

Aristotle's Conception of Science: The Case of *On Youth and Old Age, and Life and Death, and Respiration*.

John F. Hannon
Abstract

In the past two decades considerable advances have been made in our understanding of Aristotle's natural science. Through the works of Balme, Lennox, Gotthelf and others,¹ Aristotle's biology has received increasing attention, and the accounts in the *Historia Animalium* and the *de Partibus Animalium* are no longer seen as mere lists of observations, but as systematic presentations of evidence and explanation with a distinct methodology and deep philosophical relationships to Aristotle's logical and metaphysical works. However, despite this increased attention, it has been difficult to gain a single bird's eye view of Aristotle's project in biology. There are three factors that contribute to this. First, there is the sheer quantity of texts which are involved: any work that attempts to approach the subject systematically has to cover roughly a third of the corpus. A second difficulty is that although Aristotle does define a notion of distinct areas of study, and thus places some limitations on individual domains of inquiry, his texts nevertheless presuppose significant understanding of his views on logic, metaphysics and even rhetoric (as I argue)—any one of which could be the subject of an independent book. Thirdly, although Aristotle does provide signposts throughout his discussion and makes explicit connections between works, the larger philosophical connections are rarely discussed explicitly and instead Aristotle assumes that his readers themselves would draw the necessary connections.

These three difficulties mean that although considerable advances have been made in our understanding of Aristotle's biological science, many of these results are relatively unknown outside of a small group of specialists, and many important relationships between different aspects of Aristotle's theory are often missed. Given that Aristotle is arguably the first person to make systematic observations in comparative biology, this means that an important moment in the history of science is often overlooked. Yet, further than this, because Aristotle is arguably creating a new scientific paradigm, it is a

¹ For key texts, see the brief citations at the end of this abstract.

philosophically interesting moment in science, and many of the same problems that Aristotle deals with remain with us today.

The object of my dissertation is to provide a unified view of Aristotle's theory and practice in the field of biology that is capable of addressing some of these challenges. For the reasons cited above, this is only possible if one concentrates on a short text. Fortunately, there is a small work that presents a relatively unified approach using observation, experiment, and classification in order to develop detailed explanations of empirical phenomena. This is the text entitled On Youth and Old Age, and Life and Death, and Respiration (YOLDR) at the very end of the *Parva Naturalia*. This is an important text not only because it appears to be the last work in the biological section of the corpus, but also because the main theory developed in this work, an account of respiration, appears to be recognized by Aristotle himself as a model area for biological explanation.² The hope is that by focusing on this text it may be possible to see the relationship between theory and practice in Aristotle's science, and explore a wide variety of issues, including Aristotle's empiricism, how he uses the writings of his predecessors, and the relationship between the four causes, particularly form and matter.

This dissertation attempts to explore these questions both philosophically and philologically. I begin this process by dealing with some of the philological questions the text raises in this introduction. The first of these questions concerns whether this work should be read as a single work at all; the second is to begin to discuss the differences between Aristotle's conception of "respiration" and our own contemporary theories, and the third is to provide a brief account of the recent history of the text. After this general introduction, I present a full text of the work, a translation, and historical notes when the topics are not covered elsewhere in this dissertation.

However, the key philosophical parts of the theory are my four interpretive essays that follow. Each essay is an independent attempt to explore an issue that YOLDR raises. Yet, the four essays are closely linked and together explore the methodology of science that Aristotle's work presupposes.

² de Partibus Animalium, 642a31-642b4.

In the first of these essays, I provide a general philosophical framework that grounds the essays that follow. This essay begins by discussing Aristotle's impressions of the state of empirical science in his time. As I explain, relying closely on the first book of the *de Partibus Animalium*, Aristotle's discussion suggests that he felt empirical science was being neglected. This is apparent in YOLDR itself: one of Aristotle's most consistent objections to previous theorists is that they were inexperienced in observable facts (*apeirotêrôs tôn sumbainontôn*).³ Plato and Empedocles are also scolded for ignoring important classes of animals in their analyses. In all these objections we can identify a common theme: what we need when we investigate nature is experience of the right sort, and this is precisely what Aristotle thinks his predecessors lacked.

In order to explain an investigation of the "right sort," I turn to the last chapter of the *Analytica Posteriora* and the first chapter of the *Metaphysica*. Although there are differences between these works, both in content and motivation, I argue that one can derive a unified account of the development and justification of empirical knowledge. This account involves four primary steps: (1) the appearance of the observed entity through *perception*, the (2) retention of these precepts in *memory*, (3) the recognition of general trends through one's *experience*, and (4) finally, the knowledge of causes that comes from *scientific understanding*. At the base of this structure lies the idea that perception is "an innate judging capacity,"⁴ and as such it is capable of distinguishing objects within the visual field without the assistance of memory or *nous*. This is important because it means that many of the objects that biological science deals with are immediately apparent to the perceptive faculty. I argue that this goes deeper than it is generally supposed, and Aristotle believes it is possible to actually "see" universals when the perceptive apparatus is working correctly, and thereby the perceptual and *noetic* realms are moved closer together.⁵ These initial perceptions then accumulate in memory, which I argue is closely connected to a primitive notion of genus and species, two concepts that will play a very important role in YOLDR. With the move towards experience, Aristotle introduces the notion of "sameness."

³ YOLDR, 470b9.

⁴ *Analytica Posteriora*, 99b35.

⁵ As with Sellars, Aristotle presupposes that all observations are made "under standard conditions." Sellars (1997), pp. 42-43. Of course, what an individual creature "sees" will be in part dependent on the other capacities that creature has.

In my dissertation I define "sameness" as sameness of form and distinguish this idea from identity (which presupposes a single entity) and similarity (which serves in Aristotle's science mainly as a heuristic). With experience Aristotle also introduces a primitive form of judgment that can be used as a basis for science, such as is seen in the Cnidian school of medicine.⁶

Although the Cnidians may have thought that experience alone was sufficient for understanding the natural world, I argue that the final step in this development is essential for understanding Aristotle's empirical science, and this is the move to scientific understanding (*episteme*). I argue that one of the most essential tools for this transition from experience is the use of the syllogistic. Although the syllogistic is a passing curiosity in most modern logic courses, I argue that in Aristotle's system it is an important tool that enables Aristotle to impose a systematic classification on biological phenomena. Although I believe the best account of Aristotelian deduction is that which was first developed in the 1970s through the work of Corcoran. I revert in part to an older interpretation of the syllogistic, in order to emphasize certain formalistic features that will make it easier to understand some of the arguments in later chapters. However, whatever reading that one uses to understand the syllogistic, an important question remains open, and this is how the syllogistic can accommodate "for the most part" (*to epi to polu*) inferences. The problem is made acute by Aristotle's assumption that the inferences of science are necessary in two senses: the inferences always have to hold, and they can only concern phenomena that cannot be otherwise. Given these presuppositions, it is difficult to see how things that only happen "for the most part" can be proper subjects for syllogistic inferences. My solution to this apparent dilemma relies on the notion that Aristotle uses the phrase "for the most part" not to describe biological phenomena that are the subject of science, but to describe why exceptions to these general rules occur.

The end result of this first interpretive essay is the idea that the inferences of science have to necessarily hold, and that Aristotle saw empirical science through the lens of the syllogistic. If we combine this with the idea of genus and species, and the notion that the best explanations of science involve commensurate universals, then one can

⁶ See Boylan (1979), pp. 12-18.

understand why Aristotle chose to investigate comparative biology, and why he approaches the subject in the systematic way that he does in YOLDR.

The second interpretive essay turns to a more philological topic, and this is the concept of "analogy" (*analogia*) in Aristotle's biology. Although there are some occurrences of this word in Greek before Aristotle, I argue that the word represents a uniquely Aristotelian contribution, and that when Aristotle uses the word in his biological works he is presupposing a very particular form of reasoning that occurs in his syllogistic when two species cannot be subsumed under the same genus. When we understand this, we can see that it is possible to define the notion of a "valid analogy," and thus analogy itself can be a tool of scientific proof and not merely a heuristic. In fact, it is observed that there is a precise situation in which such reasoning is necessary: when one attempts to generalize over two syllogisms that cannot have the same middle terms. A considerable effort then is spent defining this notion of analogy, and determining the conditions under which an analogy is true or false. This allows me to formulate conditions for a "valid" analogy which relies on four principles: a principle of formal structure, a principle of formal coherence, a principle of difference, and a principle of relevant formal similarity. My work closely parallels that of Malcolm Wilson's work,⁷ with one important exception: I do not think that the use of analogy presupposes any specific content, but merely a certain formal structure and a concept of reasonableness.

With this understanding in place, I turn to Aristotle's use of the word "analogy" (*analogia*) in YOLDR, and attempt to use this syllogistic framework to explain how and why Aristotle uses the word in each case in this work. Using several concrete examples from the text, I argue that analogies are used to abbreviate argument when a large number of cases would have to otherwise be reviewed. An important factor in this discussion is that the analogies indicate both sameness and difference: sameness because there is something in common between the examples cited, but difference, because Aristotle appears to deliberately refrain from introducing a term that could subsume all the cases involved. Because we are not accustomed to seeing analogies as highlighting difference, Aristotle's conception of analogy in science is somewhat different than our modern notion.

⁷ Malcolm Wilson, *Aristotle's Theory of the Unity of Science*.

Although these findings provide some insight into analogies in Aristotle, the more important lesson I draw from this discussion is that it gives a reason for Aristotle not to subsume all cases of explanation under a single genus. Combining the results of this essay with the results of the previous essay, it is possible to explain why Aristotle organizes his examples in YOLDR in the way that he does. I further argue that this way of organizing data itself represents a scientific advancement over Aristotle's predecessors, and is part of the reason why Aristotle's classification of animals under the rubric of respiration largely mirrors modern cladistic divisions.

With the third essay I explore Aristotle's discussions of his predecessors in YOLDR. In this significant portion of the text Aristotle reviews the theories of Diogenes, Anaxagoras, Democritus, Plato and Empedocles and reveals how he read his predecessors philosophically. Aristotle's quotations of early philosophers in his work represent a very different way of doing philosophy than the pre-Socratics, or even Plato, and modern commentators have presupposed many reasons why these discussions appear from Owen's argument that Aristotle's science relied on these discussions for its first principles, to Cherniss' argument that they have been introduced in part to give Aristotle the opportunity to advance his own theory.⁸ My approach pays attention to the particular contexts in which these discussions occur, and argues that it is best to take these discussions one at a time and not presume that Aristotle is doing the very same thing in a largely empirical work such as YOLDR, as he does in other works. In fact, when we pay close attention to how Aristotle uses the arguments of his predecessors in YOLDR, we see that they are used mainly to provide the constraints that any scientific theory must meet in order to provide genuine understanding.

I draw four lessons from Aristotle's discussion of his predecessors. First, Aristotle uses their examples to show why it is necessary to give necessary and sufficient conditions for the appearance and non-appearance of a regularly occurring phenomenon; secondly, that one must develop a complete typology of all cases that occur; thirdly, that one must make extensive empirical investigations including experimentation, and rely on these investigations for evidence, and finally, one must understand animals as self-contained

⁸ Owen (1961/1986) or Cherniss (1935).

functional systems, and take into account the function of an organ within the larger organism. That these are not merely attempts to privilege Aristotle's own theory is apparent by the fact that Aristotle generally refrains from mentioning his own theory in this entire discussion. There are other issues that arise in this discussion. One key moment is when Aristotle discusses the example of the *clepsydra* of Empedocles. This example is often seen as one of the first experiments in natural science,⁹ but I argue this is a misunderstanding, because it is rather an argument by example (*paradeigma*). As an argument by example, it does not have the same requirements of generalization. This being the case, there is the further question of whether Aristotle presents a charitable reading of that example. I argue that Aristotle recognizes an ambiguity in Empedocles' wording, and includes the passage explicitly in order to highlight the unscientific nature of Empedocles' prose. I argue that in doing this, Aristotle is adding one final constraint on scientific discourse: that one must use language consistently and accurately.

Finally, in the fourth essay, I deal with Aristotle's explanation of life and death in YOLDR in considerable depth, using the framework developed in earlier chapters. The guiding principle in this essay is that Aristotle's explanation of death is considerably different from that of his predecessors such as Plato, and that these differences highlight his methodology. Aristotle's basic explanation of death is characterized as the perishing of the fire within the heart or an analogous organ. This can happen as the result of both natural and unnatural causes. The latter are easier to explain, but as Aristotle himself remarks, any adequate theory of death has to explain the more difficult case: why death is inevitable in old age.

I begin by reviewing the evidence. In my account, Aristotle makes a clear distinction between arguments according to observation (*kata ta phainomena*) and arguments according to logos (*kata to logon*), and that Aristotle conspicuously privileges the former over the latter in YOLDR. Arguments according to the phenomena fall into four general sorts. The first type are arguments by experiment, in which Aristotle attempts to disprove a proposition by deliberately manipulating objects in the environment. I argue that there are several cases of this in YOLDR, often relying on a *modus tollens* structure. Unlike the case of

⁹ Lloyd reports that this was the view of Burnet. Lloyd (1966/1992), pp. 28-33.

Empedocles, these appear to be genuine experiments. Secondly, there are examples of correlative data in which Aristotle disproves hypotheses by observing relations in nature without actually manipulating the objects in those relations. Thirdly, there is indirect data in which Aristotle seems to rely on observations of others, or appeal to general human practices. Finally, I remark that we sometimes find examples (*paradeigmata*) in Aristotle's account. but that these cases do not seem to be central to his argument. Hence, Aristotle's approach in this work is largely empirically-driven.

After reviewing Aristotle's classification of the evidence in YOLDR, I then turn to the subject of causal explanation. The five topics in YOLDR's title—youth, old age, life, death, and respiration—all fit together to form a single unified theory. A central factor in this theory is the need for an organism to maintain a precise balance between heat and coolness in order to continue to exist. The heat is generated within the heart, and the contrary cooling is produced through respiration. Hence, a discussion of heat forms the starting point for this investigation of causes. However, I argue that heat and cooling alone are insufficient to give an adequate account of death given Aristotle's requirements for explanation, and that the continuation of life also requires that an organism maintain a certain type of oily moisture. An environment can act antagonistically on the organism and eventually over time the organism will invariably lose the required moisture, given certain assumptions that Aristotle makes about possibility.

If the death of every individual sublunary organism is inevitable, the question remains how it is that species can manage to survive given Aristotle's belief that time is both infinite in the past and future directions. In passing, I argue that given certain premises upon which his system is based, Aristotle could have argued for this on largely empirical grounds. If the universe is eternal both in the past and in the future, and if it is the case that an animal as complicated as a human being can only come from another member of the same species, the mere fact that human beings continue to exist suggests that they always will exist. For, if it were possible for a species to go extinct, it would have already happened given the unlimited time in the past, and then there would be an insurmountable barrier preventing the continuity of that species into the present. Of course, such a theory overlooks the possibility of evolution, but if it were true, it would provide some reassurance that despite the fact that all individual animals die, the species will not.

This argument serves as a starting point for an exploration of the metaphysics of death under Aristotle's conception. I argue that whether an animal lives or dies depends crucially on whether it can continue to perform its primary functions. This is clear from Aristotle's frequent explanation that an organ, such as a hand, that cannot perform its function is no longer an instance of that organ except by name. Similarly, a body that cannot perform the functions of nutrition, which is the *sine qua non* of life, ceases to be a living body. I argue that functionality depends crucially on two factors: the utilization of natural forces, and the idea of a temporally-ordered series of events. I then show that the environment has a further role on the formation of an organism, and in rare cases the environment itself can be largely responsible for why a creature forms one way rather than another. Using an argument that appears in a controversial passage in the *Historia Animalium* I show that in certain limited contexts Aristotle was willing to speculate that a small change in the embryonic stage of an organism, such as taking in water, can produce rather dramatic alterations in the outward form of that organism.¹⁰ Whether the argument in *Historia Animalium* is a serious option or not, I argue that it provides ground for a claim that a form can be more or less instantiated in a given individual organism. In cases in which it is less instantiated, the organism is still a token of the same type, but instantiates that form to a greater or lesser extent. Aristotle himself seems to say as much in YOLDR when he uses the word "participation" to describe the relationship between the body and soul of an organism, despite the fact that the word is often criticized for its Platonic overtones.

In short, at the end of my dissertation I have used YOLDR to provide the reader with a picture of how Aristotelian science works that moves from questions of epistemology, through logic, and methodology of science to metaphysics. In the course of the discussion I have shown how Aristotle uses the syllogistic as a tool to organize empirical data, the constraints that he places on any acceptable scientific theory, and how these constraints are applied to the question of the life and death of an organism. At the conclusion of this account one final piece is added: I explain how scientific progress is possible on Aristotle's account. By relying on a theory that requires a complete enumeration of cases, and

¹⁰ *Historia Animalium*, 589b29-590a8.

necessary and sufficient explanations for those cases, Aristotle's system retains the possibility of responding to new instances, and there is an imperative that any explanation be altered to accommodate those new instances. Hence, although many scientific revolutions have occurred since Aristotle developed his account, and although we can draw attention to changes in conceptual paradigms from one system to the next, we must at the same time recognize that a basic set of continuities remain. YOLDR is an important text to help us see those continuities.

Secondary Literature

- Balme, D. M. Aristotle: De Partibus Animalium I and De Generatione Animalium I (with passages from II. 1-3) translated with notes by D. M. Balme with a report on recent work and an additional bibliography by Allan Gotthelf. Oxford: Oxford University Press, 1999/1972.
- Cherniss, Harold. Aristotle's Criticism of Presocratic Philosophy. Baltimore: Johns Hopkins Press, 1935.
- Corcoran John, "A mathematical model of Aristotle's syllogistic," Archiv für Geschichte der Philosophie 55: 191-219 (1973).
- Gotthelf, Allen and James Lennox. Philosophical Issues in Aristotle's Biology. New York: Cambridge University Press, 1987.
- Lennox, James G. Aristotle's Philosophy of Biology: Studies in the Origins of Life Science. New York: Cambridge University Press, 2001.
- Lloyd, G.E.R. Polarity and Analogy: Two Types of Argumentation in Early Greek Thought. Indianapolis: Hackett, 1992/1966.
- Owen, G.E.L. "*Tithenai ta phainomena*" in Logic, Science, and Dialectic: Collected Papers in Greek Philosophy, edited by Martha Nussbaum. Ithaca, NY: Cornell University Press, 1986. (pp. 239-251.)
- Sellars, Wilfred. Empiricism & The Philosophy of Mind with a study guide by Robert Brandom. Cambridge, MA: Harvard University Press, 1997.
- Wilson, Malcolm. Aristotle's Theory of the Unity of Science. Toronto: University of Toronto Press, 2000.