that this offspring will itself be sterile. When he turns to the previously noted exception that the male mule is able to conceive at seven years of age, Aristotle explains this again with reference to two general principles of embryology: (i) the male sex is naturally hotter than the female, and (ii) the male does not contribute any material substance to the mixture (748b31-749a1).¹²⁹ These principles are not peculiar to mules and indeed Aristotle has gone to great lengths Books I and II of the *GA* to show that they hold for all animals that come into being from the union of male and female. In what sense, then, if any, does Aristotle’s settled explanation avoid the pitfalls of the previously examined demonstrations? In what sense is his explanation *appropriately general*?

The first thing we should note in answering this question is that Aristotle does not refer to his own explanation as a *demonstration*. We might be tempted to think of it as such, perhaps even dressing it up in syllogistic garb as something like:

Sterility belongs to animals with an excessively cold nature.
An excessively cold nature belongs to mules.
Sterility belongs to mules.

¹²⁸ Trans. A. Platt.

¹²⁹ Although the male mule can reproduce after seven years (presumably with the female horse or ass), he produces a 'ginnus', or a deformed offspring produced also by horse and ass when the embryo is diseased in the uterus.

This formulation, however, is problematic. First, although Aristotle does indeed place a great deal of emphasis on the excessively cold nature of mules, this is not the only relevant feature that explains their sterility. Moreover, it is not clear that the principle he employs is in fact more general than the kind targeted by the problem, since the cause (being excessively cold-natured) is coextensive with the kind (mule). Remember that the problem with the earlier demonstrations was that their principles extend beyond the kind (and, as I've argued, progressively so). Since Aristotle's explanation identifies the cause as the correct level, then, it conforms to the guidelines laid out earlier in the chapter.

We might accept this defense for the principle of T7 about excessive cold, but we are left with the principles that the male sex is naturally hotter and contributes no material substance. Surely these are general in the very sense that their scope is too wide, extending beyond the kind in question. And, I think, this much can be admitted without sacrificing our argument. It is important that these principles are used not to explain mule sterility, but rather to explain the particular exception of male mules reproducing (with horse or ass) after the age of seven. In such cases the offspring (which Aristotle calls a 'ginnus') is deformed, resembling the 'metachoera' in swine or the dwarf in humans (749a1-5).

Contemporary biologists, of course, offer a much more convincing account of mule sterility. Horses have 32 pairs of chromosomes, while asses have only 31. As a result, the offspring inherits 32 horse chromosomes and 31 ass chromosomes, and when these pair up there is one chromosome left over, and this extra chromosome poses a problem for the creation of sex cells. Thus it turns out that Aristotle was right to locate the explanation of sterility in very particular features of horses and donkeys respectively, though not right about just what those particular features are.

Oddly enough, there are no recorded cases of male mules being sterile, but there have been a few dozen cases of female mules giving birth after mating with a horse or donkey. Indeed, Herodotus references a mule giving birth while Xerxes was at Sardis, and treats it as an ill omen for the invasion of Greece in 480 BC.¹³⁰

Why did Aristotle recognize the exception in the case of males (which is, apparently, false) but not females? We have seen that his theory assumes (i) that the male is hotter and (ii) that the male contributes form rather than matter. Perhaps, then, this is another case of Aristotle fudging the “empirical data” to fit his theory.

2.5 POSITIVE USES OF LOGICAL REASONING

We have looked in depth at how the *logikós* mode of reasoning functions in Aristotle’s approach to the question of sterility in mules. I have argued that *logikós* arguments are not essentially dependent upon principles external to the science or domain of inquiry, but rely rather on principles that are too general relative to the question at hand. I will now turn to the question of whether Aristotle rejects the use of *logikós* reasoning altogether.

We might think that there is no place for *logikós* reasoning in natural science, given Aristotle’s negative remarks in *GA* II 8 and elsewhere.¹³¹ Recall what Aristotle said in T5. He rejects an explicitly *logikós* explanation of mule sterility because it is ‘too general and empty’ and ‘not based on appropriate principles’. In line with these difficulties, he puts forward the following prohibition on the proper manner of investigation in science: “We must not inquire into questions of natural science in this manner any more than any other questions

¹³⁰ For more on the place of mules in Herodotus, see Strong (2010).

¹³¹ The terms '*logikós*' and '*kenos*' are paired again at *EE* I 8, 1217b21.

(τοῦτον μὲν οὖν τὸν τρόπον οὔτε περὶ τῶν ἄλλων δεῖ ζητεῖν οὔτε περὶ τῶν φυσικῶν)” (748a13-14). This might be taken to suggest a categorical prohibition against the use of *logikós* reasoning in natural science. However, in other contexts we find Aristotle himself using and apparently endorsing *logikós* reasoning in natural science. As I will argue in more detail below, in his discussions of the infinite in *Physics* III 5 and *De Caelo* I 7, Aristotle employs *logikós* reasoning to show that there cannot be an infinite body.¹³² Indeed, there are many other cases where Aristotle employs *logikós* reasoning in conjunction with other modes in order to establish key scientific and meta-scientific theses. For instance, when Aristotle sets out in the *Posterior Analytics* to show that it is not possible for the terms in a chain of demonstrations to be indefinitely many, he draws on both *analutikos* and *logikós* modes of reasoning (*APo.* I 21, 82b34-36; 84a7-11; 84b1-2). A few chapters later, he uses *logikós* reasoning again to show that it is impossible for all deductions to have the same principles (I 32, 88a18-19). In addition, *Physics* VIII 8 uses a series of both *logikós* and *phusikós* arguments to establish the scientific thesis that only circular motion can be continuous and infinite. Although I limit my discussion to the positive uses of *logikós* reasoning in *Phys.* III 7, *De Caelo* I 7, and *Metaphysics* XI 10, I expect a similar analysis could be given to show consistency between my interpretation and the other uses in *APo.* and *Phys.* VIII. Accordingly, it seems that in *GA* II 8 he must be prohibiting the use of a certain kind of *logikós* reasoning, namely *logikós* reasoning that is *excessively* general. If the explanation is made at the correct level of generality and the natural scientist takes into consideration the relevant empirical data, then a *logikós* argument can indeed play a positive role in natural-scientific investigation.

¹³² Similar arguments are found in *Metaphysics* XI 10.

Aristotle's discussion of the infinite begins in *Physics* III 4, where he notes several times the appropriateness of the subject to natural science. This appropriateness stems first from the fact that the things with which natural science is primarily concerned – magnitudes, change, and time – will necessarily be either infinite or finite. For this reason, the natural scientist must inquire into both the fact and the reason, determining whether there is such a thing as the infinite or not (εἰ ἔστιν ἢ μή) and, if there is, what it is (καὶ εἰ ἔστιν, τί ἐστίν) (*Phys.* III 4, 202b35).¹³³ Additionally, Aristotle thinks the appropriateness is clear from that fact that all of his predecessors who made worthwhile contributions to natural science gave some account of the infinite (*Phys.* III 4, 203a2-4).¹³⁴

The initial discussion makes it seem as though the natural scientist should be concerned with the infinite quite generally, but Aristotle clarifies that the problem *most* appropriate to natural science (μάλιστα δὲ φυσικοῦ) is whether there is a *sensible* infinite magnitude (III 4, 203b35-204a1; cf. 202b30-203a4, 203b3-4). He separates the general question from the question appropriate to natural-scientific inquiry again in III 5.

[T7] But perhaps this question is a general one (καθόλου ἢ ζήτησις) – whether the infinite can be present in mathematical objects and things which are intelligible (ἐν τοῖς νοητοῖς) and do not have extension. Our investigation concerns the objects of sense (περὶ τῶν αἰσθητῶν) and the other objects of our course of inquiry (περὶ ὧν ποιούμεθα τὴν μέθοδον), whether there is or is not among them a body infinite in extent.¹³⁵ (*Phys.* III 5, 204a34-204b4)

ἀλλ' ἴσως αὕτη μὲν [ἐστίν] καθόλου ἢ ζήτησις, εἰ ἐνδέχεται ἄπειρον καὶ ἐν τοῖς μαθηματικοῖς εἶναι καὶ ἐν τοῖς νοητοῖς καὶ μηδὲν ἔχουσι μέγεθος· ἡμεῖς δ' ἐπισκοποῦμεν περὶ τῶν αἰσθητῶν καὶ περὶ ὧν ποιούμεθα τὴν μέθοδον, ἅρ' ἔστιν ἐν αὐτοῖς ἢ οὐκ ἔστι σῶμα ἄπειρον ἐπὶ τὴν αὔξησιν.

¹³³ See *APo.* II 1-2.

¹³⁴ Cf. *De Caelo* I 5, 271b1-16.

¹³⁵ Trans. R. P. Hardie and R. K. Gaye.

We are faced with two questions regarding the infinite. First, we have the general question of whether the infinite can be present in any body whatsoever, whether perceptible, intelligible, or mathematical. This question extends beyond the scope of the inquiry at hand, which is concerned primarily with the objects of sense, so Aristotle introduces the more narrow question, appropriate to the natural-scientific investigation, of whether there is an infinitely large body among the objects of sense.

With these questions in place, Aristotle next distinguishes between and employs two modes of argumentation in support of the view that there is no such infinite body. First, he introduces two very brief *logikōs* arguments to show that the infinite cannot be present in a body of any kind, whether physical, intelligible, or mathematical.

[T8] If we argue *logikōs*, it would appear that there is not [an infinite body], as follows. (*Phys.* III 5, 204b4-5)¹³⁶

λογικῶς μὲν οὖν σκοποῦμενοις ἐκ τῶν τοιῶνδε δόξειεν ἂν οὐκ εἶναι·

Before considering the arguments that follow, we should note that Hussey reads the use of δόξειεν ἂν at 204b4 as governing the text to 205a6, so that the arguments of 204b4-205a7 are put forward as “prima facie only”, while the arguments that follow from 205a8-206a8 are “put as clinching (‘it is clear’, 205a9, ‘it is manifest’, 205b24)” (1983, 79). However, there is no reason to suppose the use of δόξειεν ἂν at 205a5 extends further than the *logikōs* considerations. This is in line with what we have seen elsewhere (e.g. *GA* II 8), where Aristotle uses the same designation to introduce *logikōs* argumentation as one possible – and plausible – mode of inquiry.

¹³⁶ Hussey (trans.). Alternatively, Hardie and Gaye: “We may begin with a dialectical argument and show as follows that there is no such thing.”

The first argument holds that there cannot be an infinite body, for an infinite body would necessarily be unbounded. This argument thus works with the definition of body as what is 'bounded by a surface'.¹³⁷ The second (parenthetical) argument shows that number taken in abstraction cannot be infinite, since number or that which has number is numerable; and since it is possible for the numerable to be numbered, it would be possible to go through the infinite.

Each argument draws on a definition: the former, of 'body', and the latter, of 'number'. These are what we might call analytic truths. And in contrast to the *logikós* argument in *GA* II 8, which draws on principles peculiar to the science of biology (although ultimately too general and false), the arguments here draw on principles more general than or external to natural science. The definitions of body and number used in these *logikós* arguments are not particular to any one science, but provide a general understanding that transcends the physical, intelligible, and mathematical approaches.

However, we might still consistently maintain that these arguments are *logikós* because of the generality of the kinds to which they apply, rather than the externality of the principles from which they argue. The latter view is taken by Hussey, who thinks the arguments are *logikós* because they use principles external to natural science. Thus, he says "[t]he question of whether there is a self-subsistent Infinite is not germane to physics and has to be treated with 'formal' arguments i.e. ones not drawing on any particular science" (1983, 79). We have seen that this is not the sense of *logikós* as it is used in *GA* II 8, and I think there is good reason to adopt the same reasoning for T8. Accordingly, the *logikós* arguments are general *relative to* the more narrow question of whether there is an infinite

¹³⁷ The *phusikós* arguments that follow work with a definition of body as "what has extension in all directions" (204b20).

physical body. Admittedly, this is a question specific to the domain of physical inquiry. However, Aristotle is not critical of the *logikós* arguments because they are made at the appropriate level of generality relative to the more general question which asks about intelligible and mathematical bodies in addition to physical bodies. In other words, the *logikós* argument answers the general (*katholon*) question which concerns physical, intelligible, and mathematical bodies, while the *phusikós* argument answers only the more narrow question about physical bodies.

Surprisingly, given what we have seen in *GA* II 8, Aristotle offers no critique of either argument. His use of the optative δόξειεν with ἄν in T8 does not signal a lack of commitment to the argument or (*pace* Bolton) that the argument is merely dialectical. Rather, it indicates that this is one route we might take to show that there is no infinite physical body. But he is quick to specify that we can also prove this in a way more appropriate to physical inquiry, i.e. in a more *phusikós* manner, by restricting our proof to physical bodies. As we will see, in addition to restricting the scope of his arguments to the question at hand, Aristotle's *phusikós* considerations also utilize principles particular to natural science and appeal to observation for support.

After offering these brief *logikós* considerations, Aristotle narrows in on the question of whether there might be an infinite physical body.

[T9] If, on the other hand, we investigate the question more in accordance with principles appropriate to physics, we are led as follows to the same result.¹³⁸ (*Phys.* III 5, 204b10-11)

φυσικῶς δὲ μᾶλλον θεωροῦσιν ἐκ τῶνδε.

¹³⁸ Trans. R. P. Hardie and R. K. Gaye.

Aristotle here transitions to an investigation of the problem according to the *phusikós* mode of reasoning. Note that he says this argument is *more phusikós*, which implies that *phusikós* reasoning, like *logikós* reasoning, admits of degrees.

The series of arguments that follow are applicable to physical bodies only and appeal to a number of Aristotelian principles of natural science, such as the principle that ‘contraries must balance’ (204b14; 205a6) and that every physical body has an appropriate place to which it moves and in which it rests (205a10-12; 205b24). Aristotle also appeals to empirical considerations, arguing that an infinite body existing apart from the elements would have to be present in our world, but nothing of the sort is observed (204b30-35). He concludes the chapter by remarking that “[i]t is plain from these arguments (ἐκ τούτων) that there is no body which is actually (ἐνεργείᾳ) infinite” (*Phys.* III 5, 206a7-8). On Hussey’s reading, since the optative in T8 is taken to indicate a merely *prima facie* plausibility that governs the text ranging from 204b4-205a7, we must restrict the τούτων here to the section where the optative is no longer operating (205a8 ff.). However, on a more natural reading of T8, the optative governs only the *logikós* reasoning, so that this conclusion in refers to all the *phusikós* arguments in III 5.

Aristotle’s inquiry into the question of whether there is an infinite body continues in the first book of *De Caelo*, where he again employs *logikós* reasoning as an independent but compatible method of investigation. Zingano is thus mistaken about the absence of ‘*logikós*’ language in *De Caelo*. He says that “[t]he *De Caelo* never uses the word *logikós*” (2017, 16), but Aristotle uses the comparative ‘*logikóteron*’ at I 7, 274a23.¹³⁹ The arguments in I 5 apply to the primary body which moves in a circle, i.e. the sphere of the fixed stars, while the arguments

¹³⁹ One might worry that it doesn’t follow from something being “more *logikós*” (*logikóteron*) that that thing is *logikós* (*haplós*). However, if A is more black than B, then both are clearly black.

in I 6 apply to the bodies which move towards and away from the center, i.e. the elements. This *κατὰ μέρος* approach is contrasted with the general (*καθόλου*) or ‘more *logikós*’ (*λογικώτερον*) approach taken in I 7 to show that no body of any kind can be infinite (*De Caelo* I 7, 274a19-23; 275b12).¹⁴⁰ So we see again that *logikós* reasoning is general relative to the question under investigation. It is not an essentially dialectical method or a metaphysical kind of argumentation that draws on principles external to natural science. Aristotle’s inquiry into the infinite proceeds at different levels: he takes a *phusikós* or ‘kata meros’ approach to show that the infinite cannot be present in any physical body, whether it moves in a circle (i.e. the primary body) or toward and away from the center (i.e. the elements); but he also uses *logikós* reasoning to show that the infinite cannot be present in any kind of body whatsoever.

Aristotle’s positive use of *logikós* reasoning in his discussion of the infinite can also help us make better sense of his suggestion that we might consider a *logikós* argument when examining the question of mule sterility in *GA*. For in his discussion of the infinite, Aristotle nowhere objects to the use of *logikós* reasoning or raises any suspicions about its efficacy (at least relative to the more general question). Due to the success of *logikós* reasoning in the *Physics* and *De Caelo*, then, Aristotle might have thought in *GA* that we should try adopting a similar approach in order to explain all cases of reproduction, especially because that was the strategy adopted by his predecessors. Of course, as we have seen, in that case such reasoning is not successful precisely because the approach is too general relative to the question of mule sterility. *Logikós* reasoning in *Physics* and *De Caelo* works because it is used to address the

¹⁴⁰ The general approach is said to have been taken in the ‘discussion of principles’, which commentators assume is a reference to *Physics* III 4-8. (Although suspicion has been raised about the authenticity of *De Caelo* I 7, since Aristotle normally refers to *Physics* III 2-4 as ‘On Nature’. See Ross *Physics*, 5.) However, there is a question of whether the reference might be to the more specific passage containing the *logikós* arguments (i.e. III 5, 204b4-9).

more general question of whether there is an infinite body of any kind. It does not work in *GA*, however, because the argument is there taken to apply to all cases of reproduction, while the question asks only about one specific case, namely the mule.

2.6 CONCLUSION

This chapter focused on the role of *logikós* reasoning in Aristotle's natural science, especially in the discussion of mule sterility in *GA* II 8. We saw that *logikós* reasoning is not merely dialectical, nor does it essentially rely on principles drawn from outside the domain of natural science in order to impart conviction. It is essential to this mode of reasoning only that the principles employed are general relative to the specific question under investigation. This discussion also shed light on the link between Aristotle's theory of science and his practise, especially his use of demonstration. With this new interpretation in place, we examined some of Aristotle's positive uses of *logikós* reasoning in his investigation into the question of whether there is an infinite body. In each case, Aristotle distinguishes between a more general question and a more specific question, and the *logikós* arguments he offers apply only to the former; they remain general relative to the more specific questions, and so are rightfully labelled *logikós*. Accordingly, Aristotle's methodology is more complex and dynamic than scholars have traditionally thought.

2.7 APPENDIX ON VERBS OF INVESTIGATION

We find in Aristotle two grammatically distinct uses. Most often, he employs the adverbial use – *logikós* – in conjunction with a variety of verbs of investigation, although on a few occasions he employs the adjectival use – *logiké* – when speaking about demonstration or virtue. The adverbial use is employed in conjunction with the following verbs of investigation:

Verb	Meaning	Text
σκοπέω	to look at; to behold, contemplate; to look to, consider, examine	GC I 2 Phys. III 5 Cael. I 7 (<i>logikós</i> implied)
ἐπισκοπέω	to look upon or at, inspect, observe, examine, regard	Phys. VIII 8
θεωρέω	to look at, view, behold; to contemplate, consider, observe	Phys. III 5 (with <i>phusikós</i>) Cael. I 7 (with <i>kata meros</i>) APo. I 22 APo I 32
ἐπιχειρέω	inf. to endeavour or attempt to do	Cael. I 7 (with <i>logikóteron</i>)
δείκνυμι	to bring to light, display, exhibit; to point out	APo. I 22

BIBLIOGRAPHY

- Barnes, J. (1994) *Aristotle: "Posterior Analytics," 2nd edn.* Oxford.
- Bolton, R. (1987) "Definition and Scientific Method in Aristotle's *Posterior Analytics* and *Generation of Animals*", in Gotthelf and Lennox (1987): 120-166.
- (2009) "Two Standards for Inquiry in Aristotle's *De Caelo*" in *New Perspectives on Aristotle's De Caelo*, (eds.) A. Bowen and C. Wildberg. Brill: 51-81.
- Burnyeat, M. (2001) *Map of Metaphysics Zeta.* Pittsburgh.
- Falcon, A. (2005) *Aristotle and the Science of Nature: Unity without Uniformity.* Cambridge.
- Falcon, A. and D. Lefebvre (2017) *Aristotle's Generation of Animals: A Critical Guide.* Cambridge.
- Falcon, A. and M. Leunissen (2015) "Eulogos in Natural Scientific Inquiry" in *Theory and Practice in Aristotle's Natural Philosophy*, (ed.) D. Ebrey. Cambridge: 217-240.
- Groisard, J. (2017) "Hybridity and Sterility in Aristotle's *Generation of Animals*" in *Aristotle's Generation of Animals: A Critical Guide.* (eds.) A. Falcon and D. Lefebvre. Cambridge: 153-170.
- Hankinson, R. J. (2014) *Simplicius, On Aristotle's On the Heavens 1.5-9.* London.
- Hardie R. P. and Gaye, R. K. (1984) (trans.) *Physics*, in J. Barnes (ed.) *The Complete Works of Aristotle.* Princeton.
- Hussey, E. (1983) *Physics Books III and IV.* Oxford.
- Karbowsky, J. (2014) "Empirical *Eulogós* Argumentation in Aristotle's *Generation of Animals* III.10," *British Journal for the History of Philosophy* 22, 1: 25-38.
- (2016) "Justification 'by Argument' in Aristotle's Natural Science," *Oxford Studies in Ancient Philosophy* 51: 117-58.
- Laggatt, S. (1995) *Aristotle On the Heavens Book 1 and 2.* Warminster.
- Lennox, J. (1995) "Material and Formal Natures in Aristotle's *De Partibus Animalium*?" in *Proceedings of the Boston Area Colloquium in Ancient Philosophy* 11: 217-240.
- (2001) "Aristotelian Problems" in *Aristotle's Philosophy of Biology: Studies in the Origins of Life Science.* Cambridge: 72-95.
- (2010) "Aristotle's Natural Science: the Many and the One," *Apeiron* 43(2-3): 1-24.

- (2015) "Aristotle's *Posterior Analytics* and the Aristotelian *Problemata*" in *The Aristotelian Problemata Physica: Philosophical and Scientific Investigations*, (ed.) R. Mayhew. Brill.
- Lloyd (1996) "Theories and Practises of Demonstration" in *Aristotelian Explorations*.
Cambridge: 38-66.
- Mosquera, G. (1998) "L'interprétation de l'argument *logikós* chez Aristote," *Études classiques*:
33-52.
- Nussbaum, M. (trans. & comm.) (1978) *Aristotle's De Motu Animalium*. Princeton.
- Platt, A. (1984) (trans.) *Generation of Animals*, in J. Barnes (ed.) *The Complete Works of Aristotle*.
Princeton.
- Reeve, C. D. C. (2016) *Aristotle: Metaphysics*. Hackett.
- Ross, W. D. (1924) *Aristotle: Metaphysics*, vol. ii. Oxford: 168 and 171.

(1936) *Aristotle's Physics*. Oxford.
- Steinkrüger, P. (2018) "Aristotle on Kind-Crossing," *Oxford Studies in Ancient Philosophy* 54:
107-158.
- Strong, A. K. (2010) "Mules in Herodotus: The Destiny of Half-Breeds," *The Classical World*
103(4): 455-464.
- Zingano, M. (2017) "Ways of Proving in Aristotle" in *Reading Aristotle: Argument and Exposition*, (eds.) W. Wians and R. Polansky. Brill: 7-49.

CHAPTER 3
The Hunt for Definitions: Posterior Analytics II 13

3.0 INTRODUCTION

Socrates initiated a turn away from the speculative natural philosophy of his predecessors toward the study of human life and virtue. He is credited, by Aristotle, with two major innovations: the use of inductive arguments and universal definitions.¹⁴¹ These were both taken up by Socrates' successors. We see the search for universal definitions playing a central role in Plato's early 'Socratic' dialogues, in which the character of Socrates finds some purported expert on an ethical topic and puts forward the 'What is X' question. This is followed by an elenctic exchange between Socrates and his interlocutor, as one definition is proposed, some inconsistency discovered, a new or revised definition proposed, another inconsistency discovered, and so on, until the interlocutor either reaches a state of *aporia* or escapes Socrates' questioning.

Plato carried on the Socratic programme and remained committed to the search for definitions. He introduced a number of his own innovations, including the two-stage 'dialectical' procedure of collection and division. Although it is a matter of debate whether this procedure constitutes a formal method or an informal skill acquired through hands-on training, most scholars agree that Plato uses collection and division in an attempt to generate real definitions and discover basic natural kinds, 'carving nature at the joints' (*Phaed.* 265e1-3). Plato introduces the method in the *Phaedrus* and applies it in the *Philebus*, *Sophist*, and *Politicus*. It is clear that division occupies an important place in his mature philosophical method.

¹⁴¹ *Metaph.* XIII 4, 1078b26-28.

Aristotle inherited the method of division from Plato and the Academy. He often appears heavily critical, but it has been noticed that Aristotle criticizes division in order to reform—rather than reject—the method. His discussion is scattered throughout a number of works, including the *Topics*, *Analytics*, *Metaphysics*, and *Parts of Animals*, but aim in this paper is to get clear on the role of division in the context of the *Posterior Analytics*. First, I examine Aristotle’s critique of division in II 5, wherein he rejects division as a method of demonstrating definitions and introduces an important problem. Next, I show that this problem motivates Aristotle to formalize the method of division—a task which is carried out in II 13. In this chapter, he develops a number of rules to ensure that division will include all and only predicates that are essential to the subject in question.

I argue that II 13 contains a single, unified method for generating real definitions of basic natural kinds. This method first locates a cluster of predicates that belongs uniquely to the species under consideration. Although some commentators have found the ‘cluster’ method to be a distinct procedure, I maintain that it is in fact complementary to and consistent with the method of division. I argue that division acts as a correctional procedure that we perform on the results obtained by the ‘cluster’ method. The rest of II 13 expands on this method and discusses the divisional safeguards used to prevent various errors that the traditional method of division is prone to make. Accordingly, division is not merely a pedagogical device used to present the results of an inquiry into the essence of a kind. Aristotle is interested in division not merely a tool for classification and taxonomy, but as a method that will actually assist us in the search for definitions. This paper takes seriously Aristotle’s claim that II 13 will tell us ‘how we should hunt out the items predicated in what something is.’¹⁴²

¹⁴² *APo.* II 13, 96a23.

3.1 THE CRITIQUE OF DIVISION

The first book of the *Posterior Analytics* lays out in detail the method of demonstration (*apodeixis*), by which we arrive at unqualified scientific knowledge (*episteme haplos*). Early on in the second book, Aristotle examines the various *aporiai* associated with the question of whether and to what extent definitions might be demonstrated. In *APo.* II 5 he considers and rejects the view that definitions might be demonstrated through the process of division.

First, Aristotle points out that in a division the conclusion is taken as an assumption. If we are seeking a definition of ‘man’, the divider assumes first that everything is either animate or inanimate, and then assume that man is one of these, namely, animate. Next, she assumes that every animal is either terrestrial or aquatic, and that man is terrestrial. So, at every step in the division there is a mere assumption rather than an inference. Second, Aristotle faults the divider because even though she could make some valid inference during the process, she does not. For instance, given the assumption that man is an animal and that every animal is either terrestrial or aquatic, our divider could infer that man is either terrestrial or aquatic. But she does not do this. Rather, she simply assumes that man is terrestrial, and continues to divide.

The third and perhaps more serious problem concerns the resources of division to ensure that we arrive at a real definition. For, even if each assumption is true and man is in fact a terrestrial animal, we have no reason to think that this is the *definition* of man. Specifically, Aristotle worries that we might either posit some additional non-essential

predicate or omit some predicate that is essential. Either way, the set of predicates arrived at through division will fail to express the real definition of the subject in question.¹⁴³

Although the first two problems are insurmountable—division cannot get us beyond mere assumption in order to demonstrate a definition—Aristotle offers a solution to the problem of adding and omitting predicates. He thinks that, with the proper revisions in place, we will be able to ensure that division can get us a set that includes all and only predicates contained in the definition we are seeking.

[T1] These points are ignored. It is possible to solve the difficulties if you assume everything in what the thing is, make the division consecutive by postulating what is primitive, and leave nothing out.¹⁴⁴ (*APo.* II 5, 91b29-31)

Ταῦτα μὲν οὖν παρίεται μὲν, ἐνδέχεται δὲ λῦσαι τῷ λαμβάνειν ἐν τῷ τί ἐστι πάντα, καὶ τὸ ἐφεξῆς τῆ διαιρέσει ποιεῖν, αἰτούμενον τὸ πρῶτον, καὶ μηδὲν παραλείπειν.

This solution is developed in II 13 and we will return to it below. But it is important to emphasize in the context of the *aporiai* that division does not demonstrate definitions. Rather, Aristotle compares the procedure to induction (*epagoge*) insofar as neither demonstrates anything, but both show something and give us knowledge of ‘what something is’ (i.e. the essence) in some other way.

Aristotle raises a further problem with division in the next chapter, when he considers the possibility of hypothetical demonstration. He asks:

[T2] Why will man be a two-footed terrestrial animal and not an animal and terrestrial? For the assumptions do not make it necessary that what is predicated form a unity – rather, it is as if the same man were musical and literate. (*APo.* II 5, 92a29-33)

¹⁴³ “For why should all this not be true of man and yet not show what a man is or what it is to be a man? Again, what prevents you from positing some additional item, or from removing something, or from passing over something in its essence?” (91b25-27)

¹⁴⁴ All translations from the *Posterior Analytics* are from Barnes (1994).

διὰ τί ἔσται ὁ ἄνθρωπος ζῶον πεζὸν δίπουν, ἀλλ' οὐ ζῶον καὶ
πεζόν <καὶ δίπουν>; ἐκ γὰρ τῶν λαμβανομένων οὐδεμία ἀνάγκη
ἔστιν ἔν γίνεσθαι τὸ κατηγορούμενον, ἀλλ' ὥσπερ ἂν ἄνθρωπος ὁ
αὐτὸς εἴη μουσικὸς καὶ γραμματικὸς.

The worry here is that the method of division cannot account for the unity of the *definiens*. There is nothing in the procedure to ensure that the items predicated in what the thing is (i.e. the essential predicates) will form a unity, rather than a mere list of terms held together by some accidental connection. A solution to this problem, too, will depend on the reforms to division carried out in II 13.

3.2 THE CONTEXT OF THE HUNT

The purported aim of *Posterior Analytics* II 13 is to ‘say how we should hunt out the items predicated in what something is’ (96a23). The chapter promises, in other words, to offer a method for discovering definitions. In the preceding chapters, Aristotle distinguished between three kinds of definition: (i) the nominal definition, which is ‘an account of what the name is’ (93b30) given in ‘the conclusion of the demonstration’ (94a9); (ii) the causal definition, which is ‘an account which shows why a thing exists... differing in arrangement from a demonstration’ (94a1-4); and (iii) the formal definition, which is ‘an indemonstrable positing of what it is’ (94a10). Formal definitions are unique in that they are either taken for granted or made known by some method other than demonstration. So, Aristotle tells us in II 9:

[T3] Of some things there is something else which is their explanation, of others there is not. Hence it is plain that in some cases what something is is immediate and a principle; and here you must suppose, or make clear in some other way, both that the thing exists and what it is. (*APo.* II 9, 93b21-4)

Ἔστι δὲ τῶν μὲν ἕτερόν τι αἴτιον, τῶν δ' οὐκ ἔστιν. ὥστε δῆλον
ὅτι καὶ τῶν τί ἐστι τὰ μὲν ἄμεσα καὶ ἀρχαί εἰσιν, ἃ καὶ εἶναι καὶ τί
ἐστιν ὑποθέσθαι δεῖ ἢ ἄλλον τρόπον φανερὰ ποιῆσαι·

It is clear that the method advanced in II 13 will not yield nominal definitions, since these are grasped independently of any method and appear to simply represent the common understanding of the term. For instance, we get the nominal definition of thunder as ‘a certain noise in the clouds’ (93a23). Neither will the method of II 13 yield causal definitions, since Aristotle has already explained how we arrive at causal definitions in II 8. He offers the causal or scientific definition of thunder as ‘a noise in the cloud caused by the extinction of fire’ (93b8). So, if II 13 does in fact present a method for discovering definitions, it appears that these must be formal definitions.

3.3 THE METHOD FOR HUNTING THE *INFIMA SPECIES*

With this context in mind, let us turn to the text of II 13. To begin, Aristotle isolates a kind of predicate or attribute. He is not concerned with predicates that hold of something only occasionally (as, for example, being musical holds of man), but rather with predicates that hold of something always (as being rational holds of man). Of these permanent predicates, some extend beyond the subject without going outside its kind (*genos*), while others extend beyond both the subject and its kind.

Aristotle considers the mathematical example of the triplet. He supposes that existence is a permanent predicate of the latter kind, and so holds of triplets but also extends beyond the kind to non-numbers (since existence holds of everything that is). In hunting out definitions, however, we are concerned with the former kind of permanent predicates, i.e., those which extend beyond the subject without going outside its kind. Returning to the

example of the triplet, we find that odd is just this kind of predicate, since odd holds of every triplet and extends further (since it also holds of quintuplets, septuplets, etc.), but it does not extend beyond the kind number.

Now that this kind of permanent predication has been isolated, Aristotle offers the following advice for discovering essences:

[T4] We should take items of this type up to the point at which we have first taken just so many that, while each extends further, all of them together do not extend further: this must be the essence of the object. (*APo.* II 13, 96a32-35)

τὰ δὴ τοιαῦτα ληπτέον μέχρι τούτου, ἕως τοσαῦτα ληφθῆ πρώτον ὧν ἕκαστον μὲν ἐπὶ πλεόν ὑπάρξει, ἅπαντα δὲ μὴ ἐπὶ πλεόν· ταύτην γὰρ ἀνάγκη οὐσίαν εἶναι τοῦ πράγματος.

Returning again to the mathematical example of the triplet, we find several predicates that extend further without extending beyond the kind: number, odd, prime₁, and prime₂. Each of these predicates taken alone holds of other numbers (odd holds of quintuplets, prime₁ and prime₂ hold of pairs), but all of these properties taken together hold of nothing apart from triplets. Aristotle here describes a framework in which the essence or definition of a thing is initially discovered by isolating a cluster or set of predicates.

It is clear that the cluster method makes a number of assumptions, so that some work must already be done prior to its employment. First, the method is applied to an *infima species*, such as the triplet, and so we must have already identified the species in order to search for its definition. Moreover, we must already have identified the kind or genus in order to isolate those permanent predicates which do not extend beyond it. So, we first identify an infima species and genus, and then apply this method to discover the predicates which constitute the definition or essence of the species.

3.4 DIVISION AND ORDER: 96b26-97a6

Once the cluster method has been introduced, Aristotle returns to his discussion the method of division which had been criticized in II 5. Perhaps surprisingly, he claims that division will be useful in the pursuit of definitions. We might worry that division is of no use, since it assumes what ought to be demonstrated. However, Aristotle assures us that this is not problematic.

[T5] They might indeed be thought to be of no use at all but to assume everything straight off – as if you were to make your assumptions at the beginning without a division. But it makes a difference which of the predicates are predicated first and which later – e.g. whether you say *animal tame two-footed* or *two-footed tame animal*. For if every item is made up from two things, and if *animal tame* constitutes a single item, and if man (or whatever the single thing in question may be) is next made up from this and the difference, then you must make a division before making your postulates. (*APo.* II 13, 96b30-35)

καίτοι δόξειέν γ' ἂν οὐδέν, ἀλλ' εὐθὺς λαμβάνειν ἅπαντα, ὥσπερ ἂν εἰ ἐξ ἀρχῆς ἐλάμβανέ τις ἄνευ τῆς διαιρέσεως. διαφέρει δέ τι τὸ πρῶτον καὶ ὕστερον τῶν κατηγορουμένων κατηγορεῖσθαι, οἷον εἰπεῖν ζῷον ἡμερον δίπουν ἢ δίπουν ζῷον ἡμερον. εἰ γὰρ ἅπαν ἐκ δύο ἐστί, καὶ ἔν τι τὸ ζῷον ἡμερον, καὶ πάλιν ἐκ τούτου καὶ τῆς διαφορᾶς ὁ ἄνθρωπος ἢ ὁ τι δῆποτ' ἐστὶ τὸ ἐν γινόμενον, ἀναγκαῖον διελόμενον αἰτεῖσθαι.

It seems that Aristotle is here concerned with the objection raised in *B* 6 and the thesis that essences or real definitions are somehow unitary (See [T2]). His argument for this thesis involves three steps. First, Aristotle assumes that every species is made up from two things (namely, a genus and a differentia). Second, he assumes that the genus and first differentia will constitute a single item (so that '*animal tame*' is a unity). Finally, he assumes that the infima species is made up from the unity of the genus ('*animal tame*') and differentia ('two-footed'). In his example, we begin with the definitional formula for man, arrived at through the cluster method:

Animal Tame Two-footed

This formula, according to Aristotle, represents a unity composed of two elements – a genus and a difference. Thus, we may bracket the appropriate unity:

(Animal Tame) Two-footed

If we postulate a definition before making a division, then we may very well end up with:

(Two-footed Tame) Animal

This definition, however, attempts to express an essence that is not unitary. For, ‘two-footed tame’ does not constitute a single item. Indeed, there are many tame animals that are not two-footed. Similarly,

(Two-footed Animal) Tame

is unacceptable because there are animals that are not two-footed. So, once we have our cluster of essential predicates, we ought to employ the method of division in order to ensure that these predicates have the proper order. This order will guarantee that the definiens is a unity, so we avoid the objection raised by [T2] that division will leave us with a mere list of terms held together by some accidental connection.

The proper order will also ensure that we do not omit any essential predicates.

Aristotle is worried that we might attempt to divide a genus by some difference that is not proper to it. This happens when we identify the first kind and then take a lower division, passing over something in between. For instance, we might attempt to divide ‘animal’ into ‘whole-winged’ and ‘split-winged’. But ‘whole-winged’ is not a proper difference of animal. Rather, it is a difference only of ‘winged animal’.

[T6] Again, only in this way is it possible to ensure that you omit nothing in what the thing is. For if, when the first kind has been taken, you then take one of the lower divisions, not everything will fall into it. E.g. not every animal is either whole-winged or split-winged – rather, every winged animal is (this it is *this* of which this is a difference). The first difference of animal is that into which every

animal falls; and similarly for everything else, both the kinds outside it and the kinds subordinate to it (e.g. the first difference of bird is that into which every bird falls, and of fish into which every fish). If you continue in this way you can know that nothing has been omitted: otherwise you are bound to omit something without knowing it. (*APo.* II 13, 96b35-97a7)

Ἔτι πρὸς τὸ μηδὲν παραλιπεῖν ἐν τῷ τί ἐστὶν οὕτω μόνως ἐνδέχεται. ὅταν γὰρ τὸ πρῶτον ληφθῆ γένος, ἂν μὲν τῶν κάτωθεν τινα διαίρεσεων λαμβάνῃ, οὐκ ἐμπεσεῖται ἅπαν εἰς τοῦτο, οἷον οὐ πᾶν ζῷον ἢ ὀλόπτερον ἢ σχιζόπτερον, ἀλλὰ πτηνὸν ζῷον ἅπαν· τούτου γὰρ διαφορὰ αὕτη. πρώτη δὲ διαφορὰ ἐστὶ ζῶου εἰς ἣν ἅπαν ζῷον ἐμπίπτει. ὁμοίως δὲ καὶ τῶν ἄλλων ἐκάστου, καὶ τῶν ἔξω γενῶν καὶ τῶν ὑπ' αὐτό, οἷον ὄρνιθος, εἰς ἣν ἅπας ὄρνις, καὶ ἰχθύς, εἰς ἣν ἅπας ἰχθύς. οὕτω μὲν οὖν βαδίζοντι ἔστιν εἰδέναι ὅτι οὐδὲν παραλείπεται· ἄλλως δὲ καὶ παραλιπεῖν ἀναγκαῖον καὶ μὴ εἰδέναι. οὐδὲν δὲ δεῖ τὸν ὀρίζομενον καὶ διαιρούμενον ἅπαντα εἰδέναι τὰ ὄντα. καίτοι ἀδύνατόν φασί τινες εἶναι τὰς διαφορὰς εἰδέναι τὰς πρὸς ἕκαστον μὴ εἰδόμενα ἕκαστον·

We know that ‘whole-winged’ and ‘split-winged’ fail as differentiae of ‘animal’ since there are many animals that do not fall into either kind. So, we will avoid omission if we divide a kind by its ‘primary differentiae’, which are those into which all members of the kind will fall.

3.5 THREE RULES FOR DIVIDING: 97a23-b6

Following a brief digression, Aristotle returns to his discussion of the rules of division.

Recall the prescriptions of II 5: “It is possible to solve the difficulties if you assume everything in what the thing is, make the division consecutive by postulating what is primitive, and leave nothing out” (91b29-31). Aristotle reiterates this point in II 13:

[T8] To establish (or construct: κατασκευάζειν) a definition through divisions, you must aim for three things: you must take what is predicated in what the thing is; you must order these items as first or second; and you must ensure that these are all there are. (*APo.* II 13, 97a23-26)

Εἰς δὲ τὸ κατασκευάζειν ὄρον διὰ τῶν διαιρέσεων τριῶν δεῖ
στοχάζεσθαι, τοῦ λαβεῖν τὰ κατηγορούμενα ἐν τῷ τί ἐστὶ, καὶ
ταῦτα τάξει τί πρῶτον ἢ δεύτερον, καὶ ὅτι ταῦτα πάντα.

There are three steps involved in securing the correct definition of some species S. First, we must collect the essential predicates of S. As we have seen, we are able to collect these predicates through the ‘cluster’ method introduced at the beginning of the chapter. Next, we must arrange these in their proper order, according to the rules discussed above. Finally, we must ensure that nothing is omitted.

[T9] You will order the items as you should if you take the first term; and you will do this if you take the term which follows all the others but is not followed by them all (there must be some such term). Once this is taken, the same now goes for the lower terms: the second term will be the one which is first of the others, and the third the term which is first of the next group (if the topmost term is removed, the next will be first of the others). Similarly in the remaining cases. (*APo.* II 13, 97a29-34)

τὸ δὲ τάξει ὡς δεῖ ἔσται, ἐὰν τὸ πρῶτον λάβῃ. τοῦτο δ' ἔσται, ἐὰν
ληφθῇ ὁ πᾶσιν ἀκολουθεῖ, ἐκείνῳ δὲ μὴ πάντα· ἀνάγκη γὰρ εἶναί
τι τοιοῦτον. ληφθέντος δὲ τούτου ἤδη ἐπὶ τῶν κάτω ὁ αὐτὸς
τρόπος· δεύτερον γὰρ τὸ τῶν ἄλλων πρῶτον ἔσται, καὶ τρίτον τὸ
τῶν ἐχομένων· ἀφαιρεθέντος γὰρ τοῦ ἄνωθεν τὸ ἐχόμενον τῶν
ἄλλων πρῶτον ἔσται. ὁμοίως δὲ καὶ ἐπὶ τῶν ἄλλων.

First, we must take the predicate which follows all others but is not followed by them any of them. Returning to the example we discussed above, we will first take the predicate ‘animal’ since this follows the other terms – if something is ‘tame’ or ‘two-footed’ it is necessarily an animal – but is not followed by them all – since if something is an animal, it is not necessarily ‘tame’ or ‘two-footed’.

3.6 THE PROBLEM OF HOMONYMY: 97b6-25

In the final section of II 13, Aristotle explains how we are to avoid homonymous terms in division, emphasizing the importance of defining the species before the genus. First, he explains what we ought to do in abstract terms and follows this up with a clever example.

[T10] You should look at items which are similar and undifferentiated, and first seek what they all have in common. Then do the same again for other items which are in the same kind as the first group and are of the same form as one another but of a different form from the first group. When you have for what all these have in common, you must do the same for the remaining groups (inquiring next whether the items you have taken have anything in common) until you come to a single account: this will be the definition of the object. If you arrive not at a single account but at two or more, then plainly what you are seeking is not one item but several. (*APo.* II 13, 97b14-15)

Ζητεῖν δὲ δεῖ ἐπιβλέποντα ἐπὶ τὰ ὅμοια καὶ ἀδιάφορα, πρῶτον τί ἅπαντα ταῦτόν ἔχουσιν, εἶτα πάλιν ἐφ' ἑτέροις, ἃ ἐν ταύτῳ μὲν γένοι ἐκείνοις, εἰσὶ δὲ αὐτοῖς μὲν ταῦτα τῷ εἶδει, ἐκείνων δ' ἕτερα. ὅταν δ' ἐπὶ τούτων ληφθῇ τί πάντα ταῦτόν, καὶ ἐπὶ τῶν ἄλλων ὁμοίως, ἐπὶ τῶν εἰλημμένων πάλιν σκοπεῖν εἰ ταῦτόν, ἕως ἂν εἰς ἓνα ἔλθῃ λόγον· οὗτος γὰρ ἔσται τοῦ πράγματος ὀρισμός. ἐὰν δὲ μὴ βαδίξῃ εἰς ἓνα ἀλλ' εἰς δύο ἢ πλείους, δῆλον ὅτι οὐκ ἂν εἴη ἓν τι εἶναι τὸ ζητούμενον, ἀλλὰ πλείω.

Aristotle illustrates this method by considering the case of magnanimity. If we are seeking the definition of magnanimity, we should consider some set of magnanimous people and ask ourselves what one feature they all have in common *as such* (*kath auto*, in virtue of being magnanimous) (97b17). Aristotle takes for example Alcibiades, Achilles, and Ajax. These men all share the feature, in virtue of which they are called magnanimous, that they are 'intolerant of insult'. Next, we do the same for another set of magnanimous men.

Aristotle takes for example Lysander and Socrates, who share the common feature, in virtue of which they are called magnanimous, of 'being indifferent to good and bad fortune'. Next, we take these two features – indifference to fortune and intolerance of insult – and determine whether they have anything in common. If they have something in common, then this will be the definition of magnanimity. However, if they have nothing in common, then

there will be two forms of magnanimity. The point here is that we ought to search for the definition of a species before we seek a definition of its genus, since it is more difficult to recognize cases of homonymy at the higher level.

3.7 CONCLUSION

I have argued that *APo.* II 13 contains a single, unified method for generating real definitions of basic natural kinds. As we have seen, this method first locates a cluster of predicates that belongs uniquely to the species under consideration. Division then acts as a correctional procedure performed on the results obtained by the ‘cluster’ method, in order to prevent various errors that the traditional method of division is prone to make. So, division for Aristotle is not merely a pedagogical device or tool for classification, but a formal method that will aid us in the hunt for definitions.

BIBLIOGRAPHY

- Balme, David (1987) ‘Aristotle’s Use of Division and Differentiae’ in Gotthelf and Lennox: 69-89.
- Barnes, Jonathan (2002) *Aristotle: Posterior Analytics*. Oxford.

- Byrne, Patrick (1997) *Analysis and Science in Aristotle*. SUNY.
- Charles, David (2000) *Aristotle on Meaning and Essence*. Oxford.
- Deslauriers, Marguerite (1990) 'Plato and Aristotle on Division and Definition', *Ancient Philosophy* 10: 203-219.
- (2007) *Aristotle on Definition*. Brill.
- Falcon, Andrea (2000) 'Aristotle, Speusippus, and the Method of Division' *The Classical Quarterly* 50 (2): 402-414.
- Ferejohn, Michael (1982) 'Definition and the Two Stages of Aristotelian Demonstration' *Review of Metaphysics* 36: 375-395. (See 384)
- Goldin, Owen (2004) 'Atoms, complexes, and demonstration: Posterior Analytics 96b15-25,' *Studies in History and Philosophy of Science* 35: 707-727.
- Heath (1949) *Mathematics in Aristotle*. Routledge.
- Henry, Devin (2011) 'A Sharp Eye for Kinds: Collection and Division in Plato's Late Dialogues,' in *Oxford Studies in Ancient Philosophy*. Oxford: 229-55.
- McKirahan, Richard (1992) *Principles and Proofs*. Princeton. 111, 117-21
- Pellegrin, Pierre (1986) *Aristotle's Classification of Animals: Biology and the Conceptual Unity of the Aristotelian Corpus*. Trans. A. Preus. University of California Press.
- (1987) 'Logical Difference and Biological Difference: the Unity of Aristotle's Thought' in Gotthelf and Lennox.
- Ross, W. D. (1949) *Aristotle's Prior and Posterior Analytics*. Oxford.

4.0 CONCLUSION

Through the previous analysis of the various modes of argumentation employed by Aristotle throughout his natural scientific works, I hope to have shed some light on the relation between Aristotle's theory of science and his actual scientific practice. I have challenged the reading of Aristotle as a thoroughgoing methodological empiricist and argued that he permits a variety of non-empirical arguments to support controversial theses in properly scientific contexts. This more moderate view has roots in the early commentators, as we saw in the discussion of the dual knowledge criterion in the Introduction (0.1). However, I also argued that we ought not limit the modes of argumentation employed by Aristotle to only two, as do those who find a strict distinction between the natural-scientific mode and the dialectical mode, where the former leads to knowledge and the latter only to opinion. The more accurate approach, it seems, is to read Aristotle as something of a methodological pluralist.

We considered the role of rational (*kata ton logon*) argumentation and perceptual (*kata tēn aisthēsin*) argumentation in Aristotle's defence of cardiocentrism throughout the biological works. We saw the use of abstract *a priori* principles about the number and location of the source of soul in a substance (the Centrality Principle and the Unity Principle). We also considered the role of logical (*logikōs*) argumentation and physical (*phusikōs*) argumentation in Aristotle's discussion of mule sterility in *Generation of Animals* II 8 and his discussion of the infinite in *Physics* and *De Caelo*. Although he occasionally speaks disparagingly of *logikōs* reasoning as an 'empty' Platonic method of inquiry, we have seen that Aristotle also employs *logikōs* reasoning when there are questions posed at different levels of generality. And finally, we have seen that Aristotle sets up the method of division in *Posterior Analytics* II 13 as a formal *a priori* method for hunting out definitions of natural kinds. Accordingly, division

occupies a preliminary stage in his account of scientific inquiry, since demonstration—by which we arrive at scientific knowledge—must proceed from definitions.

In all of this we took a somewhat unusual approach. Rather than outlining and then *comparing* the doctrines of the *Posterior Analytics* with the practice of other treatises, in the first two chapters we examined the theoretical standards found within the natural-scientific works themselves; in the third, we examined the method of division as it appears in the *Posterior Analytics* without drawing a comparative account, for instance, to the discussion of division in *Parts of Animals* I. These three topics—rational argumentation, logical argumentation and division—are studied together because they each provide an avenue through which we can approach questions about the variegated nature of Aristotle’s argumentation.

The general thrust of the investigation into the modes of argumentation in Aristotle’s natural science was to push back against those who read Aristotle as a thoroughgoing methodological empiricist. The trend of reading Aristotle as a methodological empiricist has been prominent in scholarship of recent decades and is, oddly enough, very closely tied to academic scholarship on the 20th century Russian–American author Ayn Rand and the so-called ‘Objectivist’ movement. For instance, Lennox and Gotthelf played a large role in the recent popularity of Aristotle’s biological works, examining their relation to his more general philosophy of science as presented in the *Posterior Analytics*. They published many books and articles on the subject, including their landmark co-edited volume *Philosophical Issues in Aristotle’s Biology* (1987). They also acted as co-editors for the Ayn Rand Society Philosophical Studies series, publishing two volumes: *Metaethics, Egoism, and Virtue: Studies in Ayn Rand’s Normative Theory* (2011) and *Concepts and Their Role in Knowledge: Reflections on Objectivist Epistemology* (2013). In addition, Robert Mayhew, Fred D. Miller Jr. and Gregory Salmieri are

all prominent ‘empiricist’ interpreters of Aristotle, who also sit on the Editorial Board of the Ayn Rand Society Philosophical Studies series.

In an attempt to make Aristotle more appealing to 20th and 21st century philosophical sensibilities, these scholars present a sanitized version of Aristotle, ignoring or otherwise attempting to explain away the rationalist dimensions of his work and method. They make Aristotle a champion of empiricism, but they fail to take into account or recognize Aristotle’s use of abstract arguments that lack empirical foundation. By contrast, I have taken a broader perspective on the modes of argumentation in Aristotle’s natural science in order to present a fuller and more accurate picture of the methods at play.

In many properly scientific contexts, we find Aristotle contrasting perceptual and physical arguments with rational and logical arguments, using arguments of all kinds to defend controversial theses; in his work on what we might call the philosophy of science, the *Posterior Analytics*, we find the method of division occupying a central role in the hunt for definitions. This suggests that the strict thoroughgoing empiricist readings of Aristotle go wrong in assuming that there is only one kind of properly scientific method or standard—namely, empirical induction—by which we can arrive at and evaluate scientific knowledge or *epistêmê*. In addition to the dialectical method outlined in the *Topics* and, according to some scholars, employed in scientific works such as the *Physics*, Aristotle makes use of several kinds of argumentation besides empirical induction. He is not a thoroughgoing methodological empiricist, but rather a methodological pluralist, making use of a variety of modes of argumentation in his investigation of the natural world.

Curriculum Vitae
Adam W. Woodcox

EDUCATION

- 2014 – 2019 **University of Western Ontario**
 Ph.D. in Philosophy
- 2012 – 2014 **University of Western Ontario**
 M.A. in Ancient Philosophy
- 2011 – 2012 **McMaster University**
 B.A. in Classics, *summa cum laude*
- 2007 – 2011 **McMaster University**
 B.A. (Hons.) in Philosophy, *summa cum laude*

HONOURS AND AWARDS

- 2018 Michael Smith Foreign Study Supplement
- 2016 – 2019 Social Sciences and Humanities Research Council Joseph-Armand
 Bombardier Canada Graduate Scholarships Doctoral Scholarship
- 2016 – 2019 Tri-Agency Doctoral Excellence Research Award
- 2015 – 2016 Ontario Graduate Scholarship
- 2013 – 2014 Social Sciences and Humanities Research Council Joseph-Armand
 Bombardier CGS-Master's Scholarship

RELATED WORK EXPERIENCE

- Summer 2019 Research Assistant, Department of Philosophy, University of Western
 Ontario. Dr. Dennis Klimchuk. Aristotle's Legal Theory.
- Summer 2018 Research Assistant, Department of Philosophy, University of North Carolina
 at Chapel Hill. Dr. C. D. C. Reeve. Aristotle's *Generation of Animals*
- Summer 2014 Research Assistant, Department of Philosophy, University of Western
 Ontario. Dr. Devin Henry. Bridging the Gap between Aristotle's Science
 and Ethics

Summer 2013 Research Assistant, Department of Philosophy, University of Western Ontario. Dr. Devin Henry. Aristotle on the Unity and Diversity of Life

PUBLICATIONS

2018 "Aristotle's Theory of Aging," *Cahiers des études anciennes* LV: 65-78.

PRESENTATIONS

- May 2019 "Logikós Argumentation in Aristotle's Natural Science," Classical Association of Canada, McMaster University
- October 2018 "Logikós Argumentation in Aristotle's Natural Science," Canadian Colloquium for Ancient Philosophy, Université de Sherbrooke
- May 2018 "A Cheap Nature? Aristotle on the Many Functions of the Heart," Canadian Society for the History and Philosophy of Science, University of Regina
- June 2017 "Aristotle on the Causes and Limits of Aging," Aging in Ancient Thinking, University of Montréal
- May 2017 "Reason and Perception in Aristotle's Natural Science," The Classical Association of Canada, Memorial University
- May 2017 "The Hunt for Definitions: *Posterior Analytics* II 13," Canadian Philosophical Association, Ryerson University
- May 2017 "Aristotle on the Causes and Limits of Aging," Canadian Society for the History and Philosophy of Science, Ryerson University
- October 2016 "The Hunt for Definitions: *Posterior Analytics* II 13," Society for Ancient Greek Philosophy, Fordham University
- October 2016 "Beauty, Complexity, and Chance: The Stoic Critique of Epicurean Mechanistic Cosmogony," Canadian Colloquium for Ancient Philosophy, McMaster University (Poster)
- May 2016 "The Stoic Theory of Cognitive Development," The Classical Association of Canada, Laval University
- March 2014 "Beauty, Complexity, and Chance: The Stoic Critique of Epicurean Mechanistic Cosmogony," Seventh Biannual Classics Graduate Student Conference, Harvard University