

*Pre-explanatory and Explanatory Strategies  
in Aristotle's Study of Animals*

**I Introduction**

Aristotle approaches the study of perishable life via separate studies of plants and animals.<sup>1</sup> He deals with certain aspects of perishable life in common for animals and plants in the short essays collectively known as *Parva naturalia*. But it is far from obvious that dealing with those aspects amounts to a full-fledged study of the phenomenon of perishable life. What Aristotle says in common for animals and plants is in fact embedded in his study of animals.<sup>2</sup> Rather than overcoming the division of the study of perishable life into separate investigations of animals and plants, this idiosyncratic strategy ends up strengthening it. In the end, the reader of the *Parva naturalia* comes away with the distinct impression that the study of animals remains Aristotle's primary, and indeed overriding, concern. My task in this chapter is to look at how Aristotle approaches the topic of animals with a focus on the methodological decisions that control and indeed shape it.

The first thing to note is that the writings concerned with animals comprise over 25 percent of the surviving Aristotelian corpus.<sup>3</sup> If we concentrate on the extant works on natural philosophy, this number becomes truly impressive: approximately 60 percent of the extant works on natural philosophy are concerned with the study of animals.<sup>4</sup> This number is even more staggering when we consider that the writings on natural philosophy are over 40 percent of the extant corpus of writings transmitted under the name of Aristotle. Clearly, Aristotle aimed at offering a scientific account of the natural world in which animal life was by far the most conspicuous *explanandum*.

<sup>1</sup> Chapter 1, Section 3.    <sup>2</sup> Chapter 2, Section 3.

<sup>3</sup> In the two-volume edition of Aristotle's works produced by Bekker (BEKKER 1831), which is the first truly critical edition of Aristotle and the most common entry point into the Aristotelian corpus, the study of animals comprises 386 pages out of a total of 1,462 pages.

<sup>4</sup> That is, 386 pages out of a total of 605 in the edition produced by Bekker.

We cannot say with confidence when or where Aristotle wrote these works. For one thing, we know too little about Aristotle's life. For another, we have no independent way to fix the relative chronology of his writings. The first period away from Athens is often regarded as especially important for the development of Aristotle's science because the zoological data collected in the *HA* appear to refer to places on the coast of Asia Minor. Scholars have used this observation to establish a connection between the research activities that constituted the basis of the impressive corpus of writings on animals and the years that Aristotle spent away from Athens – especially the years of residence in the Troads (Assos) and on the island of Lesbos (Mytilene).<sup>5</sup> While suggestive, this connection fails to do justice to the centrality of the study of animals to several aspects of Aristotle's philosophy. It also presupposes that the works on animals that have reached us are a finished product that can be ascribed to a particular period of Aristotle's philosophical development. Scholars have often assumed that Aristotle completed his study of animals and then turned to different endeavors. But this is far from being an obvious, let alone safe, assumption given how little we know about Aristotle. In connection with this last observation, it is worth recalling the conclusion that James G. Lennox has reached in an article explicitly concerned with the question of the place of the study of animals in Aristotle's intellectual biography:

A question I am often asked – “when do you date the biology?” – suggests that all of it was composed during a single period. *But surely the task of amassing, sifting, integrating, and explaining the incredible amount of factual data found in these treatises was the work of a lifetime* – indeed, as [David M.] Balme says, it is *an incompletable task*. The information upon which these highly condensed, organized, and generalized treatises rest must have taken a very long time to amass – not to mention working out the highly integrated, explanatory theory for it all.<sup>6</sup>

For Lennox (and Balme), the writings that have come down to us are best understood as a work in progress. In the rest of this chapter, I would like to give the reader at least an idea of how Aristotle conceives of his task in these writings.

<sup>5</sup> This suggestion was first made by D'Arcy Thompson in the prefatory note to his translation of the *History of Animals* (THOMPSON 1910). It was further elaborated by Desmond Lee (LEE 1948: 61–67). However, it did not go unchallenged. See SOLMSEN 1978: 467–484 (answered in LEE 1985: 3–8). A recent, thorough attempt to reevaluate the extant evidence for possible research trips by Aristotle (and Theophrastus) can be found in KULLMANN 2014C: 78–112.

<sup>6</sup> LENNOX 1996: 247–248 (emphasis mine).

## 2 The Collection and Presentation of the Zoological Data

*Posterior Analytics* II is concerned with scientific inquiry (ζήτησις).<sup>7</sup> At the outset of the book, Aristotle famously states that the things we seek are the same as the things we know scientifically.<sup>8</sup> They are four in number:

- (1) the fact that (τὸ ὅτι)
- (2) the reason why (τὸ διότι)
- (3) whether something is (εἰ ἔστι)
- (4) what something is (τί ἔστιν).

It is possible to know the fact without knowing the reason why. In a similar way, we may know whether something exists without knowing what it is. But whenever we know the fact, we seek the reason why. In a similar way, whenever we know whether something exists, we seek what it is. In other words, there is a natural progression in the scientific inquiry from (1) to (2) and from (3) to (4). While a scientific inquiry directed at (2) aims at an explanation, one geared toward (4) has definition as its goal. For Aristotle, explanation and definition are not two disconnected goals. On the contrary, the search for the explanation and the search for the definition converge toward one and the same result. Consider the following passage:

Clearly, the what-it-is and the why-it-is are the same. What is a [lunar] eclipse? Privation of the moon's light by the interposition of the earth. What is the reason of the [lunar] eclipse? Or: Why does the moon suffer an eclipse? Because of the failure of light due to the interposition of the earth.<sup>9</sup>

I will not deal with the question of how definition and explanation go together in Aristotle's theory of science. What is immediately relevant to the present discussion is that *the scientific enterprise as is understood by Aristotle advances in stages*. At the most general level, science proceeds from a stage in which the existence of the things that are to be studied and the facts about them that need an explanation are established to a stage in which those things are defined and the relevant facts about them are explained.<sup>10</sup> The theory outlined so far is general; as such, it applies to all

<sup>7</sup> A recent, helpful introduction to the topic of scientific inquiry and its relation to scientific knowledge as presented in *APo* II, I can be found in BRONSTEIN 2016: 74–83. See also LENNOX 2021a: 40–64.

<sup>8</sup> Aristotle, *APo* II 1, 89a23–24.

<sup>9</sup> Aristotle, *APo* II 1, 90a24–27. Compare Aristotle, *APo* II 8, 93a4.

<sup>10</sup> According to recent, influential reading (CHARLES 2000: 23–77), the stages of scientific inquiry are three, not two. At the first stage of inquiry, the investigator would only grasp an account of what the name signifies. The second and third stage of inquiry would coincide with the two outlined above. For a critical discussion of this interpretation of Aristotle's theory of scientific inquiry, see BOLTON 2017:

scientific domains.<sup>11</sup> The study of animals is no exception to the rule: a zoological investigation aimed at establishing the facts about animals in need of causal explanation should precede the inquiry into their causes. What Aristotle says about stages of inquiry in his *Posterior Analytics* does not require him to present the facts and their explanations separately in distinct works. In fact, the division of the study of animals into treatises that are concerned with offering causal explanations on the one hand, and a treatise devoted to presenting the facts in need of an explanation on the other, is a *unicum* in the Aristotelian corpus.<sup>12</sup>

Following Lennox, we may want to distinguish between the following three theses:

- (1) A zoological investigation that establishes the facts in need of explanation should precede the inquiry into their causes.
- (2) The writing of a treatise presenting the zoological facts in need of explanation should precede the writing of treatises concerned with their causal explanations.
- (3) The study of a treatise presenting the zoological facts in need of explanation should precede the study of treatises concerned with their causal explanations.<sup>13</sup>

While the general theory of inquiry outlined in the *Posterior Analytics* commits Aristotle to (1) and (3), this theory tells us nothing about (2). Any scientific enterprise should begin by collecting the relevant data, which will then become the object of an investigation that has the explicit goal of explaining them – thesis (1). Moreover, the treatise that collects and presents those data should come before any one of the treatises that explain them in the order of study – thesis (3). But we should refrain from drawing any chronological conclusions as to the relative dating of these writings – thesis (2). The study of animals is no exception to the rule. In fact, this study illustrates this complex situation in an especially clear way.

The Greek manuscript tradition has transmitted a treatise entirely devoted to the collection and presentation of the zoological data – namely,

227–248. While David Charles defends a three-stage account of Aristotle's theory of scientific inquiry, Robert Bolton argues for a two-stage approach. I side with Bolton in this controversy, but I will argue that the two main stages are to be further articulated. See Chapters 4 and 5 in this book.

<sup>11</sup> According to Lennox, Aristotle's *Posterior Analytics* provides an erotetic framework for any scientific inquiry – that is, a set of questions that ought to guide any scientific investigation of any given domain (LENNOX 2021a: 38, 122).

<sup>12</sup> LENNOX 1996: 244. Compare LENNOX 2019b. The same division resurfaces in Theophrastus's study of plants, which is consciously modeled after Aristotle's study of animals. More on this in Chapters 4 and 5.

<sup>13</sup> LENNOX 1996: 236.

*HA*. This work comes before the writings concerned with the explanation of those data in the order of exposition. But it does not follow from this observation that *HA* was written before those writings. A lifelong engagement with the zoological writings led David Balme to formulate a developmental hypothesis, according to which *HA* is the last of the works on animals written by Aristotle.<sup>14</sup> This hypothesis, known as the Balme hypothesis, entails that Aristotle continued to revise the main results reached in his study of animals until the very end of his life.<sup>15</sup> This hypothesis has not gained universal acceptance.<sup>16</sup> For our purposes we can bracket the Balme hypothesis and concentrate on the aims of *HA*. These aims have been greatly clarified by the work of Balme. Against the prevalent (at the time) view that *HA* is primarily concerned with offering an exhaustive, hierarchic classification of animals, Balme argued that this treatise is “a collection of all observable differentiae, collected *qua* differentiae.”<sup>17</sup> “Differentia” (plural “differentiae”) is the Latin translation of the Greek “διαφορά.” By this term, Aristotle means “any way in which *X* may differ from *Y*.”<sup>18</sup> A possible rendering in English is “difference.” According to Balme, *HA* is primarily concerned with animal differences – namely, the ways in which animal kinds differ from one another; for instance, the ways in which they differ with respect to their modes of generation or their modes of locomotion. On this reading, a first goal of *HA* is definitional: arriving at a definition of the relevant phenomena via the collection and analysis of all the relevant differences. None of these differences are by themselves sufficient to reach an adequate definition of an animal. But if we divide the different kinds of animals by adopting the method of division by multiple differences Aristotle outlines in *PA* I 2–3, then we can reach the relevant definitions.<sup>19</sup> Another, related goal of *HA* is explanatory. Aristotle refers to this second goal in a key methodological

<sup>14</sup> BALME 1987: 18.

<sup>15</sup> The expression “Balme hypothesis” was coined by LENNOX, who offers an illuminating discussion of the evidence supporting this hypothesis in LENNOX 1996: 229–248. A more recent (independent) discussion of the evidence can be found in PELLEGRIN 2017: 60–67.

<sup>16</sup> See KULLMANN 2007: 146–156 (followed by ZIERLEIN 2013: 71–77 and SCHNIEDERS 2019: 166–174).

<sup>17</sup> BALME 1961: 212 (reprinted, with amplifications, in GOTTHELF-LENNOX 1987: 86).

<sup>18</sup> The term “διαφορά” does not seem to have a technical meaning in *HA*. See the programmatic statement made in *HA* I 6, where Aristotle promises “to grasp the differences [διαφοράς] and the features [συμβεβηκότα] that belong to all animals” (491a9–10). In this case, “differences” and “features” seem to be used interchangeably.

<sup>19</sup> For an outline of this method of division, see FALCON 1997: 127–146. An in-depth analysis of the discussion offered in *PA* I 2–3 (which includes a criticism of the dichotomous method of division) is offered in BALME 1992: 101–105.

passage where he tells us that “after this [collection of all the relevant zoological data] we must try to find their causes.”<sup>20</sup>

This picture of the aims of *HA* has been considerably refined by Allan Gotthelf and James G. Lennox.<sup>21</sup> They have shown that Aristotle is concerned not only with laying out animal differences but also with finding out significant groupings of animal differences. For instance, Aristotle is often interested in what a large kind (e.g., birds) has in common with other large kinds, and only then discussing what distinguishes birds or is even unique to them. The same phenomenon can be observed when Aristotle is concerned with sub-kinds of animals (e.g., kinds of birds). Again, the focus is on what a certain sub-kind shares with other sub-kinds followed by a discussion of what is unique about that sub-kind. The theoretical motivation for this idiosyncratic procedure can be traced back to the requirement that explanations be given at the right level of generality.<sup>22</sup> This requirement shapes Aristotle’s overall research project beyond the study of animals.<sup>23</sup> Hence, we should not be surprised to see it at work also in *HA*. Here Aristotle not only collects the relevant differences but also lays them out with a view to generate explanations that reflect the methodological procedures outlined in his *Posterior Analytics*.

What emerges from this picture is a study of animal differences that is geared toward not only definition but also explanation.<sup>24</sup> Since explanation must conform to the procedures of scientific inquiry outlined in Aristotle’s *Posterior Analytics*, the relevant differences are not only collected but also presented with a view to the subsequent stage of inquiry. So *HA* is not completely innocent with respect to explanation to the extent that the relevant zoological data are not only collected but also organized for the sake of their subsequent explanation. In this sense, it is better to think of the  $\delta\tau\iota$ -stage of inquiry as a *pre-explanatory* (or *pre-demonstrative*) stage of investigation.<sup>25</sup>

<sup>20</sup> Aristotle, *HA* I 6, 491a10–11. The full passage can be found at the end of this section.

<sup>21</sup> LENNOX 1987: 90–119 (reprinted in LENNOX 2001a: 7–38); LENNOX 1991: 269–294 (reprinted in LENNOX 2001a: 39–71); LENNOX 2019b; GOTTHELF 1988: 100–133 (reprinted in GOTTHELF 2012a: 390–314); GOTTHELF 2012b: 261–292. Seminal works in this field of study are also KULLMANN 1974 and PELLEGRIN 1982 (English translation in PELLEGRIN 1985).

<sup>22</sup> See Chapter 1, Section 3.

<sup>23</sup> For an attempt to study how this explanatory requirement is at work beyond the study of life, see FALCON 2018: 181–195.

<sup>24</sup> While there is considerable consensus around this conclusion, there is also room for a *distinguo*. Devin Henry has recently argued (in HENRY 2014: 145–169) against a strong (exclusive) reading of the aims of *HA*. In his view, in addition to the conceptual tools to produce scientific explanations and definitions, *HA* provides us with classificatory tools to arrange animals into a hierarchy of kinds based on shared differences and similarities.

<sup>25</sup> Allan Gotthelf (in GOTTHELF 2012b: 261–292) speaks of a *pre-explanatory* stage of investigation. James G. Lennox (in LENNOX 1991: 269–294, reprinted in LENNOX 2001a: 39–71) prefers to speak

I would like to end this introduction to *HA* by recalling a famous passage that marks the transition from the outline of the relevant animal differences (*HA* I 1–6) to the collection of the zoological data offered in the rest of work. This passage points forward to the goals of explanation and demonstration via a discovery of the relevant causes:

We have stated these things in this way now – in outline – to provide a taste of the range and sorts of things we must study; later we will have to speak in greater detail, in order that we may grasp the differences and the features that belong to all. *After this, we must try to discover the causes* [μετά δὲ τοῦτο τὰς αἰτίας τούτων πειρατέον εὐρεῖν]. For that is the natural way to pursue such an inquiry, once one has completed an investigation concerning each of these: *for it becomes apparent from this investigation both about which things the demonstration must be and from which thing it must proceed* [οὕτως γὰρ κατὰ φύσιν ἐστὶ ποιεῖσθαι τὴν μέθοδον, ὑπαρχούσης τῆς ιστορίας τῆς περὶ ἕκαστον· περὶ ὧν τε γὰρ καὶ ἕξ ὧν εἶναι δεῖ τὴν ἀπόδειξιν, ἐκ τούτων γένηται φανερόν].<sup>26</sup>

### 3 Pre-explanatory Strategies in HA

In this section I would like to look at the way in which Aristotle organizes and presents his zoological data with a special focus on the bodily parts of animals. Animals differ from one another not only by having (or lacking) certain parts but also by having them arranged in different ways. Aristotle's systematic study of how animals differ with respect to their parts takes up most of the first four books of *HA* (*HA* I 7–IV 7). Aristotle tells us that his presentation of the zoological data begins with parts rather than modes of life and activities of animals because it is “chiefly, and firstly, with respect to the parts that the wholes also differ.”<sup>27</sup> According to Aristotle, different animals have different body parts because they are engaged in different activities that are constitutive of different modes of life. For instance, fishes have fins because they are marine animals: they displace their bodies in water by means of their fins. We can restate this insight as follows: fins are useful to fishes for swimming, which is their characteristic activity (πράξις). The explanatory connection between a part such as fins in fishes and the activities that are constitutive of the different modes of life (βιοί)

of a *pre-demonstrative* stage of investigation to emphasize that the collection and presentation of the data *HA* are geared toward the production of demonstrations. We are allowed to use both descriptions as soon as we realize that, at least in principle, all causal explanations can take the form of a scientific demonstration. I add the qualification “at least in principle” because Aristotle's practice in his explanatory treatises never reaches the stage of demonstrative science.

<sup>26</sup> Aristotle, *HA* I 6, 491a7–14. <sup>27</sup> Aristotle, *HA* I 6, 491a15.

becomes a major concern at the explanatory stage of his inquiry. At the pre-explanatory stage, Aristotle's main goal is to offer a survey of those parts with a view to their subsequent explanation. The question that concerns us is how this survey is organized and what are the epistemic principles controlling the presentation of the relevant zoological data.

The first thing to note is that Aristotle is quite explicit about his overall strategy in *HA*. His methodological explicitness is not only remarkable but also unmatched in antiquity. While Aristotle is not the first to engage in a description of the body parts of the human being and the other animals, he is unique in his self-conscious attempt to provide his reader with clear instructions on how the relevant data are collected and presented. Aristotle's most important move is made in *HA* I 6, where he tells us that the review of the parts of animals begins with a discussion of the human body because the human being is the animal that is most familiar to us. Aristotle justifies this decision with the help of an example taken from our everyday life. We establish the value of some money in a foreign currency by translating it into our own currency:

We must speak first about the parts of the human being; for just as each [nation] establishes the value of foreign currency with what is most familiar to itself, so we must do the same in the other cases. *The human being is of necessity the most familiar to us* [ὁ δ' ἀνθρώπος τῶν ζῴων γνωριμώτατον ἡμῖν ἐξ ἀνάγκης ἔστι].<sup>28</sup>

Beginning the review of bodily parts in animals with the human being is introduced as a non-arbitrary decision – indeed, as a first, necessary step. Apparently, as investigators of the animal kingdom, we have no choice but to start our review from the human body because of our proximity to it. This proximity makes the human body the most familiar to us, and so the natural starting point for a systematic review of the body parts of all known animals. Aristotle begins his review of the differences in animals with the *external* parts, starting from the top of the human body and moving down. He then turns his attention to the *internal* parts of the human being. In a second key methodological passage, Aristotle tells us that we face special challenges when we look inside the human body. The internal parts, Aristotle says, are the least known to us.<sup>29</sup> While Aristotle does not elaborate on the reasons

<sup>28</sup> Aristotle, *HA* I 6, 491a19–33. Following Peck, I supply “nation.” But “polis” or “the δοκιμαστής,” namely the person officially in charge with validating the coins to be used in the marketplace, could be equally acceptable amplifications of the Greek text. I owe this point to BEMER 2014: 176.

<sup>29</sup> Aristotle, *HA* I 6, 494b19–26: “the parts that are externally visible are arranged in this way and as we have stated. They have a name and are best known on account of our proximity to them. It is the opposite for the internal parts. The internal parts of human beings are the least known, so our

for our relative lack of knowledge about the inside of the human body, we should keep in mind that the dissection of the human body, including its dissection *post mortem*, was forbidden during almost all Greek antiquity.<sup>30</sup> As a result, ancient Greek knowledge about the internal parts of the human body was largely dependent on knowledge acquired from the dissection of animals. Aristotle's survey of the internal parts of the human being betrays this epistemological dependence. For instance, Aristotle says that the stomach of the human being *resembles* that of a dog; he also maintains that the lower part of the intestinal tract of the human being *is like* that of a pig; finally, he claims that the human liver *is like* that of an ox.<sup>31</sup>

The asymmetry between Aristotle's knowledge of the internal and external parts of the human body is well known.<sup>32</sup> I am recalling this asymmetry here because it suggests that Aristotle's decision to begin his review of the bodily parts of animals starting from the human being cannot be explained only in terms of our familiarity with the human body. As a matter of fact, this familiarity does not extend to include the inside of the human body. If, therefore, we want to understand why Aristotle reviews both the external and the internal parts of the human body *before* turning to the parts of the other animals, we must bring to the fore another methodological assumption that shapes his review of the body parts of animals in *HA* I–IV. This assumption is made explicit in the discussion of the relative position of the external parts in the human body.

The relative position of the parts with respect to up and down, front and back, right and left would seem to be clear to sense-perception in the case of external parts; however, we must speak about this for the same reason as we discussed the other parts – so that an orderly sequence of topics may be observed and the different ways in which these parts are arranged in the other animals as well as in the human being may not be overlooked as we enumerate them.<sup>33</sup>

In this passage Aristotle recalls his thesis that living bodies display up to three functional parts: up/down, front/back, and left/right. These functional parts are most clearly articulated in the human body because of its

examination [of these parts] must trace them back to the parts of the other animals with which they have a natural resemblance.<sup>30</sup>

<sup>30</sup> Helpful remarks on the Greek attitude toward the human body vis-à-vis dissection can be found in VON STADEN 1992: 223–241. On the relation between dissection and anatomy in classical antiquity, see BUBB 2022: 1–8 (with introduction to the relevant secondary literature).

<sup>31</sup> For the stomach, see *HA* I 16, 495b24; for the lower intestinal tract, see *HA* I 6, 495b27; for the liver, see *HA* I 17, 496b24.

<sup>32</sup> LLOYD 1983: 27. <sup>33</sup> Aristotle, *HA* I 15, 494a20–26.

erect posture. Other animals either do not have all three dimensions or they have them confounded to a degree.<sup>34</sup> Aristotle does not mean to say that these functional parts are not present in other animals; he only means to say that in these animals these functional parts are found together in the same place. Of course, we can tell them apart even when they are mixed up in the same place since we can trace them back to different powers of the soul present in the living body. For instance, the front is where the sense-organs are implanted, whereas the up is the entry point of nourishment. While this functional distinction may not be evident to sense-perception, the investigator can always see it by means of reason. Consider a snake: we can easily recognize a front and a back in its elongated body; however, we cannot distinguish, or cannot distinguish easily, an up and a down, or a right and a left, in that body. The reason is to be found in its elongated shape. And yet we possess a theory enabling us to argue for the existence of these bodily distinctions regardless of whether we see them. To the best of my knowledge, Aristotle is the first to equate the living body to an organized body, and he is also the first to distinguish the different kinds of perishable living beings in terms of the different levels of their bodily organization. It should also be clear that different degrees of organic unity correspond to the different levels of bodily organization. The highest level of organic unity is found in the living body that displays the greatest level of organic complexity.<sup>35</sup>

I will not engage in a full review of all the relevant passages where this conception of the perishable living body is at work.<sup>36</sup> I am content to refer the reader to Aristotle's *De anima*, where the soul is defined as the first actuality of a natural, organic body that has life potentially.<sup>37</sup> Much ink has been spilled on the meaning of "organic."<sup>38</sup> To be sure, Aristotle means to say that the living body is an organ of the soul. In other words, the whole living body is an instrument that the soul employs in the exercise its powers.<sup>39</sup> But this living body is to be minimally organized in a certain way if it must perform its function in an optimal way. The brief allusion to parts in plants that follows immediately after in the text may be meant to drive home this very point. When Aristotle says that roots are to plants

<sup>34</sup> Aristotle, *HA* I 15, 494a32. <sup>35</sup> See Chapter 2, Section 4.

<sup>36</sup> The addition of the qualification "perishable" is meant to exclude celestial bodies, which Aristotle envisions as being made of a celestial simple body unique to them.

<sup>37</sup> Aristotle, *DA* II 1, 412a28.

<sup>38</sup> Most useful on this front is MENN 2002: 107–117. Compare KOSMAN 2013: 100–104; KXHIELDS 2016: 171–173.

<sup>39</sup> This claim is repeated in *PA* I 1, 642a11–12, where Aristotle says that not only each of the parts but also the whole body is an instrument for the sake of some goal. Compare also *PA* I 5, 645b12–20.

what mouth is to animals, he reminds us not only of the analogous functions that these parts have in plants and animals but also of the existence of distinct levels of organization in the different kinds of perishable living bodies. So I do not think that the traditional reading is hopelessly misleading. According to this reading, which goes back at least to Alexander of Aphrodisias, the natural body that is potentially alive is organic in the sense that it consists of bodily organs.<sup>40</sup>

What matters for our present purposes is the highly abstract conceptualization of the perishable living body at work in *HA*. A certain idea of organization is invoked when we are told that the human body displays the relevant organization in the clearest possible way. This organization is clear to sense-perception only in the case of the human body, and only with reference to its external parts. What I would like to take away from this brief discussion is the following conclusion: Aristotle begins his review of the parts in animals from the human body not only because the human body is the most familiar to us but also because *the human body can serve as an objective standard of reference*. By offering a review of the parts of the human body, Aristotle launches into a study of what he takes to be the paradigmatic case of the perishable living body. Equipped with the conceptual resources developed in the context of this study, he can engage in the study of the living body of other animals. As Aristotle himself says in the last passage cited above, this strategy ensures that the investigators of the animal kingdom do not overlook anything of importance as they review the body parts of other animals.

Two epistemic principles control the review of the relevant zoological data. While the first requires us to proceed from the *more knowable to us*, the second mandates that we proceed from *the more knowable per se* (alternatively, *more knowable by nature*). These principles need not clash with one another. According to Aristotle, the human body not only happens to display the highest degree of organic unity but it also happens to be the most familiar to us. If this conclusion is accepted, the strategy Aristotle adopts for the review at the pre-explanatory stage of inquiry is close to the one he employs at the subsequent, explanatory stage. Let me return to how Aristotle negotiates the transition from the study of the uniform parts to the study of the non-uniform parts at the outset of *PA* II 10. Aristotle begins his discussion by stating that all animals must have a part by which they take in the nourishment (the mouth), and another part where the nourishment is processed (the stomach). There is, however,

<sup>40</sup> Alexander of Aphrodisias, *De anima* 16.11–12.

a great deal of variation in bodily organization beyond this important commonality. Aristotle recommends handling this variation *starting from the human being*:

Those beings that are equipped with sense-perception in addition to *being alive* [ζῆν]<sup>41</sup> are more diverse in their visible aspect, and some of them more than others. There is still greater variety among those whose nature partakes not only of *living* [ζῆν] but also of *living well* [εὖ ζῆν]. Such is the human being. Among the animals known to us, either the human being alone or the human being most of all partakes of the divine. So, both because of this and because the shape of the external parts of the human being is most familiar [to us], we must speak about it first. *The reason is that the natural parts are disposed right away according to nature only in the human being* [εὐθὺς γὰρ καὶ τὰ φύσει μόρια κατὰ φύσιν ἔχει τοῦτω μόνω], and the upper part of the human being is oriented toward the upper part of the whole: the human being alone among animals is upright.<sup>42</sup>

In this passage Aristotle is more forthcoming about the reasons why we ought to start the study of the non-uniform body parts from those of the human being. While Aristotle still mentions our familiarity with the external parts of the human body, he now adds that the anatomical arrangement of the non-uniform parts in the human body is the most natural. This claim holds not only for the external but also for the internal parts. Finally, Aristotle says that the human body alone displays what he takes to be the most natural arrangement of body parts. When we take all these reasons into account, we have no choice but to start our review of the non-uniform parts from those of the human being.

What is exceptional about the human animal is its erect posture, which aligns the human body with the body of the universe. The human body is regarded as the body that displays the greatest level of organization because the human being partakes of living well (as opposed to merely living). To unpack this idea, we must return to the Aristotelian insight that the body is an instrument employed by the soul to discharge its powers.<sup>43</sup> According to Aristotle, the human soul has the power to live in accordance with reason. The passage just quoted does not elaborate on the connection between displaying a greater level of bodily organization and rationality, but we may think of reason as a power that the human being alone has in addition to the other cognitive powers it shares with the nonhuman animals. It is also

<sup>41</sup> Recall that the distinction between two levels of life, namely plant and animal life, is made with reference to the presence (or absence) of sense-perception. Hence, the living beings that are equipped with sense-perception in addition to life are animals.

<sup>42</sup> Aristotle, *PA* II 10, 656a3–13. <sup>43</sup> See above pp. 86–87.

prima facie plausible that the presence of this additional (higher) power requires an additional (higher) level of bodily organization.

I have elaborated on the methodological remarks Aristotle offers in his review of the internal and external non-uniform parts of the human body to show that Aristotle employs the human animal as a starting point for his anatomical study of nonhuman animals. The implicit rule of inquiry at work is that our study ought to start from that which displays the greatest level of organization since this is also the thing that displays the higher level of unity. The clearest and most general formulation of this rule is found in a fragment from the lost *Protrepticus*.<sup>44</sup> By the end of *HA* I, the review of the human body is complete. Aristotle turns to the parts of the other animals at the outset of *HA* II. His survey of these parts is over only at the end of *HA* IV 6. We should not underestimate how complex is the project of offering a systematic survey of all the parts of all the animals other than the human being. At the very least, the investigator is expected to have developed a strategy to present the zoological information in an orderly manner.

Two conceptual distinctions are at work in Aristotle's survey. The first is the division of bodily parts into external and internal parts; the second is their division into uniform and non-uniform ones. When we combine them, we obtain a survey of the zoological data that begins with the *external non-uniform parts*, continues with the *internal non-uniform parts*, and ends with an examination of the *uniform parts*. But there is at least another key methodological insight that controls how Aristotle presents his zoological data. This is the rule of inquiry that requires us to proceed from those animals that display a more organized, or at least a more determinate, living body. Admittedly, Aristotle never invokes or states this rule; but as he moves away from the human body, he appears to find progressively less organization and less determination. We may object that Aristotle finds progressively less organization and less determination precisely because he is less familiar with these animals. This is certainly true, but we should not forget that these animals occupy a lower position in Aristotle's scale of nature. In his view, they occupy a lower position because they are less complete or even less perfect. We are back to the methodological insight that informs the architectonic decision to begin the examination of the non-uniform parts of animals from the human body because this is the most organized and most articulate living body.

To fully appreciate how Aristotle moves on, and indeed forward, with his project of a systematic review of the bodily parts in animals, we need to

<sup>44</sup> I introduced this fragment in Chapter 1, Section 3.

return to a division introduced in the previous chapter: that between *blooded* and *bloodless animals*. To understand what this division entails, we must return to the outline of animal differences advanced at the outset of *HA*, where we are told that all animals are supplied with moisture, the privation of which results in death.<sup>45</sup> The moisture present in blooded animals is of course blood, which runs in the blood vessels. The presence of blood and blood vessels entails the presence of a few related parts. Among them, I recall the heart, viscera, and flesh. When these bodily parts are absent, we should posit the presence of a set of bodily parts that is functionally analogous. I will return to this important aspect of Aristotle's theory in a moment. For the time being, let me stress that the review of blooded animals grows out quite naturally from the discussion of the bodily parts in the human being since the latter is the most perfect among the blooded animals. When we look more closely at how Aristotle reviews the zoological data about blooded animals, we discover that the following groups of animals are discussed (in this very order): live-bearing four-footed animals, egg-laying four-footed animals, birds, fishes, and snakes. In other words, the review of the zoological data is organized with the help of the large kinds (μέγιστα γένη) introduced in *HA I 6*.<sup>46</sup>

In some cases, these kinds are already identified by the Greek language (fishes, birds, snakes).<sup>47</sup> When they are available, Aristotle is happy to adopt existing names. By adopting these names, Aristotle is also turning them into terms of art. But the absence of a name in a natural language does not prevent Aristotle from recognizing a new group when he has reasons to think that the animals in question possess a common nature. Clearly, Aristotle considers the live-bearing four-footed animals and the egg-laying four-footed to be large kinds even if there is no name in the natural language to designate them.<sup>48</sup> Aristotle elaborates on this front in

<sup>45</sup> Aristotle, *HA I 4*, 489a20–21.

<sup>46</sup> A full discussion of how Aristotle introduces, and indeed defends, his articulation of animals into μέγιστα γένη in *HA I 6* can be found in GOTTHELF 2012d: 293–306. On μέγιστα γένη, compare BEMER 2014: 309–334.

<sup>47</sup> I note, in passing, that it is far from clear that snakes are a large kind (μέγιστον γένος). There is textual evidence that Aristotle considers them a kind (γένος). See Aristotle, *HA I 15*, 505b25–31.

<sup>48</sup> It is quite tempting to treat “live-bearing four-footed animals” and “egg-laying four footed animals” as name-like expressions with a fixed taxonomic meaning. Upon reflection, however, we should resist this temptation. To begin with, Aristotle consistently speaks of “four-footed *and* live-bearing animals” and “four-footed *and* egg-laying animals.” He is also ready to switch the terms around when needed. For instance, Aristotle is interested in the *egg-laying* animals and divides them into *four-footed* animals (lizards and the like) and *footless* one (fishes). This practice, combined with the linguistic usage described above, suggests that Aristotle is not employing these descriptive phrases as name-like expressions and is not primarily concerned with developing a fixed taxonomic vocabulary. Compare GOTTHELF 2012d: 301 and LENNOX 2001: xii–xiii.

the *Posterior Analytics*, where he correlates the following three features: being horned, having a third stomach, and possessing only one row of teeth. All the animals that share these features should be treated as having a common nature even if we lack a name for them.<sup>49</sup>

An extended examination of Aristotle's review of the pre-explanatory strategies adopted in the collection and presentation of the non-uniform parts in blooded animals goes beyond the scope of this chapter. Here I would like to illustrate these strategies with the help of a couple of examples taken from Aristotle's review of the external parts in live-bearing four-footed animals. The first example is this: the live-bearing four-footed animals have front legs instead of arms, and those that have their front legs divided into many toes use them as if they were their hands (with the notable exception of the elephant, which possesses a special organ, the nose, which serves as a grasping and moving instrument).<sup>50</sup> We find here an instance of how Aristotle proceeds in his review of animal differences. He deals first with the feature (or features) common to the whole kind and then turns to the feature (or features) shared by a particular sub-kind, ending with a discussion of exceptional cases. The discussion of the exceptional cases is not merely a coda motivated by an interest in the strange or the marvelous; rather, it is guided by Aristotle's concern for offering a review as complete as possible of the zoological phenomena.

Let us now turn to the second example. In his review of the live-bearing four-footed animals, Aristotle tells us that all *four-footed* animals have legs that are bony, sinewy, and fleshless, and that this is in fact a feature shared by all *footed* animals. Moreover, all *footed* animals lack buttocks (most notably, birds). The only exception is the human animal, whose buttocks, thighs, and calves are the fleshiest part of its whole body.<sup>51</sup> We find here a good illustration of Aristotle's interest in generalizing across large kinds of animals. These generalizations contradict Aristotle's stated intention to study each large kind "separately by grasping its nature individually [*χωρίς λαμβάνοντα . . . ἐκάστου τὴν φύσιν*]."<sup>52</sup> Recall that investigating *X* separately (*χωρίς*) involves studying *X* in its own right on the crucial assumption that *X* is a relatively unified domain of investigation.<sup>53</sup> If this programmatic statement is taken seriously, we should expect Aristotle to

<sup>49</sup> Aristotle, *APo* II 14, 98a13–18.

<sup>50</sup> Aristotle, *HA* II 1, 497b13–498a1. The way in which the zoological data are presented here makes sense only if the human body is taken to be the point of reference. Strictly speaking, the human being alone has arms and hands because of its erect posture.

<sup>51</sup> Aristotle, *HA* II 1, 499a31–b5. <sup>52</sup> Aristotle, *HA* I 6, 491a4–5.

<sup>53</sup> Compare Chapter 1, Section 3.

conduct his review of the differences in animals strictly by large kind. And yet Aristotle does not proceed in this way.

To understand why, we need to remain mindful that the large kinds are not his primary, or even most immediate, concern; he is primarily concerned with the commensurate (universal) relationships holding among the relevant animal differences. This concern is dictated by his theory of scientific explanation, which requires the investigator to give explanations at the right level of generality. Aristotle is expected by his own theory to register not only the differentiating features shared by the animals falling under a given large kind but also those that the large kind shares with another large kind (or with a sub-kind of another large kind of animals).<sup>54</sup> This conclusion suggests the following, important observation: the large kinds introduced in *HA I 6* are not meant to be a rigid taxonomy adopted for classificatory purposes; they are best understood as a basic division of kinds of animals subordinated to the achievement of the overriding explanatory goals Aristotle pursues in his study of animals.

We come to the same conclusion when we reflect on how Aristotle uses the division into blooded and bloodless animals. Aristotle does not employ this division because he is motivated by taxonomic concerns, but rather because he hopes to pursue his explanatory goals across the entire animal kingdom. To appreciate this point, we need to return to Aristotle's idea that the absence of blood, blood vessels, and the other related bodily parts entails the presence of functionally analogous parts (they are typically nameless). Two moves are implicit in this idea. The first is this: the parts in bloodless animals are imperfect with respect to their analogous parts in blooded animals; as a result, their description and subsequent explanation is to be conducted by relying on the results achieved in the study of the bodily parts in blooded animals. The second move has to do with analogy, which is the tool that allows us to discover the existence of structural similarities across large kinds of animals.<sup>55</sup> When this tool is first introduced in *HA*, Aristotle employs the following examples: bone is analogous to spine, nail to hoof, hand to claw, and scale to feather.<sup>56</sup>

<sup>54</sup> For full discuss of this aspect of Aristotle's methodology in *HA*, see GOTTHELF 1988: 101–113 (reprinted in GOTTHELF 2012a: 309–324) and, more recently, GOTTHELF 2012b: 272–273.

<sup>55</sup> I will have a great deal more to say on analogy as my argument unfolds in Chapters 4 to 6. For the time being, let me highlight recent discussions of analogy in Aristotle's study of animals and beyond: LLOYD 1996c: 138–159; WILSON 2000: 53–115; RASHED 2005: clii–clxiii; HENRY 2014: 145–169 (to be read along with the LEUNISSEN 2014: 170–181); RAPP 2021: 9–37; SIER 2022: 147–178.

<sup>56</sup> Aristotle, *HA I 1*, 486b19–22.

All these examples are taken from within the group of blooded animals. But the significance of analogy goes emphatically beyond this initial case. Aristotle employs analogy to move not only across large kinds of blooded animals but also from blooded animals to bloodless animals. These two moves jointly control the order of inquiry at the pre-explanatory stage of inquiry: first the differences in blooded animals, then those in bloodless animals. They also control how the differences in bloodless animals are to be approached. These differences are to be introduced and studied based on the results achieved in the study of blooded animals. It does not take long to see that the methodological insight shaping the study of bloodless animals is another incarnation of the methodological principle that the study of the less organized and less determined is to be conducted via the results reached in the study the more organized and more determined rather than vice versa.

The review of the bodily parts in bloodless animals is organized around external and internal parts; but now Aristotle discusses both external and internal parts together for each large kind before moving on to the next large kind. We are not given the reason for this change in the overall strategy. Lennox has suggested that this different organization of the zoological data may be a direct consequence of how the large kinds themselves are fixed.<sup>57</sup> Recall that the large kinds of bloodless animals are four: soft-bodied animals, soft-shelled animals, hard-shelled animals, and animals that have insections in their bodies (i.e., insects).<sup>58</sup> At the outset of *HA IV*, Aristotle adds a brief description for each of these four kinds. Taken together, those descriptions suggest that Aristotle has come to fix these large kinds with reference to the relative differences that we observe with respect to the softness or hardness of their exterior and interior parts, as well as the shape of their whole body. Hence, it makes sense for him to review these differences large kind by large kind.

I conclude this review of the pre-explanatory strategies adopted in presenting the zoological data regarding the parts of animals by recalling these descriptions. The soft-bodied animals (μαλάκικα) resemble blooded animals to the extent that they display soft and flesh-like parts outside and

<sup>57</sup> LENNOX 1987: footnote 29 (reprinted as LENNOX 2001a: endnote 29). It may be helpful to recall in connection with this observation that we are expected to discuss the differences in the bodily parts because it is “chiefly, and firstly, with respect to these that the wholes also differ” (Aristotle, *HA I 6*, 491a15; compare *PA I 4*, 644b8–10).

<sup>58</sup> This is a term of art coined by Aristotle. It is introduced in *HA I 1*, 487a32–33 with the following (nominal) definition: “I call ‘insected animals’ those that have their bodies divided in sections [καλωῶ δὲ ἔντομα [sc. ζῶα] ὅσα ἔχει κατὰ τὸ σῶμα ἔντομάς].”

a hard structure inside (e.g., the cuttlefish and the octopus). The soft-shelled animals (μαλακόστρακα) display the opposite bodily arrangement: they have a hard structure outside and soft and flesh-like parts inside (e.g., the lobster and the crab). The hard-shelled animals (δστρακόδεσμα) have a hard shell protecting a flesh-like inside. The distinction between soft-shelled and hard-shelled animals is traced back to the different nature of their external hard structure, which Aristotle describes in the following way: while the outer structure of the soft-shelled animals is crushable but not crackable, the outer structure of the hard-shelled animals is crackable but not crushable.<sup>59</sup>

A couple of questions loom large at this point. The first is how far Aristotle can pursue his explanatory goals by adopting analogy across the entire animal kingdom. The second has to do with the explanatory costs associated with this strategy. Let us focus on the second question first. Analogy helps Aristotle transfer results reached in the study of the more organized and more definite kind of animal to the study of the other kinds of animals. In this respect, analogy orients how Aristotle is going to study what he takes to be comparatively less organized kinds of animals. But it also determines some of the results he is going to establish in the context of his research. Let me illustrate this point with the help of a well-known example. According to Aristotle, soft-bodied animals like the cuttlefish and the octopus are bloodless animals. These animals do not have a heart but something functionally equivalent to it. Aristotle calls this large central part *mutis*.<sup>60</sup> Today we know better: the cuttlefish and the octopus have three hearts and a bodily organization that is not reducible to the one envisioned by Aristotle. What matters most is not the mistake itself but rather the fact that *the mistake is driven by the theory*.<sup>61</sup> Aristotle does not study these alien forms of life in their own right; he studies them based on his knowledge of blooded animals. An unintended consequence of this strategy is this: Aristotle is unable to appreciate what is unique about animals such as the cuttlefish and the octopus. This last observation raises an important question about the costs of the application of the epistemic principle that requires the investigator to start their inquiry into perishable life from what Aristotle takes to be the

<sup>59</sup> Aristotle, *HA* IV 1, 523b5–7 combined with 523b9–11.

<sup>60</sup> Aristotle, *HA* IV 1, 524b14–15 combined with *PA* IV 6, 681b18–21. In the context of this second discussion, Aristotle makes it clear that the position of the *mutis* at the center of the living body makes it functionally equivalent to the heart in blooded animals (*PA* IV 6, 681b28–30). But we know that the organ that Aristotle calls *mutis* is functionally equivalent to the liver, and not the heart, as is charitably noted in LSJ (s.v. μύτις).

<sup>61</sup> There is further, helpful discussion of this mistake and its methodological implications in LLOYD 1996c: 138–159 (especially 155–156).

most organized and most determinate form of life. This principle has an architectonic relevance that goes beyond the study of animals, but its costs may be assessed by remaining within the domain of animal life.<sup>62</sup>

Let us now turn to the first question raised above. Under the rubric of bloodless animals Aristotle deals with vastly different kinds of animals: insects, soft-bodied animals, soft-shelled animals, and hard-shelled animals. Aristotle cannot be content with highlighting the similarities that hold across these large kinds; he is also expected to engage in a vigorous study of each of those kinds with an eye toward what is specific about each of them. Put differently, the general and the specific are to be integrated into a single account since only the combination of the two gives us perfect, and so scientific, knowledge. There is no reason to think that the study of bloodless animals is meant to be an exception to the rule. But how far, and indeed how well, is Aristotle able to pursue his explanatory goals as he moves away from his study of blooded animals? I will try to answer this question by turning to the *διότι*-stage of inquiry, with a concentration on Aristotle's explanation of animal locomotion.

#### 4 Explanatory Strategies in *IA*

Let us begin by stating the obvious: we do not have a single discussion of all the bodily parts of animals in Aristotle.<sup>63</sup> In addition to the official treatment offered in *PA* II–IV, we are given separate treatments of the locomotive and generative parts.<sup>64</sup> While the locomotive parts are studied in the short treatise known with the Latin title of *De incesu animalium* (*IA*), the generative parts are discussed in the first book of the *Generation of Animals* (*GA* I 3–16). Aristotle does not elaborate on his decision to organize his explanatory work in this way, but we can offer an educated guess on his behalf. Reproduction and locomotion are the two most conspicuous life activities in which animals are engaged. It is surely no coincidence that two

<sup>62</sup> What Aristotle says on the octopus and the cuttlefish can be usefully compared (and contrasted) with what we read in a recent book on this topic (GODFREY-SMITH 2017). It seems that when we approach an alien form of life, we have no choice but to register the commonalities and the differences with a more familiar form of life (ours). In this respect, the overall strategy adopted in this recent work is not so different from the one followed by Aristotle. And yet, we do not find the additional idea that there is a paradigmatic form of life (ours) that shapes our discussion of the alien form of life. Upon reflection, this is what leads Aristotle astray.

<sup>63</sup> In this section I am relying on results published in FALCON 2021a.

<sup>64</sup> Recall that *PA* I is a general introduction to the study of animals, with a focus on the specific norms of inquiry required to engage in a successful investigation of animal kingdom. As such, the book has a more general significance. I borrow the phrase “norms of inquiry” from LENNOX 2021a.

of the large kinds that Aristotle isolates in his zoological writings, namely the four-footed egg-laying animals and the four-footed live-bearing animals, are identified by means of their distinctive modes of reproduction and locomotion. Considering this, it is no surprise to discover that the study of the relevant bodily parts involved in animal reproduction and locomotion requires not only extensive but also separate discussions.<sup>65</sup>

Here is the opening statement of *IA*:

As regards the parts that are useful to animals for movement with respect to place, we must investigate due to what sort of cause each part is such as it is and for the sake of what it belongs to them, and also the differences in the parts of one and the same animal as compared to the parts of animals different in kind.<sup>66</sup>

Right from the start Aristotle adopts a resolutely teleological approach to the phenomenon of animal locomotion: he promises to deliver a causal explanation of the presence of the locomotive parts by asking for what reason animals have them. Among other things, such an explanation entails finding out the relevant final cause.<sup>67</sup> Moreover, Aristotle promises an explanation not only of why animals have the bodily parts they do but also of why they have them in the way they do. This requires an explanation of why the bodily parts involved in locomotion differ within the same animal (e.g., why front and hind legs in live-bearing four-footed animals bend in opposite ways) as well as across different kinds of animals (e.g., why egg-laying four-footed animals bend their legs in a different way, unique to them – namely, laterally and away from their own body).

What makes the *IA* an especially interesting case study is the methodological explicitness by which Aristotle first introduces and then uses the relevant theoretical framework to fulfil the promises outlined above. Aristotle provides his reader with three explanatory principles. The first principle is the axiom that “nature does nothing in vain, but it always does what is best from among the possibilities for the substance of each kind of animals.”<sup>68</sup> While Aristotle invokes this teleological principle several times

<sup>65</sup> A separate review of the reproductive parts is offered at the pre-explanatory stage. See *HA* I 13–14; *HA* II 1, 500a15–25; *HA* III 1; *HA* IV 11 (secondary sexual characteristics). Activities related to reproduction are discussed in *HA* V–VI. For an attempt to explain why the reproductive parts are explained in the context of Aristotle’s *GA*, see GOTTHELF-FALCON 2017: 17–21.

<sup>66</sup> Aristotle, *IA* 1, 704a4–9.

<sup>67</sup> The emphasis placed on final causality does not mean that the other causes are not relevant to our attempt to account for animal locomotion.

<sup>68</sup> Aristotle, *IA* 2, 704b15–17. There is fuller discussion in FALCON 2021b: 19–31. The nature in question is not cosmic nature but rather the internal source of change and rest introduced in *Phys.* II 1, 192b20–23.

in the course of his natural investigation,<sup>69</sup> he offers its fullest and most precise formulation here.<sup>70</sup> The second principle is the abstract but powerful way of thinking about the living body we have already seen at work in *HA*. For Aristotle, a perishable living body must be organized in a certain way to support life. This body can display up to six functional dimensions: up/down, front/back, and left/right.<sup>71</sup> A perishable living body engaged in locomotion requires all of them. In other words, an upper and a lower part, a front and a back, and finally a right and a left side must be present in a living body equipped with the power to displace itself.<sup>72</sup> The third, and final, principle is about motion: pushing and pulling are the sources of all *per se* motion from one place to another.<sup>73</sup> While the first two principles are native to Aristotle's study of animals, the third originates in Aristotle's general discussion of motion.<sup>74</sup> This is a relatively unsurprising development. To the extent that Aristotle is about to engage in an investigation of the locomotive parts insofar as they are useful for locomotion, he is concerned not only with certain bodily parts but also with a special kind of motion, namely animal locomotion. So it is perfectly appropriate for Aristotle to remind us (and himself) of a general principle of motion immediately relevant to his project. Unsurprising as it is, this development is not trivial. It shows that Aristotle does not conceive of the study of animal locomotion as a separate, let alone independent, investigation; on the contrary, his investigation is guided by the theoretical framework developed in *Phys.* I–VIII.

As we proceed in the study of how Aristotle explains animal locomotion, we should bear in mind the following distinction, which also marks the beginning of Aristotle's actual investigation: bodily displacement takes place either by jumping or by progression (the Greek term is *πορεία*). While in jumping the living body is displaced all at once, in progression the

<sup>69</sup> For instance: Aristotle, *DC* I 4, 271a33; *DC* II 11, 291b13–14; *DA* III 12, 434a31; *PA* II 13, 658a8–9; *PA* III 1, 661a23–24; *GA* II 5, 741b–5; *GA* II 6, 744a36–37. It is worth noting that this explanatory principle is also invoked by Theophrastus in his study of plants (*CP* I 1.1). On Theophrastus and teleology, see Chapter 5, Section 3.

<sup>70</sup> This teleological principle has been closely studied: LENNOX 1997: 199–214 (reprinted in LENNOX 2001A: 205–223); LEUNISSEN 2010: 119–121, 124–135; HENRY 2013: 225–263; MOREL 2016: 9–30; STAVRIANEAS 2021: 165–193; RANGOS 2021: 233–265.

<sup>71</sup> Aristotle, *LA* 2, 704b19–22.

<sup>72</sup> None of this applies to celestial bodies. Aristotle explains celestial motion in terms of a special simple body that naturally move in a circle. See FALCON 2005: 55–84.

<sup>73</sup> Aristotle, *LA* 2, 704b22–23.

<sup>74</sup> The proof that all motion in place is *per se* or *per accidens*, and all *per se* motion can be reduced to pushing and pulling, is offered in *Phys.* VII 2, 243a11–244a6. Here Aristotle takes upon himself the task of showing that all motion in place can be reduced to a case of pushing and pulling.

living body is displaced part by part.<sup>75</sup> This second mode of bodily displacement is Aristotle's primary focus in *IA*. The parts of the living body involved in progression are called "instrumental parts."<sup>76</sup> By adopting this expression, Aristotle indicates that these parts are used by the animal as tools to move its body from one place to another. Finally, Aristotle tells us that an animal that can displace itself must exhibit the following (minimal) level of bodily complexity: one part of its body is acted upon by being pressed, while another acts on it by pressing. An important corollary of this zoological theorem is that without bodily parts nothing can displace itself.<sup>77</sup>

Up to this point Aristotle has proceeded at a very general level of investigation, but now he turns to the explanation of the vastly different ways in which animal progression takes place in nature. While some animals progress on land, others do so in water or in air; moreover, some use their feet as an instrument of locomotion, whereas others employ different bodily parts (e.g., wings or fins); finally, there are also animals that can move quickly and efficiently even though they are footless (e.g., snakes). It does not take long to see that a strategy is needed to handle the richness and complexity of the animal world. The strategy devised by Aristotle consists of two steps. The first is the decision to concentrate on the animals that progress on land by means of feet. Aristotle begins his explanation of how animals locomote with an examination of *footed animals*. He takes the foot to be the paradigmatic instrument of animal locomotion.<sup>78</sup> But this does not solve all our problems given that animals progress on land by means of either two, four, or many feet. In addition, there are animals that progress on land without feet (snakes). Where should we start looking for an explanation of how these different kinds of animals displace their bodies? Aristotle answers this question by developing an explanatory model that works for *blooded animals*. These animals are either two-footed or four-footed. A direct consequence of this strategy in two steps is that the study of many-footed animals is temporarily bracketed since these animals are all bloodless.

<sup>75</sup> Aristotle, *IA* 3, 705a3–6.

<sup>76</sup> Aristotle, *IA* 3, 705a20. Compare *HA* I 6, 491a25–26: All non-uniform parts are instrumental parts – namely, tools the animal uses to engage in the activities that are constitutive of its distinctive mode of life (e.g., flying or swimming).

<sup>77</sup> Aristotle, *IA* 3, 705a20–24.

<sup>78</sup> Aristotle defines the foot as the part that is in contact with the ground and as such is productive of locomotion (*IA* 5, 706a31–32).

Aristotle's first and most important goal is to develop a model that explains how blooded animals progress on land by means of feet. This model is subsequently extended (with the relevant adjustments) to explain how bloodless animals progress on land. IA 6 plays a central role in his overall argument. Here Aristotle develops an abstract model for the explanation of how animals that are footed and blooded progress on land. This model is quite general. It is meant to apply to both two-footed and four-footed animals.<sup>79</sup> Aristotle thinks of blooded animals as abstract locomotive units and asks under what conditions they can engage in locomotion. His answer is that these locomotive units must have a common origin of motion, and this origin must be equally well disposed with respect to all the body parts involved in locomotion. All the locomotive units Aristotle envisions in IA 6 are *centralized locomotive systems*: they have a single source of locomotion that is at an equal distance from all the locomotive parts. Aristotle makes this single source of motion the ultimate cause of bodily displacement.<sup>80</sup>

This highly abstract analysis generates the following important result:

It is clear then that motion with respect to place belongs either *only or above all* [ἢ μόνοις ἢ μάλιστα] to those animals which make their own change with respect to place by means of two or four points [of motion].<sup>81</sup>

To understand the force of this pronouncement, we must keep in mind that Aristotle's focus is still on animals equipped with two or four feet. When Aristotle says that locomotion belongs only or above all to these animals, he signals to his reader that he is treating these animals as his paradigmatic locomotive systems. Momentarily, we will see how Aristotle goes beyond these *paradigmatic locomotive systems*. For the time being, it is important to clarify what Aristotle means by "point of motion." This expression is native to his theory of animal locomotion. With it Aristotle refers to the bodily part that makes contact with the ground (or the surrounding water or air).<sup>82</sup> Given his focus on two-footed and four-footed animals, Aristotle must refer, first and foremost, to the feet of these animals. In his view, these animals progress on land either by

<sup>79</sup> Four-footed animals can be either live-bearing or egg-laying animals.

<sup>80</sup> Aristotle, IA 6, 707a12. Aristotle is committed to cardiocentrism, so this source of motion must be a perceptual soul to be found in the heart of blooded animals. Yet, it is significant that Aristotle refrains from talking about the soul or the heart in IA 6. For a perceptive reflection on the self-imposed constraints controlling Aristotle's discussion in IA 6, I refer the reader to CORCILIOUS 2021a: 141–164.

<sup>81</sup> Aristotle, IA 7, 707a16–19.

<sup>82</sup> Compare Aristotle, HA I 5, 490a26–32. This text may presuppose the discussion offered in IA (rather than vice versa).

means of two or four points of motion. In due course Aristotle clarifies that blooded animals move by means of *exactly* four points of motion. He does so by replying to the possible objection that birds and humans move by fewer than four points of motion. His reply is that birds use their legs when they fly and their wings when they progress on land, just as humans use their shoulders and their arms when they walk.<sup>83</sup> But at this stage of his inquiry this conclusion is not yet available.

In *IA 6* Aristotle develops a highly abstract account of what a locomotive unit of a certain kind requires to perform its primary function, which is to move from one place to another. Aristotle generates this account for the explanation of how *blooded animals* progress on land. He subsequently adopts, indeed adapts, it to explain the motion with respect to the place of *bloodless* animals. Aristotle's overall strategy becomes clear as soon as we realize that he conceives of bloodless animals as locomotive systems to which *additional* points of motion are attached to the original four. Moreover, because additional points are attached to the original four, these systems do not display the same level of integration and unity as the one envisioned for blooded animals. One concrete example may help us appreciate how Aristotle approaches the study of bloodless animals. An ant moves by means of six feet. For Aristotle, the ant is neither a two-footed nor a four-footed animal; rather, it is a *many-footed* animal. Aristotle conceives of the ant as a locomotive system consisting of four + two points of motion. We may think that having more than four feet allows an animal to displace its body in a better, quicker, and more efficient way. However, Aristotle never makes this observation. Instead, his first and foremost concern is to highlight that a unit consisting of more than four points of motion is a less unified, and less well-integrated, locomotive system. It is a less unified, and less well-integrated, locomotive system because Aristotle thinks of this organic unit as having four +  $n$  points of motion (where  $n$  must be an even number).<sup>84</sup> According to him, there must be a controlling center in this second kind of locomotive system too, but this center cannot be equally well disposed with respect to all the (four +  $n$ ) points of motion.<sup>85</sup>

<sup>83</sup> *IA 10*, 709b20–26.

<sup>84</sup> Aristotle defends the claim that, unless mutilated or defected, animals move by an even number of points. He does so in connection with his explanation of how footed animals progress on land, which is his initial case study (*IA 8*, 708a21–b21).

<sup>85</sup> Recall that bloodless animals do not possess a heart, but they have something that plays an analogous role in their physiology. The controlling center is to be found in the part functionally analogous to the heart, or so Aristotle would like to argue.

Aristotle conceives of bloodless animals as less perfect locomotive systems. These locomotive systems are less perfect because *they exhibit a lower level of organic unity*. This explains why he claims that, unlike blooded animals, these animals can survive for a while if they are severely mutilated. Some of them, Aristotle adds, can even move with the same type of locomotion with which they were moving before they were mutilated. They can do so because they are “just as if they were compounded out of several animals.”<sup>86</sup> Aristotle mentions the centipede. In his view, all animals that have an elongated body and are like the centipede enjoy a weaker type of unity compared to blooded animals. In a few cases, their organic unity is so weak that these animals consist of a few relatively independent locomotive units. In these extreme cases, each locomotive unit can not only survive but also displace itself when it is separated from the others. Or at least this is what Aristotle seems to believe.<sup>87</sup>

In a few passages Aristotle engages in the explanation of specific aspects of the locomotion of bloodless animals while he is still concerned with the study of blooded animals, and under a common rubric. He does so because he thinks that this strategy results in an optimal treatment of certain topics. Recall that if a common explanation can be given, then it must be given. Offering a serial explanation instead of a common explanation is no viable alternative in such cases for Aristotle.<sup>88</sup> When we keep in mind this (self-imposed) explanatory constraint, we see why Aristotle is not imposing a too rigid structure on his discussion of locomotion. Aristotle remains flexible to adapt to the complexity of his task, which is to provide as complete a study as possible of how animal progress on land, in water, or in air. A good illustration of his flexibility is the explanation of the role of the tail in flyers.<sup>89</sup> Aristotle finds it convenient to discuss the flight of insects in this very context. He tells us that their flight is slow and is not efficient because they lack a tail. Aristotle must think that dealing with the flight of insects here strengthens his claim that the tail in flyers is functionally equivalent to a rudder.

The occasional, indeed common, treatment of blooded and bloodless animals does not mean that Aristotle has second thoughts about his momentous decision to study how bloodless animals displace their body after his study of locomotion in blooded animals is in place. To see what licenses this approach, we need to recall the methodological insight we

<sup>86</sup> Aristotle, *IA* 7, 707b3.      <sup>87</sup> Aristotle, *IA* 7, 707a27–29.

<sup>88</sup> See Chapter 1, Section 3 for additional reflections on the principle requiring the investigator to give explanations at the right level of generality.

<sup>89</sup> Aristotle, *IA* 10, 710a4–24.

have already discussed in connection with *HA*: bloodless animals do not have blood, blood vessels, and a heart, but they have something functionally *analogous* to those bodily parts.<sup>90</sup> Analogy is the tool that allows Aristotle to progress beyond his paradigmatic locomotive systems. It is an especially useful tool because it does not reduce or eliminate the complexity of the data, but it gives us a way to map that complexity.<sup>91</sup>

The explanatory strategy outlined so far allows Aristotle to offer a unified account of animal locomotion that applies to both blooded and bloodless animals without reducing or eliminating the differences between the two groups of animals. This strategy is not without explanatory costs. One is obvious even at a cursory glance: *the treatment of locomotion in bloodless animals is disappointingly selective*. Bloodless animals become the primary focus of the discussion only at the tail end of *IA* (i.e., in *IA* 16–19). Aristotle has already explained why bloodless animals equipped with feet must be many-footed animals. As a result, questions about number of feet and points of motion are no longer addressed. Instead, Aristotle concentrates his discussion on the explanation of how feet are attached to the body of bloodless animals, and on the reason why they bend their limbs in the way they do. Aristotle appears to be especially interested in the case of crabs and *karaboi*. Both are soft-shelled animals, and this is relevant to the explanation of the way in which they bend their limbs: while crabs use their limbs for progression on the ground, *karaboi* employ them for swimming.

It is difficult to resist the impression that Aristotle's answer to the question of how bloodless animals progress would have been significantly different if his answer did not depend on the assumption that all animal progression ought to be understood in light of the results achieved in the study of blooded animals. For one thing, this discussion would have been more detailed. For another, it would have been more convincing. But adopting an alternative route was not a real option for Aristotle. Beginning the study of animal progression by focusing on bloodless animals and moving from there to the case of blooded animals would have been a complete non-starter for Aristotle. It would have amounted to engaging

<sup>90</sup> Aristotle, *HA* I 4, 489a22–24.

<sup>91</sup> For recent discussions of the use of analogy in the context of Aristotle's study of animals, see LLOYD 1996: 138–159 (with an emphasis on the heuristic value of analogy for Aristotle) and HENRY 2014: 145–169 (with an emphasis on the classificatory and explanatory role of analogy in Aristotle). The second essay is to be read along with the comments offered in LEUNISSEN 2014: 170–181. I return to the topic of analogy and its overall impact on the Peripatetic study of perishable living beings in Chapter 4, Section 4, and in Chapter 6, Section 3.

in the study of animal locomotion starting from a less perfect and less developed form of animal life. We are not obligated to follow Aristotle since we do not accept his assumption that bloodless animals represent a less perfect and less developed form of animal life. We can easily object to Aristotle that crabs or octopuses have a very high degree of bodily organization and articulation. And yet this is emphatically not how Aristotle thinks. If one accepts his starting point, one is also compelled to follow his explanatory strategy.

One final aspect of Aristotle's overall strategy deserves close attention. A definite explanatory pattern can be observed at several junctures of Aristotle's treatment of locomotive parts. Aristotle always begins his inquiry by explaining the presence of a given locomotive part in certain kinds of animals (e.g., the presence of feet in *footed* animals), and then explains the absence of the same part in other kinds of animals (e.g., the absence of feet in *footless* animals). Consider the explanation of how snakes progress either on land or in water. Snakes are blooded animals, so they must displace their body by means of four points of motion. But the only way to move efficiently at four points of motion while having an elongated body is by bending it. So snakes progress by bending their body. They touch the ground (or the water) at two points, one in the front and one in the back of their bodies. Because of their narrow and elongated shape, we cannot see four but only two points of motion. But even if we do not see the four points by means of sense-perception, we can discriminate a functional right from a functional left at each of the two points we see. In other words, snakes are locomotive systems that fit the model elaborated for all blooded animals.<sup>92</sup>

While important, the explanation of how snakes progress by bending their body is only a first, *interim* result. A full explanation of how snakes move requires an explanation of why they are footless. Snakes are a *prima facie* exception, and so also a potential challenge, to the basic account of animal locomotion developed for what Aristotle takes to be the paradigmatic case of locomotion – namely, the progression on land by means of feet. By explaining how snakes progress on land (or in water) without employing feet, Aristotle can show that they are no exception to his basic account of animal locomotion. Their motion, properly explained, not only confirms but also strengthens the case for his basic account. In this respect, Aristotle's discussion of why snakes do not have feet is not a digression from the stated task of explaining why animals have the parts they do. It is

<sup>92</sup> Aristotle, *IA* 8, 708a9–20.

rather an integral part of Aristotle's larger task, which is offering an account of the different modes of locomotion that does full justice to the complexity of the zoological data.

The stretch of text concerned with the explanation of why snakes are footless is one of the best known, and most intensely discussed, because it also contains crucial information on how Aristotle would like to apply the teleological principle that nature does nothing in vain but always the best given the nature of the animal.<sup>93</sup> Here, suffice it to say that Aristotle takes the properties of having an elongated body and being blooded as the two starting points of his explanation. Aristotle regards them as basic facts that belong to the essence of snakes.<sup>94</sup> In other words, to be a snake is to be blooded and to have an extra-long body. Given this, there are only two theoretical options on the table: either snakes have a foot placed at each of the four points of motion or they have no feet. But having four feet is far from being ideal in the case of an extra-long body. A four-footed animal with an extra-long body would move with great difficulty and very slowly. Snakes are clearly better off without feet. Instead of progressing on land (or in water) by using feet, they move by bending their extra-long body. This turns out to be an extremely effective mode of locomotion.

Among blooded animals, fishes too are footless. In their case, however, the absence of feet is explained by invoking their distinctive mode of life rather than the shape of their body. Like snakes, fishes are blooded animals, so they must move at exactly four points of motions. Unlike snakes, they are marine animals. Since they live in water, they have fins rather than feet. The attachment of their fins, as well as the presence of a tailfin, is explained by exploiting the analogy between swimming and flying, which are regarded as analogous modes of locomotion. At this point, Aristotle has already explained the mechanics of flying. Therefore, he can also adopt the result achieved in the explanation of how flyers move in air to explain how swimmers displace themselves in water.

The above remarks go some way toward mitigating what appears to be a way too brief and cursory discussion of progression in water (swimming). To be sure, swimming is a highly distinctive mode of locomotion, but it is also a mode that can be approached by adopting a comparative method of study. Aristotle's view must be that the adoption of such a method allows us to know all we need to know about swimming and the bodily tools marine

<sup>93</sup> I refer the reader to *STRAVRIANEAS 2021*: 165–193.

<sup>94</sup> For the claim that the definition of what the animal is ought to refer to its being blooded or bloodless, see *PA IV 5*, 678a33–34.

animals employ to displace themselves in water (fins and tailfin). As a result, Aristotle's strategy in dealing with the different modes of locomotion is this: he *first* develops an explanation for how animals progress on land by means of feet; he *then* extends this explanation by considering what is specific about progression in air by means of wings and a tail. By the time he gets to the mode of locomotion characteristic of swimmers, there is not much left to explain. At this point, Aristotle keeps his discussion very short, since he can rely on the explanatory resources already introduced for progression on land (walking) and progression in air (flying). This strategy may also explain why there is no mention of cetaceans. There is nothing distinctive about their mode of locomotion. Like all blooded animals, cetaceans move by means of four points of motion. Like fishes, they displace their body in water by means of fins and a tailfin. By contrast, there is a great deal that is interesting about the way in which cetaceans control their bodily temperature. This explains why they feature in Aristotle's discussion of respiration but they are absent from his treatment of locomotion.

Aristotle's study of animal locomotion ends with a discussion of a difficult case: the displacement of hard-shelled animals. Some of these animals appear to be able to displace themselves, but it is far from clear how they move, and whether they are engaged in the form of locomotion that is Aristotle's primary concern in *IA* – namely, animal progression. Aristotle approaches this whole topic by announcing that the motion of these animals is a real puzzle (*aporia*): while they move, it is unclear whether they have a right and a left in their body. His solution to the puzzle consists in considering hard-shelled animals a maimed or mutilated kind of animal. Once more, Aristotle invokes analogy. The implication is that hard-shelled animals have a principle of motion in their body, so we should be able to detect a right and a left side apart in their body. What Aristotle says seems to contradict this. He says that the hard-shelled animals move, but they do so against nature because they are not naturally able to move.<sup>95</sup> Perhaps we can shed further light on this issue with the help of what Aristotle says on the topic of the imperfectly developed animals in the context of his discussion of the locomotive soul. Aristotle claims that imperfectly developed animals move but they do so in an indefinite way.<sup>96</sup> In other words, the capacities of the soul needed for locomotion, as well as the relevant bodily distinctions, are present in them but in an equally indefinite way.<sup>97</sup>

<sup>95</sup> Aristotle *IA* 19, 714b14–15.   <sup>96</sup> Aristotle, *DA* III 11, 434a4.

<sup>97</sup> Aristotle appears to ascribe indeterminate *phantasia*, desire and perception, to these animals in *DA* III 11, 434a5.

Aristotle seems to be saying that the distinction between a right and a left is also present in the hard-shelled animals, but he would add that this distinction is present in them *in an indefinite way*. Be this as it may, the discussion of the difficult case of the hard-shelled animals is the last topic on Aristotle's agenda. It is regarded as a sort of coda to the study of animal locomotion for at least two reasons. First, it is no longer a case of progression, which is the stated focus of the treatise. Second, the whole kind is regarded as an intermediate group between stationary and non-stationary animals. Hence, any attempt to explain their motion is naturally placed at the very end of the discussion of animal locomotion.<sup>98</sup>

It is time to take stock. Aristotle's treatment of animal locomotion is far from a random discussion of how animals displace themselves from one place to another. Aristotle adopts an intricate but at the same time principled approach to the topic. His strategy involves recourse to the two epistemic principles we have encountered not only in the *Parva naturalia* but also in *HA*. While the first requires us to look for explanations that are commensurately universal, the second mandates that we start our study of locomotion from the form of life that exhibits the highest degree of bodily organization and articulation. Aristotle does not favor one principle over the other but tries to apply both as well as he can. His intricate discussion is also a by-product of his attempt to negotiate the different requirements imposed on him by these principles. The role of apparent exceptions to the rule is a remarkable feature of the overall argument of *IA*. It does not take long to see that Aristotle's interest in what is perceived as an exception to the rule, or a borderline case, is entirely dictated by the application of the second epistemic principle outlined earlier. As Aristotle tries to do justice to the complexity of the zoological data, he is required to go beyond the explanation he has developed for his core case: the centralized locomotive unit progressing on land by means of four feet. The discussion of apparently difficult or odd cases contributes directly to this goal. Yet this strategy has its own limitations. The reader of *IA* comes away with the distinct impression that the locomotion of bloodless animals is, to say the least, understudied. Aristotle does not develop additional principles for the study of the modes of locomotion of bloodless animals; he adapts the principles developed for the study of blooded animals to the study of bloodless animals. The outcome is not entirely convincing. In the end, Aristotle does not appear to be able to do

<sup>98</sup> Hard-shelled animals are also regarded as an intermediate kind between animals and plants (*GA* I, 731b8–13).

full justice to what is specific, or even unique, about the ways in which these animals move from one place to another.

If we accept the idea that Aristotle's extant zoological writings are not a complete science but are best understood as a work in progress, we can try to save Aristotle by suggesting that his account of animal locomotion can be revised and supplemented with additional observations. But it is important to stress that the shortcomings highlighted above cannot be fixed unless a drastic change in the overall approach to the study of animal life is accepted. At the very least, Aristotle would have to give up one of the epistemic principles that shape his whole approach to animal life. But there is no textual evidence that Aristotle is ready for such a drastic move. It does not take long to see that such a move would imply rethinking his explanatory strategy from scratch – I mean the strategy to explain the whole domain of animals and not just the phenomenon of animal locomotion.

I would like to end my analysis of how Aristotle explains animal locomotion on a bright note. Notwithstanding all the shortcomings discussed, the explanatory strategy Aristotle adopts allows him to generate a comprehensive map of how animals progress on land, in water, and in air. This result is very important to him. Arguably, it is less important to us today. It is perfectly acceptable for us to focus on a wonderful case of animal locomotion and try to extrapolate from there a few general truths about locomotion. We can easily imagine a scenario in which a great deal of research is devoted to understanding how certain kinds of animals can move easily, almost effortlessly, on a vertical surface. Unlocking the secrets of how these animals perform this feat is a result Aristotle would have surely appreciated. At the same time, he would have considered such a narrow research focus unsatisfying from a theoretical point of view. He would have insisted that we develop a comprehensive account of animal progression rather than try to learn everything about a particular case. More to the point: he would have stressed that such a comprehensive account of animal progression would have to highlight the commonalities existing in nature and would have to give a common explanation for each of them. In the end, Aristotle operates on a more demanding conception of the scientific enterprise. The bar for what counts as epistemic success in this enterprise is set higher for Aristotle than it is for us today.

## 5 Explanatory Strategies in *GA*

Aristotle's *GA* offers a comprehensive and systematic account of how animals reproduce, including a study of their generative parts. This account employs

and connects all the four Aristotelian causes, with a special concentration on the moving (i.e., efficient) cause of the generation of animals. A few additional facts surrounding generation are explained; they include hybridity, birth defects, diseases of pregnant females, and lactation. When we look at what Aristotle accomplishes in *GA*, we can safely conclude that we are in the presence of one of Aristotle's most mature, most sophisticated, and indeed most carefully organized scientific writings. In this section, I would like to illustrate some of the explanatory strategies adopted, as well as some of the decisions made, in what turns out to be a long and complex tour de force across five books. My goal is to confirm some of the results reached so far and add to them as is appropriate.<sup>99</sup>

Aristotle's initial move in *GA* consists in a three-part observation: in many cases, animals come to be from (1) the coupling of (2) a male and (3) a female.<sup>100</sup> This is our initial observation – what we observe when we first look. It is one observation (rather than three) because the items that constitute it are interdependent. Neither male nor female nor coupling, as we observe them in most cases, makes sense without the other two. This initial observation establishes our first *explanandum*. Since we want to explain a process that begins from the coupling of the male and the female, our explanation must include an explanation of the male and the female *qua* generative principles. This comprises an explanation of their respective generative parts. In other words, an optimal study of animal reproduction must comprise a study of the reproductive capacities of the male and the female, which in turn requires a reference to their generative parts. The outcome is a single, complex argument that consists of a study of generative parts followed by a study of how animals come to be, which first requires us to deal with the moving cause (alias principle) of animal generation:

This is why our argument has put together a unified whole by placing these parts [*sc.* the parts that contribute to generation] last in our account of the parts and placing right after them the principle in the account of generation.<sup>101</sup>

<sup>99</sup> For an introduction to the overall argument and unity of *GA*, I refer the reader to GOTTHELF-FALCON 2017: 16–34 and LEFEBVRE 2017: 35–55. Both articles agree that the five books exhibit a high level of unity. Disagreement is about the details of the argument.

<sup>100</sup> Hereafter I rely on the results achieved in GOTTHELF-FALCON 2017: 16–34. When I depart from those results, I indicate it in an ad hoc footnote.

<sup>101</sup> Aristotle, *GA* I 1, 716a2–4: διόπερ ὁ λόγος εἰς ἓν συνήγαγε, τῶν μὲν περὶ τὰ μόρια τελευταῖα ταῦτα, τῶν δὲ περὶ γενέσεως τὴν ἀρχὴν ἔχομένην τούτων τάξας. The Greek is difficult and is open to more than one reading. I follow the interpretation defended in LEFEBVRE 2017: 47–50.

There are at least two ways to understand this programmatic passage. On a first reading, the two studies outlined correspond to the two main sections of *GA I* – namely, a study of the generative parts (*GA I* 3–16) followed by a study of the moving principle of generation (*GA I* 17–22).<sup>102</sup> As an alternative, the parts that contribute to the generation of animals are not only the non-uniform parts but also semen, menses, and milk. If we adopt this second reading, what Aristotle has in mind when he refers to an account of the generative parts is a fuller account than the one advanced in *GA I*. This fuller account is not over until at least the discussion of milk offered in *GA IV* 8.<sup>103</sup> I adopt this second reading because it has the exegetical advantage of showing that *GA II* is a natural development of a discussion that starts much earlier in *GA I*.<sup>104</sup>

To understand how *GA V* contributes to an account of animal generation, we must place an emphasis on the following (often overlooked) fact: nothing Aristotle says in the first four books establishes that the generative process stops at birth. In fact, this generative process comes to an end only with the coming to be of a mature organism. We can restate this important insight by recalling a well-known Aristotelian dictum: “it takes a human being to generate a human being.”<sup>105</sup> By Aristotle’s lights, generation is a natural and continuous process from two fully developed human beings (the parents) to another fully developed human being. Consequently, the study of generation need not (in fact, cannot) stop at the birth of the offspring but must continue with a logical focus on the mature organism.<sup>106</sup>

If this reading is correct, a first consequence of the initial move – namely, the tripartite observation that many animals come to be from

<sup>102</sup> BALME 1992: 61.

<sup>103</sup> A third reading of how the argument unfolds in the five books of the *GA* is outlined in LEUNISSEN 2017: 56–74 (especially 57–58). She thinks that there is a first strand of investigation (*GA I* 1–II 3) that provides the conceptual framework for what follows. While *GA II* 4–8 covers embryogenesis in the most perfect among the blooded animals (the human being and the four-footed live-bearing animals), *GA III* covers embryogenesis for each of the remaining kinds of animals. On this reading, *GA IV* covers sexual differentiation, heredity, and phenomena surrounding birth.

<sup>104</sup> The view that *GA II* is a new beginning (defended, most notably, in BALME 1992) is rejected in GOTTHELF-FALCON 2017: 22–27. But this article equates generative parts with non-uniform sexual organs. I no longer endorse this equation.

<sup>105</sup> Aristotle, *Phys.* II 1, 193b; II 6, 198a26; III 2, 202a11; *GC* II 6, 333b7; *PA* I 1, 640a25; II 1, 646a33; *GA* II 1, 735a21; *Metaph.* VII 7, 1032a25 and b32; IX 8, 1049b25, XII 3, 1070a8, XIV 5, 1092a16.

<sup>106</sup> Klaus Corcilius has recently argued that *GA V* is better understood as a coda to the main argument than as an integral part of the project (CORCILIOUS 2022: 67–100). To give us an idea of what he means by “coda,” Corcilius refers us to the fourth meaning of the word in Stainer and Barret’s *Dictionary of Musical Terms*: “that closing adjunct of any movement, or piece, especially intended to enforce a feeling of completeness and finality.” His reading occupies a middle position between the view that *GA V* is a self-standing piece (see, e.g., KULLMANN 2021: 124–125) and the view advocated here.

the coupling of a male and a female – is the decision to begin the study of animal generation with an account of the generative parts of the female and the male. Another important consequence of this move is the decision to postpone the explanation of animals that (Aristotle thinks) reproduce spontaneously. This explanation is deferred until the main lines of the account of sexual reproduction are firmly in place. This means that the study of spontaneous generation is given only at the very end of *GA* III (i.e., *GA* III 11). This study is treated as a coda to the main discussion. Along with a few insects, this study attends to the generation of hard-shelled animals and other stationary animals that Aristotle considers close to plants. Finally, it is also important to stress that this study is conducted within the theoretical framework developed for the explanation of sexual generation. Aristotle is quite forthcoming about this aspect of his explanatory strategy at the outset of *GA* I 2:

As for the generation of the other animals [*sc.* those that do not reproduce sexually] we must speak about each of them according to the ongoing argument, *building it from what has been said* [ἀπὸ τῶν εἰρημένων συνείροντος].<sup>107</sup>

This is exactly how Aristotle's argument unfolds in *GA*: it begins with a study of sexual generation and ends with a discussion of the generation of those animals the coming into existence of which is spontaneous. It does not take long to see that this procedure entails a reversal of the explanatory strategy adopted by Aristotle's predecessors. Most of them worked within a cosmogonic framework. It was quite natural for them to take spontaneous generation as their model, and indeed their starting point, for an explanation of how life emerged from the earth. Among other things, this style of explanation had the advantage of relating their explanation to the ancient myths of the autochthonous birth of cultural heroes.<sup>108</sup> By contrast, Aristotle does not believe that life emerged from nonlife. His view is that life is a necessary feature of the natural world order.<sup>109</sup> More to the point: animal life is one of the two basic ways in

<sup>107</sup> Aristotle, *GA* I 1, 716a2–4.

<sup>108</sup> This aspect is explored in CAMPBELL 2014: 233–247. I briefly discussed the role that spontaneous generation plays in the zoogonic account offered by Empedocles in Chapter 1, Section 1.

<sup>109</sup> By Aristotle's lights, the natural world order is necessarily ungenerated and indestructible. The ultimate source of this necessity is metaphysical rather than physical. It can be traced back to the existence of a first unmoved mover that alone secures that the world order cannot be otherwise. Very few, even within the Aristotelian tradition, followed Aristotle on this point. For a review of eternalism in Aristotle and the Aristotelian tradition, see FALCON 2022a: 7–22.

which life necessarily manifests itself here on earth.<sup>110</sup> The only way to explain how animal life perpetuates itself is to start from sexual generation, which becomes the paradigmatic type of animal generation. As a result of this strategy, spontaneous generation is dislocated from the center of the argument of *GA*. It ends up being equivalent to an exception to the rule that must be explained based on the results reached in the study of the central case, namely sexual generation. Beginning an explanation of animal reproduction from spontaneous generation would be equivalent to trying to explain animal life starting from bloodless animals. This would be a complete non-starter for Aristotle.

In *GA* III II spontaneous generation is explained as a two-stage process that is analogous to sexual reproduction. In sexual generation we have a two-stage process: *first* the material principle is formed in the female; *then* it is acted upon by the male principle. In spontaneous generation we have an analogous complex situation. The heat in the surrounding environment, by a process of concoction, produces something analogous to the female residue. In rotting earth or earthy water, we find what Aristotle calls *pneuma*, and in *pneuma* we find vital heat. Whenever some of the latter gets enclosed, it leads to the generation of the animals. The language Aristotle uses to describe this process suggests that the agent is envisioned as an *analogue* to the immediate moving cause in the process of sexual reproduction. Unlike the power transmitted by the male, the vital heat is a non-species-specific potential for life. This means that eventual differences in the outcome cannot depend on differences in the nature of the potential for life. Rather, they depend on differences in the nature of the enclosed material. In the case of the hard-shelled animals produced in the sea, the earthy water of the sea becomes the shell as the result of a process of solidification *analogous* to the one that occurs in the case of bodily materials such as bones and horns.<sup>111</sup>

A third and final consequence of the initial move is the need to understand the respective contribution to the generative process of the male and the female, including the extent to which each contribute seed (σπέρμα).<sup>112</sup> It is quite telling that, already in the opening chapter of *GA*,

<sup>110</sup> The other one is, of course, plant life.

<sup>111</sup> I follow the reading adopted in GOTTHELF 1989: 181–193 (reprinted in GOTTHELF 2012a: 45–66). On spontaneous generation, see also LLOYD 1996d: 104–125; STAVRIANAS 2008: 303–338; WILBERDING 2022: 367–390.

<sup>112</sup> The term “σπέρμα” is ambiguous in *GA*. To begin with, σπέρμα can be used to refer to the spermatid residues produced by both the male and the female. When it is used in this way, σπέρμα can also refer to the menses. But σπέρμα is also used to refer to the exclusive contribution of the male. For a review of the relevant passages, I refer the reader to Connell 2016: 90–120 and LEFEBVRE 2016: 38–45. When σπέρμα is used in the former way, I render it as “seed.” When it

the study of seed is predicted to be of the utmost importance in understanding the distinctive roles of the male and the female in the coming to be of the offspring:

In accordance with what we said, one might posit the male and the female as sources of generation . . . *one would most of all come to believe this if one studied how the seed is produced and from where* [τοῦτο δὲ μάλιστα ἂν τις πιστεύσειε θεωρῶν πῶς γίγνεται τὸ σπέρμα καὶ πόθεν].<sup>113</sup>

In view of this anticipation, it is not surprising to find out that Aristotle turns to the study of seed as soon as he has completed his study of the reproductive parts. The question whether both the male and the female emit seed is linked to the question whether the seed comes away from all the body. Apparently, this thesis was quite widespread in antiquity. It was linked to the view that both the male and female contribute seed (σπέρμα).<sup>114</sup> For Aristotle, disarming the dual-seed theory is equivalent to disarming pangensis and vice versa. This is his first step toward a positive account of the nature of seed, and toward establishing how the male and the female contribute to the generative process.

Aristotle is centrally concerned with these questions in the second part of *GA I* (*GA I*, 17–23). His starting point is to search for the nature of the seed. First, he establishes that the seed is a residue, and then that it is a useful residue at its final stage – blood concocted and somehow particularized. Thereafter Aristotle turns to the female contribution. He establishes that the blood-like secretion produced in the female (the menses or καταμήνια) is a spermatic residue, having its nature because of the colder (and thus weaker in the ability to concoct) character of the female. By Aristotle's lights, the menses are the *matter* from which the offspring will

is used in the latter way, I opt for "semen." The word "σπέρμα" is surely ambiguous at the outset of *GA* given that Aristotle has still to establish how the male and the female contribute to generation. See LEFEBVRE 2016: 36–37. Last but not least, in *GA I* 18, Aristotle uses σπέρμα to refer to the first mixture (the first κύημα) that contains the generative contributions coming from the male and the female principles of generation. While this passage is often considered a possible interpolation, Ignacio De Ribeira Martín defends its authenticity (in DE RIBEIRA 2019: 87–124). Far from creating a textual problem, this apparently anomalous use of the term "σπέρμα" suggests that there is a genuine Aristotelian notion of seed that is common to both animals and plants. This is an important result, indeed a result that is far from obvious, since Aristotle envisions a separate study of animals and plants and programmatically confines himself to the study of animal generation to the exclusion of generation in plants. More on this in Chapter 5, Section 2.2.

<sup>113</sup> Aristotle, *GA I* 1, 716a4–8.

<sup>114</sup> For instance, the Hippocratic author of *On Generation* and *On the Nature of the Child* adopts the view that the seed (γούνη) comes from the seed of each of the two parents (*On Generation* 8), and that the seed is secreted from the whole body (*On Generation* 3). More directly, the seed is drawn from the brain via the spinal marrow (*On Generation* 1).

come into being. It is only at this point that Aristotle turns to the male contribution with the stated goal of establishing what it is. He argues that the male does not contribute any matter but rather an active power or a potential (δύναμις) that is based on certain movements (κινήσεις) conveyed by the semen.<sup>115</sup> Aristotle uses the craft analogy to argue that the male contributes the *form* by means of its role as the source of motion. In those animals that emit semen (σπέρμα), nature uses the latter as a tool just as a craftsman uses specific tools to produce a certain outcome.<sup>116</sup> At this point, the main lines of Aristotle's *reproductive hylomorphism* are in place.<sup>117</sup> More directly, Aristotle adopts hylomorphism in the second part of *GA I* (*GA I* 17–23) to explain the different contribution of the male and the female to generation. While *GA I* is not meant to stand on its own, the book provides us with an explanatory framework to proceed in the actual investigation of animal reproduction as it can be observed in the natural world around us.

### 5.1 *Explanatory Strategies in GA II*

*GA II* is not a fresh start; rather, it is a natural and inevitable continuation of the search for the moving cause of animal generation. Arguably, the first and most important step in this direction is the decision to adopt hylomorphism as the theoretical framework for the explanation of the respective contribution of the male and the female to animal reproduction. But how does sexual reproduction take place in different animals? To answer this question, Aristotle makes a second observation: there is great variation in the degree of completeness (and perfection) of the immediate outcome of the process of coming to be. While some animals produce similar, complete, live young, others give birth to something that is not yet articulated: eggs in the case of blooded animals and grubs in the case of insects. Furthermore, Aristotle traces the variation in the degree of completeness (and perfection) at birth back to the nature of the generative parts: the hotter and moister the nature, the more complete their product at birth.<sup>118</sup> This is our second observation. While the three-part observation made at the outset of *GA* controls the whole argument as it unfolds across

<sup>115</sup> What we observe in the case of certain insects where the male does not insert a part of itself into the female, but the female inserts a part of itself into the male, and the heat and the *dunamis* of the male does the causal work, confirms this suggestion. Compare Aristotle, *GA I* II, 729b22–33.

<sup>116</sup> Aristotle, *GA I* 22, 730b19–23.

<sup>117</sup> I borrow the expression “reproductive hylomorphism” from HENRY 2006: 257–288.

<sup>118</sup> Aristotle, *GA II* I, 732b27–32.

the five books, the second observation shapes and controls the argument in *GA* II and *GA* III. As Aristotle progresses in his explanation of the coming to be of animals beyond the general lines of his reproductive hylomorphism, he must take into account what is specific about the different modes of animal reproduction. In *GA* II I, Aristotle establishes that this study must begin from the live-bearing animals, must continue with the egg-laying animals, and must end with those animals that produce a grub. While a study of reproduction in live-bearing animals is offered in *GA* II, the discussion of the other two modes of reproduction is postponed to *GA* III.

At the outset of *GA* II I, Aristotle finds himself in a situation that is equivalent to the one we have discussed for the collection, presentation, and explanation of the parts of animals (*HA* and *PA*), and the explanation of how animals displace their bodies (*IA*). As soon as Aristotle has observed that there is great variation in the degree of completeness in the outcome of generation, he has no choice but to account for what is specific about the different modes of reproduction. But how does he proceed in the explanation of the different modes of animal reproduction? Where should he start, and more importantly, why? His answers to these questions can be extracted from the following passage:

Now, *we must start first from what is first* [τῶν πρώτων ἀρκτέον πρώτον]. *The perfect animals are first* [ἔστι δὲ τὰ τέλεια ζῶα πρώτα], and such are the live-bearing ones, *and first among them is the human being* [καὶ τούτων ἀνθρώπος πρώτων].<sup>119</sup>

From an operational point of view, the rule of inquiry recalled in this passage requires Aristotle to begin his account of sexual reproduction from the live-bearing animals because they are the most perfect; furthermore, this account must start from the human being because the latter is the most perfect among the live-bearing animals. We find here a version of the methodological insight that requires investigators to start their investigations from the most complex outcome, which in this case is the production of a human being. This mode of procedure can be captured with the help of the following catchphrase: *perfect animals first, and the human beings first*.<sup>120</sup>

*GA* II 4–6 is best described as a study of live-bearing animals via a study of the human being. Aristotle begins his investigation from the results achieved in the general study of generation. He applies those results to the case of the live-bearers. The structure of his explanation remains the same as before: it

<sup>119</sup> Aristotle, *GA* II 4, 737b26–27. The most complex animal is also the one that displays the higher level of organic unity. For more on this idea, see Chapter 1, Section 3.

<sup>120</sup> Mariska Leunissen (in LEUNISSEN 2017: 58–66) comes to a similar conclusion.

moves from the actual parents and their respective roles in the coming to be to the formation of the embryo (and, at least in principle, to everything that follows from there). *GA* II 4 begins with the male and the female contributions as spermatic residues of the nutritive process (with a concentration on the female residue and how it is formed). It continues with the formation of the embryo and, finally, turns to the question of its development. Aristotle calls this process “differentiation” (διάκρισις). He offers an outline of the process: the heart is the first part to be differentiated, and this is clear to both sense-perception and in theory. He adds that the formation of the parts does not happen as some think because the like is carried toward the like. Rather, the female residue has the potential to be acted upon by the male residue, so whenever the two spermatic residues come into contact and the one acts, and the other is acted upon right away. More directly, and more boldly: nothing else is required to explain a complex process such as the differentiation of the parts except the contact of the active and the passive potentials provided, respectively, by the male and the female.

But how does the actual διάκρισις of the body parts take place and why? Aristotle answers this question in *GA* II 6. Right after the heart and the blood vessels that extend from the heart, the upper half of the body appears in outline. The head is formed first, and the brain right after the heart to compensate for the heat of the latter. The eyes come to be early, but they are completed only at a later stage, after the birth of the offspring, due to the nature of their material constitution. The formation of flesh and the other sense-organs uses the purest materials. What remains is earthy, so it is used to produce bones and sinews. The bones are differentiated together with the most important internal parts. Nails and hair (but also hoof, horns, and the spurs of cocks) are formed out of the nourishment taken after birth and not used up for the growth of the other parts. This explains why they, unlike bones, keep growing throughout a lifetime (and even after death). Teeth pose a special difficulty (an *aporia*): they are bone-like, but unlike bones, they are formed after birth. A discussion of this difficulty, including a discussion of why some teeth fall out and grow back, is postponed. A full discussion of teeth is given in the context of the generative processes that take place after birth (*GA* V).

### 5.2 *Explanatory Strategies in GA III*

*GA* II and *GA* III are two parts of a single argument. The observation that there is great variation in offspring made at the beginning of *GA* II provides the platform for a study of what is specific about the different modes of

reproduction. The opening lines of *GA* III establish contact with what has been achieved in the second part of *GA* II; they also announce what is next in the order of explanation:

Now, we have spoken about the infertility of mules and about the animals that bear live young, both outside and inside themselves.<sup>121</sup> As for those blooded animals that produce eggs, in one way the things to do with generation are similar in them and in the land animals, and it is possible to seize upon something that is the same about them all; but in another way they have differences both among themselves and in relation to the land animals.<sup>122</sup>

To appreciate what Aristotle tells us in this passage, we must return to the beginning of *GA* II. After remarking that some animals bear live young while others lay eggs, and yet others produce grubs, he adds:

all the animals that bear young or lay eggs are blooded animals and all the blooded animals either bear live young or lay eggs (if they are not infertile).<sup>123</sup>

If we combine what we are told at the outset of *GA* II with this observation, we obtain the following explanatory strategy: as we proceed in our argument, we must keep in mind that certain facts about the generation of egg-laying animals are not specific to this kind of animals but are shared with live-bearing animals. These facts remain outside the scope of the investigation conducted in *GA* III because they can (indeed should) be explained in common for both live-bearing and egg-laying animals *qua* blooded animals. By contrast, the research focus of *GA* III is on the causes of those facts that *distinguish* the animals that produce eggs from those that bear live young. As we proceed in this way, we must not overlook the differences that exist among the egg-laying animals, so our discussion will also deal with the causes of what distinguishes the animals that lay eggs from each other.

The study of egg-laying animals is conducted in *GA* III 1–8. Aristotle adopts the methodological principle spelled out in *GA* II 4: *first what is first*. He begins his discussion of egg-laying animals with those that lay a perfect (i.e., hard-shelled) egg and continues with those that lay an imperfect egg. The overall explanatory strategy remains the same as in *GA* I and *GA* II. Since we are concerned with a single causal process that can be traced back to the actual parents, our explanation must start from the actual parents.

<sup>121</sup> The discussion of live-bearing animals ends with the discussion of a special problem: the infertility of mules (*GA* II 8).

<sup>122</sup> Aristotle, *GA* III 1, 749b10–15. <sup>123</sup> Aristotle, *GA* II 1, 732b8–9.

What is specific to the mode of reproduction under review is that an egg is produced, so our explanation must include an explanation of the egg. The explanation is given for the perfect egg. This too is a direct consequence of the adoption of the explanatory principle “first what is first.” If there are differences that distinguish the imperfect from the perfect eggs, they will be discussed in connection with the study of the animals that lay imperfect eggs.

The topic of egg-laying animals ends with a discussion of what is specific about the bloodless animals that lay eggs. The soft-bodied animals (the cuttlefish and the other μαλάκικα) and the soft-shelled animals (*karaboi* and creatures akin to them) are discussed in *GA* III 8. *GA* III 9 deals with insects. Most of them produce a grub. This is the third and final mode of sexual reproduction. The grub is regarded as the least complete (i.e., the most undifferentiated) outcome of the mixture of the male and female contribution. So it is described as the first outcome of sexual reproduction.<sup>124</sup> What is distinctive about the production of a grub is discussed in *GA* III 9. The generation of bees poses an *aporia*. With the discussion of this *aporia*, the explanation of sexual generation comes to an end. At this point we have both a general account of how the male and the female contribute to generation, with a concentration of what is specific to each of them (*GA* I and *GA* II 1–3), and a detailed study of what is specific about the different modes of sexual reproduction (*GA* II 4–III 10).

*GA* completes Aristotle’s study of animals for two orders of reasons. To begin with, *GA* offers a much-needed account of animal generation. This account follows a methodological principle that is stated in its clearest form in *PA* I 1:

*We must also consider whether we should follow the procedure of our predecessors, by studying how a thing naturally comes to be rather than how it is [δεῖ δὲ μὴ λεληθέναι καὶ πρότερον προσήκει λέγειν, ὥσπερ οἱ πρότερον ἐποιοῦντο τὴν θεωρίαν, πῶς ἕκαστον γίγνεσθαι πέφυκε μᾶλλον ἢ πῶς ἔστιν]. It matters quite a bit which procedure we follow. . . . In the case of building too, this comes about because the form of a house is of this sort, whereas it is not true that a house is of this sort because this is how it comes to be; the reason is that coming to be is for the sake of being, and not being for the sake of coming to be [ἡ γὰρ γένεσις ἔνεκα τῆς οὐσίας ἐστίν, ἀλλ’ οὐχ ἡ οὐσία ἔνεκα τῆς γενέσεως].*<sup>125</sup>

Here Aristotle outlines an aim for both *PA* and *GA*: while *PA* is concerned with the explanation of why animals have the parts they do, *GA* deals with

<sup>124</sup> DE RIBEIRA 2019: III–II3.

<sup>125</sup> Aristotle, *PA* I 1, 640a10–19.

the process (or processes) by which those parts come to be present in animals. Clearly, the account of the process (or processes) by which these parts come to be present in animals follows in the order of explanation. We first need an understanding of why animals have the parts they do. Hence, *PA* comes before *GA* in the order of study. Moreover, the explanation of the process (or processes) involved in the explanation of animal generation must start from the nature of what is to be produced. Aristotle illustrates this claim with the help of housebuilding. He also supplies a historical example when he recalls how Empedocles explained the formation of the (human) spinal column. Empedocles argued that the vertebrae are formed when the spinal column is twisted as the baby turns in the womb of the mother. Aristotle is not impressed by this explanation. He points out that a spinal column with its distinctive shape and number of vertebrae is already present in the generator (the father). According to Aristotle, it is a mistake to explain the spinal column by focusing on the process of its formation. The explanation of the spinal column must take its lead from the functional role that a fully formed spinal column plays in a fully developed human being. At least for Aristotle, it is because the spinal column is articulated into vertebrae that its formation takes place in the way it does and not vice versa.<sup>126</sup>

But *GA* completes the study of animals for another reason. Recall that the study of generative parts is postponed in *PA*.<sup>127</sup> Aristotle could have spoken about these parts in the context of his official study of body parts. Instead, he decided that it was better and more efficient to explain them in

<sup>126</sup> For a full discussion of this Aristotelian example, see CODE 1997: 127–143. We have independent evidence that Empedocles adopted this genetic approach to the explanation of the human being:

But some doctors and *sophistai* say that it is impossible for anyone to know medicine who does not know what the human being is; anyone who is going to treat patients correctly must, they say learn this. *Their account* [λόγος] *tends toward philosophy* [φιλοσοφία]. *Just like Empedocles or others who have written about nature* [περὶ φύσεως] *from the beginning* [ἐξ ἀρχῆς], *saying what human being is, how it originally came into being, and from what things it was compounded*. But I think that what has been written by a *sophistês* or a doctor on nature pertains less to the art of medicine than to the art of writings. ([Hippocrates] *Ancient Medicine* 20; translation and emphasis mine)

The author of *Ancient Medicine* singles out Empedocles as the most obvious and best-known example of a more general practice shared *by doctors and sophistai alike*. This testimony confirms what we read in Aristotle, who describes a practice universally accepted at the time. According to Aristotle, *all his predecessors* – no one excluded – employed this practice in their attempt to make sense of the world around them. In other words, they all adopted the same style of scientific explanation: For any given *X*, they explained what *X* is by giving an account of how *X* has come into existence.

<sup>127</sup> *PA* IV 4, 678a21–26.

the context of a study of the capacities and functions of the male and the female. Such a study is announced at the outset of *GA*:

*There remain of parts the ones that contribute to generation, about which nothing was delineated earlier* [λοιπὸν δὲ τῶν μὲν μορίων τὰ πρὸς τὴν γένεσιν συντελοῦντα τοῖς ζῴοις περὶ ὧν οὐθὲν διώρισται πρότερον], and in regard to the moving cause, what the source is. To inquire about this cause and about the generation of each animal is in a way the same thing.<sup>128</sup>

*GA* provides the missing study of the generative parts and the study of the moving cause. Both were left out of the study of *PA*. However, the focus on the moving cause is not (and cannot be) regarded as exclusive. The explanatory priority of complete nature over the process (or processes) giving rise to it ensures that a teleological dimension is needed for a scientifically adequate account of the coming to be of any animal. When we take this teleological dimension into account, we see that there is methodological unity across the whole project attempted in *PA* (augmented by *IA*) and *GA*.

## 6 Conclusion

Nothing short of a full-length monograph would do justice to what Aristotle has accomplished in his systematic study of animals. My goal in this chapter was a more modest one. I wanted to give the reader an idea of how this study is guided by certain explanatory and methodological concerns. I reached two main results. I argued that the ὄτι-stage of inquiry as collected in *HA* is shaped by the way in which these explanations are to be offered at the διότι-stage. In this sense, the ὄτι- and the διότι-stage of inquiry are interdependent and complement each other. The second result is that at the pre-explanatory and also at the explanatory stage of inquiry Aristotle follows a definite strategy encapsulated in the catchphrase “*first what is first.*” When we look in detail at how Aristotle proceeds in his practice of scientific explanation, we see that he first identifies a paradigmatic case, which is the most determined and most articulated kind of animal, and then he tries to explain the non-central cases by applying the results achieved in the study of this paradigmatic case. This strategy is implemented by recourse to analogy. I have argued that it comes with some explanatory costs, since significant aspects of the non-paradigmatic cases are not convincingly accounted for.

<sup>128</sup> Aristotle, *GA* I 1, 715a11–14.

Aristotle concentrated on the study of animals to the exclusion of plants. But this does not mean that he was not interested in the study of plants. His scattered remarks on this topic suggest that he was quite knowledgeable about plants.<sup>129</sup> Aristotle thought that a study of plants was best pursued as a *separate* explanatory project. Unfortunately, we no longer have what Aristotle wrote on plants, so we are not in a position to evaluate how he transitioned from the study of animals to the study of plants or how he implemented a systematic study of plants. But we do have an impressive corpus of writings on the topic of plants left by Theophrastus. It is time to turn to these writings. My main goal in the next two chapters is to see whether, and eventually to what extent, the research on plants conducted by Theophrastus is shaped by the explanatory and methodological concerns that animate Aristotle's study of animals.

<sup>129</sup> For a survey of what Aristotle says on the topic of plants, see WÖHRLE 1997: 387–396.