

ARISTOTLE ON “NATURE DOES NOTHING IN VAIN”

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Aristotle’s principle that “nature does nothing in vain” (NDNIV) is central to his teleological approach to understanding organisms. First, we argue that James G. Lennox’s influential account of NDNIV is unsuccessful. Second, we propose an alternative account that includes a natural state model. According to a natural state model of development, an organism will develop toward its natural state unless interfering forces prevent that from happening. Third, we argue that this account also fits Aristotle’s discussion in the *Generation of Animals* and can explain monstrosities in nature that at first sight seem to be counterexamples to NDNIV. Fourth, we take a broader look at NDNIV, arguing that it does not entail that all structures are teleological (since it accommodates the thought that by-products and some neglected items that Aristotle calls “tokens” are nonteleological), that it does not entail that there is only one function per organ, that NDNIV is not an anthropocentric principle, and that, perhaps surprisingly, the teleological structures of an organism can benefit others apart from the organism and its progeny. Finally, we argue that Aristotle endorsed an empirical justification of NDNIV wherein the principle is justified by its many successful applications.

1. The Nature-Does-Nothing-in-Vain Principle and the Natural State Model

Aristotle’s principle that “nature does nothing in vain” (NDNIV) is central to his teleological approach to understanding organisms.¹ According to Aristotle,

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1. Aristotle uses the verb ποιῆν rather than πράττειν. Elsewhere, Aristotle sharply distinguishes making (ποίησις) and doing (or acting, πράξις; e.g., *Nicomachean Ethics* VI 4 1140a2–3). The former

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not only is the principle based on what we “see,” but it is justified even though we see that many things in nature go awry. A main theme of this article is that the most charitable interpretation of Aristotle’s principle, and one that is consistent with the texts,² is that he is using a natural state model to explain variation in nature. According to a natural state model of development, an organism will develop toward its natural state unless interfering forces prevent that from happening. It is no counterexample to this model if organisms fail to actually attain their natural states (Sober 1980). Failures may happen *in* nature (that is, in the spatiotemporal course of events), but it is still true, to use Aristotle’s own phrase, that organisms *by* nature will reach their natural state if there are no interfering forces. It is in their nature to do so.

In what follows, we discuss James G. Lennox’s classic paper “Nature Does Nothing in Vain . . .” (1997/2001b),³ in which he argues that there are two versions of the principle, one of which explains why animals have certain parts and one of which explains why they lack certain parts. We agree that Aristotle intends to explain both, but we suggest that NDNIV is better represented as a single principle that differs from both of Lennox’s versions, from which both applications follow.

Although Aristotle expresses his own view using different locutions in different places, from a logical point of view there is a single biconditional that captures what Aristotle is saying:

PROPOSITION 1. Organism O has trait or structure X by nature if and only if X is not in vain for O.⁴

Proposition 1 entails both (a) if X is in vain for O, then O does not have X by nature, and (b) if X is not in vain for O, then O has X by nature. Traits that are neutral and traits that are deleterious both count as “in vain,” for Aristotle.

Proposition 1 leaves open what “O has trait or structure X by nature” means. It is here that the natural state model plays its role. As already mentioned, Aristotle’s natural state model begins with the idea that organism O has trait or structure X by nature if and only if O develops X when its development is unimpeded by interfering forces, but there is more to Aristotle’s model than this. There is the additional, and all-important, teleological idea that the natural

is a process toward a goal rather than an activity with an intrinsic goal and so may be more apt for use in Aristotle’s principle.

2. It is not the aim of this article to show that all alternatives must be wrong.

3. Page references in what follows are to the latest (2001) versions of Lennox’s papers.

4. We refer to “traits and structures” as opposed to “parts” so as to avoid metaphysical difficulties in Aristotle’s own account that are beyond the scope of this article. We also do not want to prejudge the issues raised in secs. 4 and 9.

state of an organism includes those features that would be best for the organism to have, given the kind of organism it is. A fuller statement of Aristotle's natural state model is this:

PROPOSITION 2. Organism O has trait or structure X by nature if and only if O will develop X if its development is unimpeded and X is the best trait (among the alternatives) for O to have, given the kind of organism that O is.⁵

Newton was using a natural state model when he said that objects continue to move in a straight line unless an external force acts on them (Sober 1980). However, this is not teleological; Newton's laws of motion say nothing about what would be good for a planet or a billiard ball. Proposition 2 implements the natural state model by taking that further step.

This teleological element in the natural state model is something that Aristotle asserts in *De anima* (*de An.*), when he discusses the fact that animals need sense perception. He says that "everything that is by nature is for the sake of something" (*de An.* I 12 434a30–32). The nature of an organism aims at what is best for it.⁶ As Lennox says, of the passages he discusses "the range of possibilities is represented by the generic features of the most extensive kind to which an animal belongs. Each formal nature does what is best, within that range of possibilities represented by its wider kind(s).⁷ Among these 'generic' restrictions are those related to the kinds and quantities of materials the formal nature is provided to work with in achieving the good" (2001b, 207).⁸ And there is also an important passage at the beginning of the *Parts of Animals* (*PA*) in which Aristotle says that "nature does everything for the sake of something." At the beginning of the next paragraph, Aristotle describes the natural state model: "We say 'this is for the sake of that' whenever there appears to be some end towards which the change proceeds if nothing impedes it. So it is apparent that there is something of this sort, which is precisely what we call a nature" (*PA* I 1 641b12–26; Lennox 2002).

5. Lennox (2001b, 207) briefly describes the idea that natural states are the ones that organisms have when there is no interference with their development, but he does not explore the work this model does in connection with NDNIV.

6. For the qualification to this account and for more on this passage, see sec. 5. Henry (2013, 230) argues that the NDNIV is an optimizing principle, but he does not invoke the natural state model in his paper.

7. For the purposes of this article, we accept Lennox's interpretation of formal nature, although there are problems with Aristotle's metaphysical distinction between form and matter, which we mention occasionally in footnotes. Aristotle's general metaphysics is beyond the scope of this article.

8. In secs. 7 and 8 we take up the further question, good for whom?

There is another passage, this one from *Progression of Animals* (*IA* 704b11–17), in which Aristotle brings teleology and essentialism together: “We must begin our inquiry by assuming the principles which we are frequently accustomed to employ in natural investigation, namely, by accepting as true what occurs in accordance with these principles in all works of nature. One of these principles is nature does nothing in vain, but always what is best in view of the possibilities allowed by the essence of each kind of animal; therefore, if it is better to do a thing in a particular manner, it is also in accordance with nature” (Peck and Forster 1937, slightly revised). It is from passages like this one that we extract our propositions 1 and 2.

Aristotle discusses his NDNIV principle most often in his biological works, especially in the *Parts of Animals* (*PA*), the *Progression of Animals* (*IA*), the *Generation of Animals* (*GA*), and, with a qualification we will discuss in section 5, in his work on the psyche, *De anima* (*de An.*). In what follows we concentrate on the way in which the principle is used in Aristotle’s biology, though we also consider what Aristotle says in the *Politics* (*Pol.*) and *Meteorologica* (*Mete.*). In casting our net widely, we are following a tradition of commentators who have discussed NDNIV as it appears in many of Aristotle’s works.⁹

Aristotle’s first allusion to teleology in nature comes in his earliest work *Protrepticus* (*Protr.*) and foreshadows what is to come (*Protr.* 9; Hutchinson and Johnson 2013). Not only does Aristotle relate teleology to aesthetics (see our sec. 3); he also provides a biological example of teleology and notes the way in which teleology is “seen” in nature:

[14] For we should take the position that everything that comes into being correctly comes into being for the sake of something. [15] And surely if beautifully, then correctly; and everything that comes to be (or has come to be) in accordance with nature at any rate comes to be (or has come to be) beautifully, since what is unnatural is ugly, and a natural coming into being comes to be for the sake of something. [50.12–19] And someone could see (ἴδου) this also from each of our parts; if, for example, you were to inspect (κατανοοῖς) the eyelid, you would see (ἴδοις) that it has come to be not in vain but in order to help the eyes, so as to provide them with rest and prevent things from falling into the eye. (*Protr.* 9; Hutchinson and Johnson 2013)¹⁰

9. We are not arguing for any particular chronology, but our discussion is compatible with the traditional chronology of Aristotle’s works.

10. On the authenticity of this passage, see Hutchinson and Johnson (2005, 258–62).

At this stage, the example of the eyelid is a simple one. In his later *Parts of Animals*, Aristotle explains why eyelids are needed in some animals but not in those that have hard eyes or live in water (e.g. *PA* II 13 657b30–658a3, 658a7–10). And Aristotle again says that we see teleology in nature. Section 10 of the current article addresses possible ways in which Aristotle seeks to justify NDNIV, paying special attention to Aristotle’s claim in his *Generation of Animals* that the principle is based on what we see.

The plan of the current article is as follows: after discussing Lennox’s two-part account of what NDNIV means (sec. 2), we discuss Aristotle’s application of NDNIV to passages in the *Generation of Animals* (sec. 3) and show how monstrosities are not counterexamples to NDNIV when NDNIV is understood as including a natural state model (sec. 5). We also discuss NDNIV more broadly. We analyze the relationship between structure, function, and benefit on Aristotle’s account. For example, are all structures teleological according to Aristotle? Here we discuss trade-offs, by-products, and some neglected items that Aristotle calls “tokens” (sec. 4). How does the NDNIV principle relate to Aristotle’s views on whether a structure can have multiple functions or no function at all (sec. 6)? Moreover, if structures are for the sake of something, who or what is that something? Must the function of a part of an organism be to provide a benefit to the organism itself or its progeny? Can a structure found in one organism have the function of benefiting other organisms in the same species or individuals in a different species (sec. 7)? And is Aristotle’s teleological view of nature anthropomorphic, with every organism having functions that promote human well-being (sec. 8)? Does NDNIV extend to the elements (sec. 9)?¹¹ And what is the justification of the principle (sec. 10)?

2. Lennox’s Account of NDNIV

In his classic paper, Lennox (2001b, 220 nn. 3–4) gives an account of Aristotle’s principle that nature does nothing in vain. He distinguishes two things:

(NP) Nature does nothing in vain or superfluous

and

11. Whether the principle can be extended to include seasonal phenomena, planets, and so forth is beyond the scope of this article, although it is reasonable to suppose that the natural state model and Aristotle’s view of order (*taxis*) play important roles here too, even where the teleology is thin. For discussions of teleology for the stars, see Leunissen (2010, 168–74). On seasonal phenomena, see Scharle (2008). For a broad overview, see Matthen (2009). In the following, we accept a naturalistic reading of Aristotle’s principle according to which nature is no grand designer. Compare Broadie (1990).

(NP*) Nature does nothing in vain and it does what is best (for the being of each kind of animal) given the possibilities.¹²

Lennox writes, “In general, while NP is used to explain the absence of a possible feature, the positive content of NP* is used to explain a trait’s presence” (215).

Lennox spells out the relationship between NP and NP* more fully in his footnote 4: “In the biological explanations we will be studying, the principle that nature does nothing in vain or superfluous is often used without the added positive assertion that it does what is best, given the possibilities. I will use NP to designate the negative assertion, and NP* to designate the combined assertion” (2001b, 220 n. 4). He then repeats his earlier point: “It is noteworthy that NP is used on its own to explain the *absence* of features for one reason or another thought to need explanation, while, as the last sentence in the passage we are about to discuss, NP* is typically, though not invariably, used when a part is shown to be present because it is better that the animal have it.”

Although Lennox’s NP mentions both “in vain” and “superfluous,” we think this is redundant, as superfluous traits are in vain. As mentioned earlier, we take “in vain” to cover both neutral and deleterious traits. Given this, NP is entailed by NP*. If so, it is unclear why NP* cannot explain both absences as well as presences, and, in fact, it does so in a passage that Lennox himself cites from the *Progression of Animals*, which Ross (1924, 124) considered an appendix to the *Parts of Animals*. In this passage, Aristotle uses the exact locution of NP*. Lennox translates the passage as follows: “The cause of footlessness in snakes is *both* that nature does nothing in vain, but in every case attends to what is best for each thing among the possibilities, preserving the proper substantial being of each, and its essence; and *further*, and as we’ve stated previously, none of the blooded animals can move by means of more than four points” (*IA* 8 708a9–13; Lennox’s emphasis). Lennox (2001b, 218) concludes that “NP* is here stated in full form, and is cited as part of a complex cause of the lack of limbs in snakes, the other part being the principle that restricts the blooded animals to four limbs.”

The assertion that NP and NP* have separate uses involves an inconsistency, then, since the surface grammar of the two claims and the fact that superfluous traits are in vain make it obvious that the first is a consequence of the second.

12. This does not rule out the existence of other explanatory principles (see, e.g., Lennox 2001b, 220 n. 3).

This logical relationship suggests that the second proposition explains whatever the first does. We note, finally, that Lennox's NP and NP* do not explicate what Aristotle means by "nature does nothing in vain," as each uses the very locution that requires clarification. For all these reasons, we suggest that our proposition 1, when fleshed out in terms of Aristotle's natural state model (proposition 2), is a better explication of NDNIV. These two principles are logically independent of each other, and together they explain both why some traits are present and why others are absent.¹³

3. Aristotle's Use of the NDNIV Principle

Aristotle generally uses the NDNIV principle in comparative contexts. It is noteworthy that Aristotle's comparisons are almost always with other existing animals, not with animals that are purely imaginary.¹⁴ Since other animals have feet, why do fish not have them, and since other animals do not have fins, why do fish have them? The Aristotelian scientist, like Darwin later, is mostly interested in differences between actual kinds of animals. Why is it, he wonders, that the basic functions of living beings, nutrition, locomotion, sense perception, and so forth, are carried out in myriad ways in the animal world? Why does the elephant have a trunk when no other animals do? Why do humans use their teeth, lips, and tongue for speech, when no other animals do? Why is there such variation?

Aristotle's answer is that nature does nothing in vain. As Lennox points out, this cannot mean that some Platonic demiurge is at work. Instead, in Lennox's interpretation of Aristotle, it is the formal nature of the animal in question that does nothing in vain, making use of the materials at hand. For example, in a horned animal, according to Lennox (1997/2001a, 191), it is "the nutritive actions of the animal's soul" that make its earthen nutrients move upward to form horns. "The nature making use of this material . . . is the formal nature of the animal in question—the causal agent dynamically producing and maintaining the composite substance."

13. An anonymous referee has suggested that Lennox's principle should be glossed as follows: "NP: For all F, S has F if and only if S serves a function; NP*: For all F, S has F only if F is the best way possible for S to realize a given function." We do not think that this is what Lennox says, but it is worth considering in its own right. The first problem is that it leaves it open what "function" means. There are many understandings of this concept that are not Aristotelian (see, e.g., Ariew, Cummins, and Perlman 2002). The second problem is that it fails to commit to the use of a natural state model, which we think is central to Aristotle's principle.

14. The exception in such comparisons is the "backwards-grazing oxen" of *PA* II 16 659a17–20, which are mythical creatures.

Two central examples of the NDNIV principle in the *Generation of Animals* relate to the orderly development of an animal. “As nature does nothing that is in vain or superfluous (περίεργον), it is plain that she will not do anything too late or too soon, for in that case what came about would be in vain or superfluous. Therefore the separation of the eyelids and the capability to move them must occur at the same time” (GA II 6 744a37–b2). In order for nature to do nothing in vain, the process must take place in a particular order at the appropriate time.

Aristotle makes a similar point about the formation of sinews and bones with the materials, time, and place that are natural (GA II 6 743a25). He also argues that reproductive organs, capacities, and residues are formed at the same time “because it is better thus,” as it is with all organs (GA IV 1 766a5–10), and he notes that milk is formed in the mother at the right time (GA IV 8 776a15–17).¹⁵ Aristotle also explains how the natural development of an animal continues after birth and must also take place in an orderly fashion. For example, once the period of suckling is over, an animal needs teeth to eat. Here again, according to Aristotle, “nature does nothing in vain in respect of the things that are possible in every case” (GA V 8 788b22–23), and the teeth are formed in an orderly fashion. Aristotle argues that if, as Democritus claims, the teeth were formed only at maturity (and thus too late), nature would be defaulting on one of the things it is possible for her to do.

Therefore, in the *Generation of Animals*, it is clear that NDNIV is true because the natural development of an animal proceeds in an orderly and timely fashion, just as the making of an artifact or the unfolding of a drama proceeds in an orderly way, absent interfering forces. Aristotle is using a natural state model.

In his *Poetics* (7 1450a31–36), Aristotle argues that a beautiful theatrical plot is like a beautiful animal; its parts must be arranged in an orderly fashion and it must be the right size. The analogy can be taken in two different ways. First, there is an analogy between the plot of the play and the adult animal that has its parts arranged in the right order and also that is of the right size. Second, there is an analogy between the unfolding plot of the play and the process of the animal’s development, which is orderly and takes a particular amount of time. In the case of a tragedy, the playwright writes the plot before it is enacted on stage. In the case of an animal, no one has written any plot, but because of its essential nature, the animal will develop in an orderly way, and this

15. The discussion is reminiscent of Aristotle’s view in his *Nicomachean Ethics* (e.g., II 6 1106b21–22) that the good person must do the appropriate things at the appropriate times and so on.

is what occurs if its development is unimpeded. The analogy fits both Aristotle's discussion of the parts of animals and his discussion of the generation of animals.

Another of Aristotle's examples in the *Generation of Animals* relates to the idea that there could be superfluous *activities*. Aristotle says that "nature does nothing superfluous (περίεργον, extra work)" and supports this by pointing out that the female does not need to emit semen if the male does so, because if the uterus emitted any semen outside itself, it would have to be drawn back in again (*GA* II 4 739b18–20). The idea is that natural processes do not involve superfluous steps, but whether a process is needed in the first place may depend on a process in another animal that occurs simultaneously. Here, NDNIV applies to processes as well as to parts, which is an extension of the principle.

Aristotle also expands the application of NDNIV by arguing that in animals where male and female are separate the female cannot reproduce alone, for otherwise the male would be in vain. Aristotle asserts this even though he acknowledges reports that there are species of fish that have females that reproduce on their own (*GA* II 5 741a33–b5). Aristotle is not quite convinced by this fishy report, but he takes it seriously enough for discussion. Aristotle returns to this issue later in relation to birds: "If there were no such thing as a male in the genus of birds, the egg would have been formed as it is in fishes, supposing there really is some species which generates without the male; though I mentioned earlier in this connection that this has not yet been sufficiently observed. Actually, however, both male and female exist in all birds" (*GA* III 7 757b20–24; Peck 1942). If, as Aristotle claims, the male contributes sensory soul, and the female only nutritive soul, she should not be able to reproduce another animal by herself, since sense perception is the defining feature of an animal. But then no animals should be able to generate spontaneously either, as Aristotle claims.¹⁶

While this discussion includes a comparison of different types of animals, as in the *Parts of Animals*, Aristotle is not explaining why an animal of a certain kind has a particular part but why at least some animal species need both male and female. Here we see Aristotle's NDNIV deployed to explain a polymorphism.

16. See, e.g., *GA* III 11 and *History of Animals* [*HA*] V 15. Johnson (2012) ingeniously argues that Aristotle almost foresaw abiogenesis. Just as someone may spontaneously recover health without the aid of a physician, as the ancient physicians already knew, so it is possible for spontaneous generation of an animal to be produced by heat, with the form of the animal largely determined by the matter.

4. Does NDNIV Entail That All Structures Are Teleological?

Nature presumably is not acting in vain when some properties compensate for others—for example, when trade-offs are necessary between having eyes that are hard for protection and fluid for better vision (*PA* II 13 657a30–35). Another example is the positioning of the windpipe in front of the esophagus in some animals, which needs to be righted by extra structures, in this case, the epiglottis (*PA* III 3 664b20–665a22).

One might think that Aristotle holds that absolutely everything in nature is for something, like the much-lampooned Dr. Pangloss in Voltaire's *Candide* who thought that everything was for the sake of something in this best of all possible worlds.¹⁷ That is not Aristotle's view. In his *De anima*, Aristotle is circumspect in his comments about natural objects and processes. He says, "For everything in nature exists for the sake of something or will be an accident of those things which are for the sake of something" (*de An.* III 12 434a31–2; Hamlyn 1993). The second disjunct is highly significant. There are things that are not for the sake of anything—for example, residues (leftover materials)—but are by-products of teleological processes. Sometimes the residues find a new use, but this is not always the case. As Aristotle says, the bile around the liver is a residue and is not for the sake of anything: "Now sometimes even nature makes use of residues for some benefit, yet it is not on this account necessary to seek what something is for in every case; on the contrary, when certain things are such as they are, many other things happen from necessity" (*PA* IV 2 677a16–18; Lennox 2002). Aristotle's distinction foreshadows the separation of "selection for" from "selection of" in the case of natural selection. Traits can be present because of natural selection even though there is no selection for having those traits. There is "selection of" by-products. For example, in the lineage leading to present-day mammals, there was selection of red blood, but there was no selection for redness (Sober 1984, 99–100).

On Aristotle's account, an item that is a by-product or structure can gain a new use.¹⁸ For example, excess matter is put to extra use in the horns of horned animals. And the parts of an animal may gain new functions, as with human teeth, which are used for cutting up food and for speech. Humans therefore have advantages over other animals, but, presumably, the lack of these advan-

17. On this problem in a modern context, see Gould and Lewontin (1979) and Sober (1985).

18. Leunissen (2010, esp. 18–19, 85–99) refers to these as cases of "secondary teleological causation," although her analysis of three different types of secondary teleology is controversial.

tages in other animals does not mean that nature in their case has acted in vain.¹⁹ Perhaps this is the explanation of Aristotle's distinction between parts that are not just for the sake of something but are also for the well-being of an animal (*de An.* III 435b19–21). What is best may cover what is adequate and what is really best.

The idea that an existing structure may gain a new use can also be found in Darwin. Darwin argued that skull sutures in mammals do not exist to facilitate live birth but that the sutures in fact do facilitate live birth. His idea is that skull sutures were present before live birth evolved (Sober 2011, 38–39): “The sutures in the skulls of young mammals have been advanced as a beautiful adaptation for aiding parturition, and no doubt they facilitate, or may be indispensable for this act; but as sutures occur in the skulls of young birds and reptiles, which have only to escape from a broken egg, we may infer that this structure has arisen from the laws of growth, and has been taken advantage of in the parturition of the higher animals” (Darwin 1859, 197). Similarly, Darwin says that lungs evolved from the swim bladder (190). If the swim bladder is a structure that had one function (flotation) and now is used for a new function (respiration), this would parallel Aristotle's discussion of human teeth, although Darwin is here using a theory of evolution that Aristotle does not hold.

Aristotle also notes that some structures in animals have no functional role at all. For example, there are livers in some animals that are too small to perform any function (*PA* III 7 669b25–32) and tail stubs in some animals (*PA* IV 10 689b3–6; cf. those of some apes in *HA* II 8 502b21–23). Aristotle says that these are there merely “by way of a token” (or sign [σημείον]). Aristotle's explanation is unclear, but perhaps these structures point to the characteristics of the larger grouping to which these animals belong (*PA* IV 10 689b2–6).²⁰ In the other animals, these structures do have a functional role. Aristotle could not have known how these observations would eventually support Darwin's very different theory, in which these tokens are vestiges of functional structures found in ancestors. This is why human beings have tailbones.

19. See, too, Polansky (2007, 508–9) on why stationary animals do not have locomotion (*de An.* III 9 432b19–26).

20. Ross's (1924, 127) explanation, that, according to Aristotle, these structures “indicate the normal though in such cases unfulfilled intention of nature,” seems too strong, although what is best for such creatures is surely limited by their size and other features. (Ross's use of “intention” is metaphorical.)

According to Aristotle, then, not all biological phenomena are teleological, but by-products and other nonteleological structures are parasitic on teleological phenomena.²¹

5. The Role of the Natural State Model in the NDNIV Principle

The previous section shows that Aristotelian teleology is complicated. Even if nature does nothing in vain, that does not rule out the existence of by-products and structures that by themselves have no teleological role. In addition, while nature does nothing in vain, biological processes may sometimes fail to be successful. In the *De anima*, Aristotle comments that “nature does nothing in vain and never fails in anything that is necessary except in case of maimed and imperfect animals” (*de An.* III 9 432b21–23). This is an odd way to present the principle, since it makes NDNIV sound vacuous—it seems to say that nature does nothing in vain except when it does. As we will see, there are two ways of understanding the principle, but the one that uses the natural state model provides the more plausible interpretation of NDNIV and the best explanation of Aristotle’s discussion of monstrosities.

Although Aristotle mentions monstrosities in other works, the *Generation of Animals* IV 4 provides his most detailed discussion. Some monstrosities (τέρατα), Aristotle says, are not monstrosities at all but just resemblances. Aristotle explains that people say that a calf has a child’s head, when in fact the calf’s head merely resembles that of a child. No more than resemblance is at issue here, according to Aristotle, because it is not possible for a creature of one species to be born with the head of a creature of a different species if the gestation periods of the two kinds of creature are different (*GA* IV 4 769b16–26). However, Aristotle does give examples of animals born with too many or too few limbs or without organs that they should have. Aristotle thinks that monstrosities occur more often in animals that bear numerous young because the numerous offspring impede each other’s development (*GA* IV 4 770b25–27). In other words, the young fail to develop correctly because of interfering forces. Their natures

21. Here again we see a parallel with Darwin (1859, 206), who says, “It is generally acknowledged that all organic beings have been formed on two great laws—Unity of Type, and Conditions of Existence. . . . On my theory, unity of type is explained by unity of descent. The expression of conditions of existence . . . is fully embraced by the principle of natural selection. For natural selection acts by either now adapting the varying parts of each being to its organic and inorganic conditions of life; or by having adapted them during long-past periods of time. . . . Hence, in fact, the law of Conditions of Existence is the higher law; as it includes, through the inheritance of former adaptations, that of Unity of Type.” Whereas Aristotle thinks that traits that are useless for an organism are to be explained by their connection to other traits in the same organism that are beneficial, Darwin introduces a temporal dimension and proposes that traits that are now useless are present because they once were beneficial.

have been thwarted. Aristotle is more precise in the following passage about what this means: “A monstrosity, of course, belongs to the things that are contrary to nature, but not contrary to all of nature but that which is for the most part. For nothing comes about contrary to nature that is always and by necessity, but only among those things that happen thus for the most part, and can also happen otherwise” (*GA* IV 4 770b9–13). Aristotle goes on to explain that things that occur contrary to the natural order (τᾶξις) are not simply by chance. He concludes that things that are contrary to nature are in a way in accordance with nature, whenever the formal nature fails to master the material nature (*GA* IV 4 770b13–17). The whiff of vacuity that attaches to the claim that nature does nothing in vain except in the case of monstrosities can be dispelled if what Aristotle has in mind is that there may be monstrosities *in nature* (that is, to use modern terminology, in the flow of spatiotemporal events) while at the same time it is true that, *by nature*,²² animals will reach their natural state if there are no interfering forces.²³ According to one reading, the NDNIV principle describes what happens by nature; according to the other, it refers to what happens in the course of nature (i.e., in the realm of spatiotemporal events). The former reading provides a more plausible interpretation of Aristotle’s view and is the one presented in our analysis of NDNIV.

6. Does NDNIV Entail That There Should Be Only One Function for Each Organ?

One might think that the principle that nature does nothing in vain means that if a single organ can serve multiple functions then it is “in vain” to have distinct organs, each with a single function. This is exactly how Aristotle describes organs in the bulk of his biological works. There are many organs described in the *Parts of Animals* that have more than one function. In the case of the hand, Aristotle comments as follows: “The hand would seem to be not one instrument, but many; indeed it is, as it were, an instrument for instruments. . . . For the hand becomes a talon, hoof, horn, spear, sword, and any other weapon or instrument,²⁴—it will be all these thanks to its ability to grasp and hold them

22. “By nature” (φύσει) is an Aristotelian locution. For example, according to Aristotle in the *Topics* (V 5 134a29–30, 134b5–7), humans are by nature bipeds even though a particular human may lack two legs. However, “biped” here is a distinctive property of human being. Its relationship to the formal nature of human being is not discussed in the *Topics*.

23. This should not be taken to mean that “interfering” forces are always negative. According to Aristotle, sometimes interfering forces may have positive results, as in the development of females necessary for the continuation of many species.

24. This is probably Aristotle’s way of saying that the same structure has many functions, not that there are many structures with different functions.

all. And for this the form of the hand has been adapted by nature” (*PA* IV 10 687a20–687b7; Lennox 2002). In human beings, the lips protect the teeth and are also used for speech: “In the other animals the nature of the lips is for the preservation and protection of the teeth. That is why, as they have either precise and beautiful teeth or the opposite, so too do they have the lips differentiated. But human beings have lips which are soft, fleshy and capable of separation, both for the sake of protecting the teeth (as the others do) and even more on account of the good (διὰ τὸ εὖ); for these can also be used for speech” (*PA* II 16 659b 28–33; Lennox 2002). The tongue also discriminates flavors and facilitates speech (*PA* II 16 660a1). And the mouth combines different roles in different species: “All those animals that breathe and cool themselves from outside have the nature of the mouth both for the sake of those functions and for respiration besides. For nature, in virtue of itself, as we just said, puts the parts of all animals to many distinctive uses, for example, in the case of the mouth nourishment is common to all, while strength is distinctive to some and speech to others, and again breathing is not common to all. But nature has collected these uses together in one, producing a differentiation of this part for the differences of its operation” (*PA* III 1 662a16–24; Lennox 2002). Tails too have a combination of functions (*PA* IV 10 690a2–4), and the elephant’s trunk serves as both a long nostril and a hand (*PA* II 16 658a33–659a37).

However, in the *Politics*, Aristotle formulates a new principle apparently at odds with the examples just mentioned: “Nature makes nothing in a miserly spirit, as smiths do when they make the Delphic knife to serve a number of purposes: she makes each separate thing for a separate end; and she does so because the instrument is most perfectly made when it serves a single purpose and not a variety of purposes” (*Pol.* I 2 1252b1–5; Barker 1995). The sentiment that nature does not make the equivalent of Swiss army knives when separate instruments will do just as well is echoed in the *Parts of Animals* where Aristotle says that nature eschews the kind of multipurpose military equipment that is cheap to make: “And it is better, where possible, not to have the same instrument for dissimilar uses, but rather the defensive one most sharp, and the one that is to be a tongue spongy and able to draw in nourishment. For where it is possible for two things to be used for two functions without impeding each other, nature is unaccustomed to making things as does the coppersmith who, to economize, makes a spit-and-lampstand.” However, Aristotle immediately adds the following proviso: “But where this is not possible, nature makes use of the same thing for multiple functions” (*PA* IV 6 683a19–26; Lennox 2002). Yet, this does not seem to cover the first examples we discussed.

In Aristotle’s account, then, sometimes an organ has a single function and sometimes it has multiple functions. Indeed, sometimes a system of organs is

needed for a certain function. For example, a system of bones is needed, not an isolated bone (*PA* II 9 654a32–654b18). Aristotle's account, then, is more flexible than the passage in the *Politics* suggests. Nature does what is needed in each situation.

7. According to NDNIV, Can the Traits of One Organism Be for the Benefit of Others?

Does the NDNIV principle entail that an organism will have characteristics that confer benefits only on itself unless there are interfering forces in its development? For example, if elephants have trunks by nature, does this mean that trunks are useful solely for the elephants that have them?²⁵ Can particular animals of a certain kind have traits that, by nature, confer benefits on others? And is it the function of those traits to confer such benefits?

As we have seen, Aristotle argues that an organism may have characteristics that confer benefits on its young. Milk is formed in the mother at the right time to nurture the child (*GA* IV 8 776a15–17).²⁶ However, it is controversial whether the NDNIV principle extends further.²⁷ On the face of it, a passage in the *Parts of Animals* suggests that an organism can have a trait or structure whose function is to aid a conspecific that is not its offspring and even to have the function of benefiting organisms in another species. According to Aristotle, dolphins and selachians (especially sharks) are particularly greedy, but nature has found a way to remedy that deficiency and also to benefit their prey:

25. On the organs and other parts being good for the animal, see Cooper (1987, esp. 251). Gotthelf (2012, 47) argues that good is not part of what it is to be a goal, but he still agrees that the goal is good. See, too, sec. 8 below.

26. One might argue that this presents problems for Aristotle's metaphysics. If it is part of the mother's formal nature to be capable of producing milk, then male and female have different formal natures. If this is so, it would seem to contradict Aristotle's view that male and female are mere accidents of their species (*Metaphysics* [*Metaph.*] X 9) and so will not have distinct forms. If, on the other hand, male and female have the same formal nature and different material nature, then it must be material nature that here does nothing in vain. However, Aristotle does not appear to accept the latter view since he elsewhere explains that while it is in the nature of male and female deer to have horns (antlers), female deer lack them because they would be both useless and harmful to the females (*PA* III 2 664a5–8; cf. Grene 1963, 145–48). This is not a merely material explanation for the difference, since it mentions usefulness. The case of male and female was discussed above.

27. Darwin (1859, 205) thought that his own theory would be disproved if organisms had traits whose only benefit fell on individuals in other species: "Natural selection can produce nothing in one species for the exclusive good or injury of another; though it may well produce parts, organs, and excretions highly useful or even indispensable, or again highly injurious to another species, but in all cases at the same time useful to the possessor."

Fish also differ in respect of the mouth. In some the mouth is placed straight across, and towards the front, but in others on the underside, e.g., the dolphins and selachians; and they turn belly up to seize their nourishment. And nature *appears* to do this not only for the sake of the preservation of the other animals (for during the turn the other animals escape, because of the delay; for all such creatures are carnivorous), but also in order that they do not follow their gluttonous ways regarding nourishment; for if they could grasp it easily, they would be destroyed owing to being quickly sated. And in addition to these reasons, the nature of the snout, being curved and narrow, is unable to open widely. (*PA* IV 13 696b24–35; Lennox 2002)

Lennox mentions this as a “problematic passage.” Although he does not think the point is decisive, he argues that the word “appears” (our emphasis above) can be read to mean that this is not really the case (Lennox 2001a, 199). He concludes as follows: “Given that the overwhelming preponderance of passages in *PA* II–IV tell against supposing that ‘nature’ here refers to a cosmic nature designing one animal one way in order to help other animals escape, and given the many reasons to doubt that Aristotle takes the proffered explanation seriously, this passage cannot be used as a serious piece of evidence against taking nature in *PA* II–IV as I have been suggesting” (199).

Lennox’s worry about “cosmic nature” seems out of place.²⁸ Nothing in this passage suggests that the nature of dolphins and sharks fails to explain their turning on their backs while eating; Aristotle says they do this to remedy a defect in their anatomy that makes the fish greedy.²⁹ This may also benefit other prey, but that is a by-product of the procedure, as explained in section 5. In saying this, we are not attributing to Aristotle the idea that there is a “cosmic nature” that makes everything in nature fit together to preserve the entirety. Rather, we are saying that Aristotle is prepared to claim that it is sometimes in the nature of members of one species to have traits or structures that happen to benefit the members of some other species. We also note that Johnson (2005, 208–9) quotes a parallel passage in the *History of Animals* (*HA* VIII 2 591b23–30) where the other fish can escape when the sharks turn over, which sharks do because

28. Our discussion of Lennox here is unrelated to the criticisms at the beginning of our article.

29. There is a problem about whether the explanation is purely formal or combines formal and material aspects. Charles (2000) takes the discussion of dolphin and shark gluttony to endanger Aristotle’s paradigm of explanation, that there should be one unitary teleological cause. Charles’s preferred solution is that material and formal natures interact to produce the distinctive features of a kind’s nature (333, 344–45). If this is so, the application of Lennox’s versions of NDNIV may be quite complicated. See too Ebrex (2015) on the complexities of Aristotle’s account of matter.

they have their mouths below. This suggests that the main teleological explanation relates to the sharks' own nature.

Aristotle also provides an explanation for why fish are so prolific that seems to imply that the benefit of the species is what counts: "That is why the fish kind is prolific: Nature fights back against the destruction of baby fish by sheer weight of numbers" (*GA* III 4 755a31–33; Peck 1942). Balme (1987) discusses this passage and the passage about dolphins and sharks, arguing that in both cases Aristotle means by "nature" what is the case, and what is the case is the survival of the fit. Balme explains: "Just as the very existence of species requires no deeper cause than the survival of those animals that best fit into a niche so the preservation of species requires only the survival of the fit. If the fishes were not prolific, they would not survive in sufficient numbers; if the sharks could eat them quicker, they would not escape. This must seem to Aristotle mere common sense, not needing philosophical argument" (280). Balme's account has its own problems. For example, if there are two species in which all the organisms in one are fitter than all the organisms in the other, the survival of the fitter would not guarantee the preservation of both species. More importantly, it is not clear that Balme's interpretation of "nature" in the NDNIV principle as referring to whatever happens in the spatiotemporal order is Aristotle's, as we argued before. It could be suggested, in a more Aristotelian vein, that any given fish has a greater chance of survival when it is among numerous conspecifics, even if that fish happens to be the one that gets eaten, and that its formal nature, entailing that it is one of countless offspring, ensures what is best for it and also, as a by-product, leads to benefits for others.³⁰ This is the idea that there is safety in numbers and that the survival of the species is a by-product of individuals by nature doing what is good for themselves.

The Aristotelian observation that is most difficult to reconcile with the view that the goal of a trait is to benefit the organism that has it or its offspring has been overlooked by commentators. It arises in Aristotle's discussion of the role of drones in the beehive:

So it turns out that the leaders generate their own kind, and another kind as well (viz. the "bees"); while the "bees" generate another kind (the drones) but not their own kind; this they have been deprived of doing. And since any business of nature's (τὸ κατὰ φύσιν) always has an orderly arrangement (τάξις), on that account necessity requires that the drones

30. In evolutionary biology, the puzzle is to account for why some organisms have a larger number of offspring (most of which do not survive to reproductive age) while others have a much smaller number of offspring (with a larger percentage surviving). Aristotle does not address this problem.

shall have been deprived even of generating some other kind. And this is what is found to be the case in actual fact: they are generated themselves, but generate no other creature; thus the progression of generation reaches its limit at the third term of the series. And this arrangement has been so well constituted by nature that the three kinds continue ever in existence and none of them fails, though not all of them generate. (*GA* III 10 760a28–b2; Peck 1942)

Aristotle seems to explain why drones do not reproduce by pointing out that their sterility contributes to the orderly working of the hive. The drones, being sterile, do work that benefits the offspring of other members of the hive.

It is interesting that Darwin found worker sterility in social insects a great puzzle (one that he thought for a time constituted a fatal objection to his theory) and came to invoke the hypothesis of group selection to explain it (Sober 2011, 69–76). Aristotle invokes the order of the whole group to explain worker sterility. Whether the order of the group is part of the formal nature of the animals involved is an interesting question. According to Aristotle, humans, like bees, are political or social animals (e.g., *HA* I 1 488a1–14), and so it is part of their nature to belong to an organized society. Be that as it may, neither Darwin nor Aristotle invokes a nonnaturalistic explanation for the drones' sterility.

In sum, Aristotle usually deploys the NDNIV principle so that the natural state of an organism is the state that is for the sake of the organism or its progeny, but that does not mean that others of the same or even of different species cannot benefit as a result of traits that have the function of benefiting their possessors. A possible exception is the drone in the hive, whose point seems to be its role in the hive. However, the social nature of the bee may be part of its formal nature, just as the social properties of humans are theirs by nature. Our proposition 2, that organism *O* has trait or structure *X* by nature if and only if *O* will develop *X* if its development is unimpeded and *X* is the best trait (among the alternatives) for *O* to have, given the kind of organism that *O* is, leaves it open that “the kind of organism that *O* is” might entail that what is best for *O* is to have traits that both benefit and are for the sake of individuals that are not *O*'s progeny and even individuals in other species. According to Aristotle, organisms that are essentially social will have natural states that are for the sake of others too.

8. Is the NDNIV Principle Anthropocentric?

It is one thing to say that the function of a trait is to benefit the organism that has it or, sometimes, the group of conspecifics to which it belongs, but there is a

passage in which Aristotle seems to go far beyond this narrow compass. Aristotle seems to be arguing that human beings are the final cause for everything that happens in the biological world. His comments follow from the idea that mothers provide food for their progeny and the striking view that some animals exist for the benefit of others:

This kind of acquisition [of food] is evidently given by nature to all living beings, from the moment when they are born to the days when their growth is finished. There are animals which, when their offspring is born, bring forth along with it food enough to support it until it can provide for itself. . . .

Likewise we must evidently believe that similar provision is made for adults. Plants exist for the benefit of animals, and some animals exist for the benefit of others. Those which are domesticated, serve human beings for use as well as for food; wild animals, too, in most cases if not in all, serve to furnish us with food but also with other kinds of assistance, such as the provision of clothing and similar aids to life. Accordingly, if nature makes nothing purposeless (*ἀτελές*) or in vain, all animals must have been made by nature for the sake of human beings. (*Pol.* I 8 1256b7–22; Barker 1995)

The strongest proponent of the anthropocentric view is the early Sedley, who extends this interpretation to the *Physics* (*Ph.*) II 8 (Sedley 1991). According to his interpretation, Aristotle holds that rain falls so that crops will grow in order to feed humans.³¹ Aristotle often overstates his biological views in the *Politics*, as in his comments on the Delphic knife, discussed earlier. Even so, this passage may be interpreted in a similar way to the case of the sharks. For example, while the formal nature explains why certain animals have the properties they do, such animals are also useful for humans (see Johnson 2005, 229–33). Indeed, Aristotle puts things more mildly earlier in the *Physics*: “We use everything *as if it were there for our sake*.³² We also are in a sense an end. ‘That for the sake of which’ has two senses: the distinction is made in our work

31. For a similar view, see Code (1997). For a contrary view, where the crops are part of a *reductio*, see Irwin (1988, 105–9). Sedley (2007) is a bit different. He goes beyond humans, arguing that cosmic nature is responsible for the hierarchy of plants, animals, and humans (202–3). There are two levels of explanation, local and global. The nature of a pig explains why it has the parts it does, but “the fact that the world actually contains pigs and potentially contains roast pork, is a systematically beneficial feature of it” (203). For a recent critique of Sedley’s global teleology, see Gelber (2015, 270–75). See, too, Morel (2016) on local teleology in *De motu animalium*.

32. The beginning is also quoted by Johnson (2005, 237).

On Philosophy” (*Ph.* II 2 194a34–36; Johnson 2005; our emphasis). Aristotle’s point seems to be that there is a distinction between X being for the sake of a benefit and X being for the sake of a beneficiary.³³

Aristotle’s own distinction between essence and accident provides another principled way of drawing the distinction. Other animals are accidentally food for humans, but it is no part of their essence that they should benefit humans in that way. Indeed, if there were no humans they would still be the very creatures they are. They do not exist for our sake.³⁴

In support of the anthropocentric view, however, one might argue that although the formal nature of domestic animals explains their functions, that formal nature has been manipulated by humans over the years and so is now primarily relative to us.³⁵ In fact, it is an open question how much of the supposedly natural environment is the result of manipulation by humans,³⁶ but that still would not show that everything is naturally there ultimately in order to benefit us, and it is uncharitable to attribute to Aristotle such a strong view.

9. Does NDNIV Apply to the Aristotelian Elements?

A natural state model does not automatically require a teleological interpretation. As mentioned earlier, Newton’s first law of motion can be interpreted as saying that the natural state of an object is to remain at rest or in uniform motion and that it will do this when there are no (interfering) forces, yet clearly no teleology is thereby implied. Still, one might suppose that the four elements, earth, air, fire, and water, that naturally go to their special places if unimpeded (*De caelo* [*Cael.*] IV 3 311a5–8) are therefore paradigm instantiations of Aristotle’s natural state model and would therefore exhibit teleological processes. However, Aristotle nowhere explicitly attributes teleology to the elements in his *Physics*, and he does not use teleology to explain earthquakes and the like in his *Meteorologica*. Still, there is a tantalizing passage at the very end of the *Meteorologica* in which Aristotle does claim that the elements and

33. Aristotle also refers to this distinction in his *De anima*, *Eudemian Ethics*, and *Metaphysics* (*de An.* II 4 415b2–3, 415b20–21; *EE* VIII 3 1249b15–16; *Metaph.* XII 7 1072b2–3). See Shields (2016, 202) on the later history of the distinction.

34. A referee has suggested that if nonhuman animals are for the sake of humans, it should be easier to capture and kill them. But of course, humans, with superior reasoning and technology, have no problem there.

35. In his *Nicomachean Ethics* (II 6 1106a19–21), Aristotle defines the function of a horse in relation to human use. He never does this for any animals in his biological works.

36. According to Aristotle, if humans intelligently give matter new forms, they are creating objects that are not natural but artificial (*Ph.* II 1).

the homoiomerous parts of animals (e.g., flesh) have final causes, even though he adds that it is very hard to tell what these are and does not provide any further information: “What a thing is is always determined by its function: a thing really is itself when it can perform its function; an eye, for instance, when it can see. . . . The same is true of flesh, except that its function is less clear than that of the tongue. So, too, with fire; but its function is perhaps even harder to specify by physical inquiry than that of flesh” (*Met.* IV 12 390a10–17; Webster 1984). It is unclear whether the teleology in question here refers to the elements’ natural places. Elsewhere we find that the matter of the elements (perhaps their powers) is necessary for the uniform parts such as flesh (*PA* II 1 646b5–6), that flesh (or its analogue in animals that lack flesh) is the organ of touch (*PA* II 1 647a20–2), and the sense modalities require elemental bases (*de An.* III 1 424b22–425a4). However, the role of the powers of the elements in living things seems to be relative to the parts of those organisms rather than to the natural places of those elements in the universe.

It appears, then, that teleology arises only in the context of an organism. When Aristotle continues with “the parts of plants, and inanimate bodies like copper and silver are in the same case” (*Met.* IV 2 390a17–19), he is presumably considering copper and silver as parts of artifacts, just as the parts of plants are parts of organisms. A further point against attributing teleology to the elements’ trajectories to their natural places is that there is no development of an element as it goes to its proper place.³⁷ In short, a natural state model is in play, but it is not teleological.

10. Justifying the NDNIV Principle

One might expect that Aristotle would justify the NDNIV principle in a way that parallels his defense of the principle of noncontradiction, by showing that it is presupposed by communication and thought about the world. However, Aristotle does not argue that NDNIV is a presupposition of scientific study. Nor does he treat it as a purely heuristic device.³⁸

Instead, Aristotle says that the principle is based on what we see: “Now we assume, basing our assumptions on what we see, that nature does nothing in vain in so far as is possible in each case” (*GA* V 8 788b21). The verb “to see” (from ὁράω) is not metaphorical and so raises the question how we do see that

37. For speculation of the opposite kind, see Bostock (2006, 72–74).

38. Although Leunissen treats the principle (and related ideas) as a heuristic framework throughout much of her book (e.g., Leunissen 2010, 115–19, 124, 130), she notes at the very end that final causes do not only have a heuristic value (220). Against the heuristic reading of earlier commentators, see Huby (1991) and Johnson (2005, 182–87).

nature does nothing in vain. Perhaps Aristotle thinks that his principle is obvious in the same way that he thinks that it is obvious that natural objects like rocks, plants, and animals exist. He says that it is absurd to prove that such objects exist because trying to do so would be like someone blind from birth reasoning about colors (*Ph.* II 1 193a1–9).³⁹

As is clear from the examples in the *History of Animals*, we certainly do see that many features of animals invariably go together, but how do we “see” that one thing is for the sake of another? Perhaps when features of animals invariably go together this is evidence of teleology, but that evidence is defeasible. An eye’s having some color or other is not for the sake of anything, that is, it has no functional role according to Aristotle, although for the most part eyes do have a color. By contrast, for the most part, eyes see. Here, seeing is a function or a goal of the eye. The eye is for the sake of seeing. As Aristotle says, “An eye is for the sake of something, but it is not blue for the sake of something, unless this is a peculiar property of a kind of animal” (*GA* V I 778a32–34).⁴⁰

It is reasonable to think that Aristotle’s main arguments for teleology are the arguments against his pre-Socratic opponents (esp. *Ph.* II 8, *PA* I 1).⁴¹ For example, Aristotle argues against Empedocles’s view that there is no teleology—that the development of teeth and backbones in animals is just a result of chance coincidences. According to Aristotle’s natural state model, Empedocles is misunderstanding the orderly development of the parts of animals.

Of course, regularity does not entail teleology, as many commentators and modern scientists would agree. But Aristotle has a better justification of his NDNIV principle, one that accords with his statement that we “see” that NDNIV. The principle is well supported, at least with regard to organs and functions, by its many successful applications. When applied correctly, it leads the Aristotelian scientist to seek out the teleological function that a biological structure has. When a plausible function is found, the general principle scores a success. Understood in this way, the NDNIV principle is not prior to what we discover when we investigate nature; rather, it is a useful summary of what those investigations yield.

It might be argued that the idea that the NDNIV principle is not a priori is consistent with the scientific method described in *Posterior Analytics* B 19, al-

39. See, too, “It seems that perceptible things require perceptible principles, eternal things eternal principles” (*Cael.* III 7 306a9–10; Stocks 1984).

40. This, despite the fact that Aristotle goes on to explain that blue eyes provide sharper night vision than darker eyes, but, strictly speaking, this is due to the material of the eye, not its color. This passage (*GA* VI 779b35–780a7) is discussed by Johnson (2014, 9–10).

41. See, e.g., Irwin (1988, 105–9) and Meyer (1992) for the arguments of *Ph.* II 8.

though the details of that account are notoriously obscure. There, Aristotle seems to be arguing, among other things, that one comes to grasp first principles from perception via memory and then via experience (one experience combining a series of memories into a universal).

11. Conclusion

Unlike Lennox's influential analysis of NDNIV, our analysis gives pride of place to Aristotle's natural state model, according to which an organism will develop toward its natural state unless interfering forces prevent that from happening. Our explication involves two principles, as Lennox's does, but ours are logically independent. And his explanation uses the very locution that stands in need of clarification, "nature does nothing in vain," while ours clarifies what that key phrase means.

Our discussion of Aristotle's use of his NDNIV principle has touched on many aspects of his biology. Some involve questions about the scope of the principle. We argued that NDNIV does not entail that all structures are teleological (sec. 4). Aristotle discusses by-products and (the much neglected) "tokens" that are not. We also have argued that NDNIV does not entail that each organ must have only one function (sec. 6), that NDNIV is not an anthropocentric principle (sec. 8), and that it does not apply to the elements (sec. 9). We also have suggested that the NDNIV principle, perhaps surprisingly, does not preclude an organism's having characteristics that are for the sake of others that are not its progeny (sec. 7).

We also have addressed questions whose answers rely more directly on the natural state model: we explained how NDNIV applies to natural processes (sec. 3) and how monstrosities are not counterexamples to NDNIV once it is understood as including a natural state model (sec. 5).

Propositions 1 and 2 are our explication of what NDNIV means. With respect to the question of justification, we have argued that Aristotle takes NDNIV to have an empirical justification; it is not a priori and it is not merely heuristic, either. For Aristotle, it is a unifying principle whose justification comes from its many successful applications.

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