The Human Model: Polymorphicity and Scientific Method in Aristotle's *Parts of Animals*

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Introduction

Parts of Animals II.10 makes a new beginning in Aristotle's study of animals. In it, Aristotle proposes to "now speak as if we are once more at an origin, beginning first with those things that are primary" (655b28-9).[1] This is the start of his account of the non-uniform parts of blooded animals: parts such as eyes, noses, mouths, etc., as opposed to uniform parts like blood and flesh.[2] *PA* II.10 proposes a new strategy for studying these parts: "one ought to speak about the human kind first" (656a10).[3] Beginning "first" with the "primary" things thus amounts to beginning with humans (655b28-9).[4]

Why does Aristotle think this strategy is appropriate for his project? One answer is that it reflects a fundamental anthropocentrism. Lloyd, for instance, has raised the possibility that the basic assumptions that guide Aristotle's biology may to some extent reflect the anthropocentrism of his culture, where the relation of humans to animals was "a preoccupation of popular beliefs".[5] In this paper, I develop an interpretation that both builds on and challenges this suggestion. I do so by investigating how Aristotle thinks this strategy works in theory and in practice: his justifications for adopting it and its interaction with his scientific commitments. I argue that Aristotle adopts it in part because he thinks that humans are such that his *scientific* concepts apply to them in a particularly clear way. (This too is a form of anthropocentrism: one that might be resisted by arguing that humans are not the best illustrations of these concepts—that Aristotle ought to look elsewhere for models with the features he desires.[6])

More specifically, Aristotle holds that starting with humans helps establish the causal explanations of the parts of other animals, particularly when they are recalcitrant. What makes humans suitable for this role is a special teleological relation between their parts and the ends they serve: in humans, he supposes, this connection is particularly tight (in a way I explain below). Consequently, Aristotle thinks he can use humans to illuminate which sorts of features tend to be for the sake of which ends, and then extend the results of this inquiry to the parts of the other animals.

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[1] Translations of the *PA* are from Lennox 2001b, with modifications. The Greek is from Bekker 1831. Translations of other texts are influenced by the *ROT* and Loeb editions.

[2] II.10 begins with blooded animals' external non-uniform parts (on the head). III.3 transitions (eventually) to their internal parts, then to bloodless animals' internal and external parts. IV.10 returns to blooded animals' external parts of. Cf. Lennox 2001b, 220, 254, 292-3, 305, 314; Gotthelf 2012c, 158-64.

[3] The method is new to *PA*, but also used elsewhere: *HA* I.6 (491a19-23) and *GA* II.6 (737b25-7).

[4] As Gligorijevic has emphasized to me. Cf. Quandt 1983: 368.

[5] Lloyd 1983: 42. Lloyd emphasizes the human's exceptional status (26-35) and the role of hierarchical assumptions (35-7); cf. n. 23. For criticism, see Lennox 1985, 308-315. On hierarchy and anthropocentrism, cf. Pellegrin 1986: 91ff.; Müller 2019: 119-20; Clark 1975.

[6] I thank Connell, Leunissen, and Korobili for helpful questions.

I The Human Model

The context in which Aristotle introduces his new strategy provides important clues to how he understands its purpose. *PA* II.10 begins by identifying three particularly important non-uniform parts: that "by which they receive nourishment", that "by which the residue departs", and "a third part present in all animals [that] lies midway between the two most necessary parts, within which is their origin of life" (655b29-37). However, not all living creatures have all these parts. Whereas most animals (at least, the "complete" ones) have all three, plants "have no place for useless residue" (655b32-4). More generally, plants do not have as many distinct parts as animals do: it is "of the nature of plants, being immobile, not to have many forms of the non-uniform parts (*polueidēs tōn anomoiomerōn*); for few actions require the use of few instruments (*organōn*)" (655b37-656a2). For this reason, "we should study the visible character (*ideas*) of plants independently" (656a2-3).[7] While this observation allows Aristotle to set plants aside—as outside the scope of his treatise—its emphasis on the number of "forms" of the parts puts him in a position to make the distinctions that will structure his study of animals.

Indeed, Aristotle soon introduces a similar contrast among animals: between those that are more and less "polymorphic in visible character". This contrast provides one reason for adopting his new method:

> But those things with perception in addition to life are more polymorphic in visible character, and some of these more than others. And there is generally greater variety among those whose nature partakes not only of living but, in addition, of living well.[8] Such is the human kind; for of the animals known to us (*gnōrimōn*) either the human kind alone, or the human kind most of all, partakes of the divine. So both because of this and because the shape (*morphēn*) of the external parts of the human kind is most familiar (*gnōrimon),* one ought to speak about the human kind first. For straight away the natural parts are disposed according to nature in this kind alone, that is, what is above for the human kind accords with what is above for the whole cosmos; for the human alone among the animals is upright.[9] (656a3-13)

Living creatures thus fall on a spectrum of being more or less "polymorphic" (*polumorphoteran*) in their "visible character" (*tēn idean*); or, in the earlier formulation, their natures vary in whether they have "many forms" (*polueidēs*) of their non-uniform parts.[10] Humans, Aristotle thinks (possibly wrongly!), are most polymorphic, then other animals, then plants.

This polymorphicity clearly looms large in justifying Aristotle's claim that we should discuss humans first. But what is it? And why is it important? A first step is to note that *PA* II.10 does not merely observe that living things differ in this way. It also offers an explanation: they differ because of differences in the actions they perform (cf. I.5, 645b28-9). Whereas plants perform "few actions" (and so need "few instruments", II.10, 656a2), animals and especially humans lead more complex lives.[11] Humans, apparently, are "among those whose nature partakes not only of living but, in addition, of living

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[7] On the "prospects for a unified study of living beings", see Falcon 2015, 84-5.
[8] Cf. *DA* III.12, 434b22-9, 435b4-25, *Sens.* 1, 436b12-437a3, with Howton 2019, Leunissen 2010: 57-75; and Gotthelf 2012e: 53-55.
[9] Cf. *Juv.* 1, 468a4-13.
[10] While the two formulations use different vocabulary, they should be equivalent: the second formulation's reference to the *idea* ("visible character") picks up the observation that it is a consequence of the first formulation that we should study the *idea* of plants separately (656a3, 4).
[11] Cf. *GA* I.23, 731a24-9 and *De Caelo* II.12, 292b2-10 (we have the "most actions"). Thanks to Gligorijevic. On our multiplicity of actions and intermediate status in the cosmos, see Rapp 2019; cf. Osborne 2007: 117-22.

well" (656a6). This is why they are more polymorphic: because they live well and perform more complex actions, humans have more parts of different sorts with which to do so.[12] Relatedly, IV.7 notes that some animals lack a "many-parted" (*polumeres*) body because of their "actions", whereas "those partaking of many motions are in need of many instruments" (683b4-8).

In explaining the polymorphicity of parts ("instruments") by reference to actions, II.10 extends a line of thought begun in II.1. There, Aristotle observed that the "uniform parts are for the sake of the non-uniform", in part because of facts about the "functions and actions" of the latter (646b11-13). These facts hypothetically necessitate further facts about the composition of the parts that perform them: "since the actions and movements present both in animals as a whole and in their non-uniform parts are polymorphic, it is necessary for their components to have distinct capacities; for softness is useful for some things, hardness for others", etc. (646b14-8).[13] Non-uniform parts thus have the complexity they do because it is (hypothetically) necessitated by the complexity of the actions they perform. Sometimes, their complexity consists in being composed of multiple (uniform) components with different capacities: bones, sinews, flesh, etc. (646b18-27). Sometimes, it involves a "polymorphic" shape, as in some viscera (646b32-4; cf. 647b33).

This context helps us understand *PA* II.10's strategy. II.1's idea is that the complexity of non-uniform *parts* is hypothetically necessitated by the complexity of their functions. II.10 simply extends this observation to the creature as a whole: if a *creature* has complex functions, then that creature—its visible character (656a4) or its nature (655b37-656a1)—is more polymorphic in its non-uniform parts. While II.10 is less explicit, part of the idea may be that polymorphic natures have more non-uniform parts of distinct kinds (by contrast with plants' "few instruments", II.10, 656a2, and by analogy to the "distinct capacities" of the multiple components of non-uniform parts, II.1, 646a14-8). Alternatively, again by analogy to II.1, it may also be that (collectively?) the parts have a more polymorphic "shape" (646b32-4).

This, according to II.10, is what humans are like: polymorphic in their uniform parts, because of the complexity of their actions. This is one reason Aristotle gives humans methodological priority: "both because of this and because the shape of the external parts of the human kind is most knowable, one ought to speak about the human kind first" (656a8-10).[14] In context, "this" picks up the claim that the human kind is polymorphic, a point just justified—in parallel to II.1—by appeal to the actions it engages in (656a5-7), justified in turn by its participation in the divine (656a7-8).[15] It is because, Aristotle thinks, humans are polymorphic and because their parts are most knowable that we should discuss them first.

II Why does polymorphicity matter?

My question concerns Aristotle's first reason for starting with humans: our supreme polymorphicity. What connection, exactly, does he see between polymorphicity and methodological priority? Why not

[12] The exact nature of this complexity is difficult, but see Leunissen 2010 on the distinction between living and living well, and the suggestion (with reference to 2.10's *scala*) that "'well' indicates a more complex performance of the being's life functions" (62). At the conference Korobili offered an insightful analysis of this complexity, seeing "formal" complexity as due in part to "material complexity". Cf. Karbowski 2019: 224-30 on functional and morphological complexity in a political context.

[13] Cf. Tipton 2013: 96-97.

[14] Contrast the order for the other external parts (*PA* 4.6, 682a31-3) and generation (*HA* V.1, 539a2-8).

[15] I agree with Lennox 1999 that the claim that we participate in the divine justifies the claim that we live well, which explains why we are polymorphic.

work our way up to humans, beginning with simpler creatures? A natural thought is that starting with humans is an organizational device. But what kind of device is it, and what makes it helpful?

One possibility is that humans provide a convenient table of contents for a treatise.[16] Aristotle might have thought that if humans possess a large variety of parts (if not *all*), enumerating them yields a comparatively thorough list. From this point of view, there is nothing special about human parts as such: any long, accessible list would do. Another possibility is that he thinks that starting with humans ensures that the organization of our inquiry reflects the organization of the natural world. Leunissen observes that "nature provides all kinds of hierarchies in its organization from which Aristotle can draw so as to find normative principles for the organization of his own writings in those cases where didactic or conceptual concerns yield no particular preference for discussing one natural entity or its attribute before another".[17]

While both suggestions capture something important, there is evidence that Aristotle thinks he has further reasons for adopting this organizational device. *PA* II.10 gives two justifications: greater knowability and *polymorphicity*. By contrast, when *HA* I.6 introduces a similar method, it claims only that the human is most knowable to us (491a19-22).[18] The *PA* and *HA* have different projects: roughly, the *PA* offers causal explanations for the facts reported in the *HA*.[19] While the first suggestion explains why polymorphic animals provide a thorough list, it does not explain why starting with them is particularly germane to the *PA'*s explanatory project. The second suggestion does better. It can allow that hierarchically-ordered expositions have explanatory benefits: perhaps they reveal which parts of a given explanation should be "assumed for now" and which should be argued for here.[20]

However, we may go further: does polymorphicity have anything to do with the project of identifying the causes of animal parts? There is evidence that Aristotle thinks it does: that an organization that begins with polymorphic animals helps us construct causal explanations and present them in an illuminating way—one that makes manifest how this part is for the sake of that function.[21] Such an organization is not only convenient or in line with the hierarchy of the universe—though Aristotle probably thinks it is—but is also, in his view, uniquely suited to achieving understanding of the causal structure of the phenomena.

This perspective develops Carbone's observations that Aristotle often takes a visual and spatial approach to morphology and that the human body can play a role in identifying the "body plans" central to that thinking, as well as the idea that there is sometimes a "coalescence" between morphological and

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[16] While I am not sure the view is ever put in exactly these terms, this formulation provides a useful contrast to the other options. But note Gotthelf 2012c's observation that "the list is taken from man" (160), and occasional observations that the method does not involve discussing humans as often as one might think or for the reasons one might have guessed, e.g. Lennox 1999: "while […] the anatomy of mankind is regularly discussed, it is equally true that mankind is not at center stage" (8). Quandt 1983 discusses Aristotle's use of "one serialized list or another" to organize his biological treatises, though he "[s]ometimes he abandons one list for another" (361). For additional discussion: Kullmann 2007, 448 and Kullmann 1999: 115-7.

[17] Leunissen 2017a: 177; cf. Leunissen 2017b. Gotthelf and Falcon 2017 comment on the *GA*'s idea that "the maximum possible (sc. the most complex) outcome, namely the production of a human being, is the natural place to start" (25).

[18] Though see *HA* IX.1, 608b4-8: the "traces of the characters"—differences between males and females—are clearer in some animals and especially in humans, since its nature is most "completed". Thanks to Gligorijevic.

[19] See Lennox 2012 and 2001b: 223.

[20] Cf. Leunissen 2017a: 169. Falcon 2015 also emphasizes explanatory concerns.

[21] I thank Jessica Gelber for suggestions about formulation.

teleological concerns.[22] I build on this approach, fleshing out the special role of polymorphicity and what *makes* it effective for identifying causal explanations. The answer appeals to an important feature of polymorphic animals: an especially tight correlation between a part's features and the end they serve. This makes it easier to illuminate *which* features are for the sake of *which* end. This explanation can be used to shed light on the causal explanations of the parts of other animals, particularly where they are recalcitrant: where they perform a given function, but in peculiar ways.[23]

III Identifying causes

Understood in this way, *PA* II.10's methodological innovation is meant to play an important role in Aristotle's implementation of his research program. That program, laid out in *PA* I, centrally involves division and explanation: "first to divide the attributes associated with each kind that belong in themselves to all the animals, and next try to divide their causes" (645a36-b3). Following Gotthelf and Lennox, I understand it as follows. One begins by identifying the *widest class* of animals possessing a given feature. This might be a generic (like feathers in birds) or an analogical (like eye protection across kinds) unity (Gotthelf 2012d: 193n18.). One divides this class according to *differences* in how animals in it have the feature. Then, one then identifies the widest class that possesses each difference. In this way, one prepares to give corresponding causal *explanations* of the parts (639a15-b6, 644b1-7).[24] Nature, after all, produces "a differentiation of this part for the differences of its operation" (662a23-4). Explaining a part thus requires identifying the cause common to the parts in the wider class, as well as the cause of its variation.

This is the task of the *PA.* Importantly, it does not merely identify these causes, but also sketches the reasoning behind its identifications. In Gotthelf's words, it offers "systematic discussions—arguments, actually—aimed at *establishing* what the cause (generally, the function) of the part in question

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[22] Carbone 2016: 27. Carbone notes that the fact that polymorphicity follows from functional complexity "means that the organism's shape needs to be explained teleologically, but it also means, from a methodological point of view, that studying the body plan provides the evidential support for a teleological explanation of the body's anatomy" (18). While Carbone's discussion is wide-ranging, its main focus seems to be visual, topological, and morphological thinking, including its role in explanation, via "la correspondance […] entre la position des parties […] et la fonction" (Carbone 2011: 16). Humans come in most explicitly via their role in identifying the *body plans* essential to that thinking, which then facilitate comparative anatomy (Carbone 2016: 19-21; Carbone 2011*:* 16, 49-50, 77ff., 107-8). The emphasis is less on the nature of polymorphicity and what *makes* it valuable for Aristotle's method (beyond the general relation between multiplicity of functions and of parts, and how this makes identifying differences relevant to explanation, 78; cf. 50-1, 107, 158). I offer an explicit account of how polymorphic animals' teleological structure lets Aristotle use *their* parts as models (especially in terms of hypothetical necessity), in ways that do not always refer to body plans. To the extent that connections between body plans and teleology are particularly manifest in polymorphic animals, I am offering a new argument for Carbone's account of the role of topological reasoning and what makes it work. My account also explains Aristotle's use of the human model for identifying hypothetical necessity relations in parts serving multiple functions. Wilson 2009 briefly mentions the view that "in the biology hierarchies are explanatory and supply cause"; Aristotle's tendency is "to explain the varieties as deviations from a norm" (85); cf. Wilson 2013. Cf. Stavrianeas 2018: 52, 66 on hierarchical concepts that allow evaluations across species.

[23] I am sympathetic to claims that *analogy* has a methodological role, e.g. Henry 2014; cf. Lennox 2005: 95-7. Lloyd 1983 notes how "Aristotle's interpretations of the role and function of various of the parts of the lower species of animals are influenced or even determined by doctrines derived from his study of the higher animals" (37; see 37-40). Meyer 2006 treats the human as a reference point for analogy and starting with it as a condition for zoology (27-8), helpful for understanding the functions of other animal parts (33).

[24] Gotthelf 2012d: 193n18; cf. Gotthelf 2012b: 206-8; Lennox 2001c, Cf. Leunissen 2010*:* 114-5.

is": "attempts to establish the definitions of these parts".[25] I will argue that Aristotle takes polymorphicity to be useful in constructing some such arguments.[26] The reason is that some parts are recalcitrant: it is hard to identify their causes, what they explain, and what this means for other features such parts might have.

My central example will be *PA* II.16's discussion of organs for smelling. Aristotle began investigating the sense organs in II.10, starting with humans. There, he noted that animals have nostrils in order to smell, and that in animals (like humans) with nostrils (rather than other means of smelling), their function is smelling "by means of breathing" (657a6-7; cf. *DS* 5).[27] This common cause explains certain features, including position (*PA* II.16, 656b26-657a11). II.11 turns from human sense organs to those of the "other animals", whose "sense-receptors are also well situated […] in relation to each one's proper nature" (657a11-2). II.16 tackles their organs of *smell*, turning from the common part and cause to the *differences*. There are few, aside from being positioned in the snout in long-jawed animals (658b27-33). Aristotle's account of organs of smell is thus in keeping with his program of identifying common and differentiated causes, starting with humans.

The remainder of II.16 introduces two hard cases. The second is certain "channels" for smelling:

> The birds, the snakes, and the other blooded egg-layers among the four-footed animals have the channels of the nostrils in front of the mouth, but they do not have them clearly articulated so much so that one would say they are nostrils,[28] unless on account of function); but the bird, at any rate, has them in such a way that one would not say it has a nose at all.[29] (659a36-b4)

Lest there be doubt, Aristotle soon states that "in the beak they have channels for smell, but are unable to have nostrils" (659b13). His verdict is thus that birds have neither "nostrils" nor "noses"—even though their beaks have "channels" for smelling.[30] My question concerns what "arguments" should establish such an account of beaks and channels: how to identify the appropriate causal explanation for them—one whose implications reveal why birds are "unable to have nostrils" and why their channels do not count ("unless on account of function").

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[25] Gotthelf 2012c: 164 and n.35, citing Bolton 1987 and applications in Freeland 1990, Wilson 2009.

[26] Cf. Carbone 2011: 57-60, 65, 69, 77ff., 106, and *passim* on the usefulness of body plans for grasping differences among parts and in identifying them and their functions.

[27] Some animals smell through gills, pipes, or the mid-section (659b13-9). We might capture a common and differentiated *cause* by distinguishing kinds of smelling (through breathing vs. other means). Gelber 2015 understands "references to organisms' habitats" similarly, "as references to the specific or determinate way they have their vital capacities" (284); cf. Stein 2018: 44-5.

[28] After Louis 2017's "nettement distinct au point qu'on…" (58 and 58n2). See Düring 1943: 152-3 for explanation of the difficulty. Lennox 2001b offers: "they do not have clearly differentiated nostrils to speak of" (43). One *desideratum* is to avoid contradicting 659b13. Also note: having "channels of the nostrils" is compatible with not having "nostrils" (*HA* II.12, 504a21-3).

[29] After Louis 2017, 58 and 58n3, supplying "has them" (cf. 659a2, 3). Lennox 2001b offers: "the *bird*, at any rate, has nothing one would call a nose".

[30] Might it be that "nostril" (unlike "channels", 659b1-2, 12; cf. 405a21-3) labels a part common at a lower level of generality that includes humans but not birds, so that saying a part might be called a "nostril" on account of function is to extend that label, loosely, to a more general level that includes birds? I agree there is "looseness", but work needs to be done to tease out the source; see below. One difficulty is that a "loose" extension should be to a *more general* level than the one that defines "nostrils" (cf. 658b28-9), but that function appears to be *smelling through breathing* (657a4ff.). Beak channels, however, *do* let birds *smell through breathing* (659b13-9); surely this is why they are called nostrils on account of function. I thank Leunissen for questions; cf. n. 57.

Aristotle's remarks here are puzzling: he looks to be identifying a common part—a "nostril"—and gesturing towards a common cause—a "function"—that would justify (*dia*) labelling it as such (659b2-4). However, he ultimately denies that the part is a nostril (b13). How can he support this claim? What, in the final analysis, makes a *part* be of a given type—say, a *nostril*?

In general, Aristotle inclines towards the view that non-uniform parts are defined by their functions. *PA* I.1 claims that non-uniform parts differ in virtue of their capacities: "about the non-uniform parts such as face, hand, and foot, one should say in virtue of what each of them is such as it is, and in respect of what sort of capacity" (640b21-2; cf. 722b31-2). Saying what such a part is just is to say what capacity it essentially has. But activity (*energeia*) is prior in being to capacity (*Metaphysics* Θ.8 argues). Thus, just as we cannot say what a capacity is without saying what activity it is for, so too we cannot say what a non-uniform part (defined by its capacity) is without saying what it is for.

PA I.5 adds that what they are for is a "certain action": "every instrument is for the sake of something, and each of the parts of the body is for the sake of something, and what they are for the sake of is a certain action (*praxis*)" (645b14-6). For example, "sawing is not for the sake of the saw, but the saw for sawing; for sawing is a certain use" (645b17-9). Similarly, "whenever there are actions that are for the sake of other actions, the things whose actions they are differ in the same way that their actions do" (645b28-9), and vice versa (29-32). While the exact structure of these arguments is difficult, their direction is clear. As Charles puts it, in holding that "priority between actions determines priority between organs", I.5 appears to be taking actions to be "definitionally prior to organs".[31]

Aristotle's idea is that a part is defined by its function—what it does: its characteristic *action*—and not what it is made of or its (non-functionally-defined) shape (cf. *PA* IV.12, 694b13-4). An object is a saw because it cuts wood, which hypothetically necessitates that shape.[32] A part is a hand because it grasps, which hypothetically necessitates fingers of a certain shape. The function makes it what it is. *PA* I.1's critique of Democritus reinforces the point.[33] Democritus held that "it is by virtue of its configuration and colour that each of the animals and their parts is what it is" (640b29-30), where this involves looking to "shape" and "figure" (640b29-35; cf. 640b34).[34] Aristotle's complaint is that this approach does not identify the *cause*—especially the final one (641a11-3): the "work" the part "is able to do" (641a1-2).

The underlying idea may (if borne out by *PA* II-IV) be that non-uniform part types are defined by *the functions that hypothetically necessitate* (and in this way causally explain) their other features. Two parts are of the same type (at some level of generality) if and only if they have the same hypothetically-necessitating function (at that level of generality).[35] The upshot is a question about how to fit together *PA* II.16's claims that beak channels can be called "nostrils" on account of their *function* and that they are not nostrils. Are beaks an exception to Aristotle's usual functional account of part types—or does that account, properly understood, show why beak channels are not nostrils? And how, more generally, does Aristotle go about illuminating the causal explanations of recalcitrant parts like these?

IV Polymorphicity and teleology

[31] Charles 2000: 313-4.
[32] I am sympathetic to the view that the *functions* are matter-involving (Charles 2009).
[33] The context is definitional: 640b24.
[34] For useful discussion and a different view, see Carbone 2016: 8-9. Cf. De Ribera-Martin 2018.
[35] Cf. Stein 2018: 38. The brain is a tricky case: Lennox 2020.

In the remainder of this paper, I argue that Aristotle's approach to such parts—whose explanation is not straightforward—is to appeal to what he thinks he knows about the parts of the most polymorphic animals: humans. This strategy works because being polymorphic is a consequence of—and so a good clue as to—the *teleological* relation between the functions humans perform and their parts' features. As we saw in *PA* II.1 and II.10, complex lives hypothetically necessitate complex bodies: ones with a variety of non-uniform parts. Moreover, according to I.1 and I.5, each such part is defined by its function. Humans (Aristotle thinks) are therefore animals with many functionally-defined parts, which have the hypothetically necessitated features appropriate for human life.

Aristotle's insight is that where there is a *variety* of such parts, they can be "specialized": defined in terms of a single function, or functions whose requirements do not conflict (are not too "dissimilar").[36] He develops this idea in *PA* IV.6's account of insects that use a single part for defending themselves and for taking in nourishment:

> 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; but where this is not possible, nature makes use of the same thing for multiple functions. (683a19-26; cf. 661a15-29, 682a8-12, 682b36-83a3)[37]

Animals with more distinct parts are better off: they have distinct parts for nourishment and for defence.[38] They avoid the negative consequences that sometimes follow when "dissimilar" functions are doubled up in a single part: their tongue can have just the sponginess appropriate for the nourishment humans need, without compromising it for protective sharpness.[39] After all, "nature makes the instruments to fit the function" (694b13-4).[40]

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[36] I present specialization as a consequence of polymorphicity, with polymorphicity strictly concerning only the number of parts, since this seems to fit 683a19-23 best (cf. 683b4-8). (Cf. the *Politics'* discussion of the implications of the *number* of citizens for whether offices should be doubled up: IV.15, 1299a30-b10). A complex life hypothetically necessitates polymorphicity, *because* it facilitates specialization and its functional advantages. I am nonetheless sympathetic to a stronger view (cf. 687a19): that 2.10's "few"/"many" parts are *types*, defined by ends/functions, and that the tokens that best exemplify (*apoteloito kallista*, 1252b3-4) such functional definitions are specialized ones. On this view the parts of polymorphic animals still count as especially *distinct* (first and foremost in type), by analogy to the "distinct capacities" of the components (646b17) of non-uniform parts with polymorphic actions and in contrast to the "conjoined" capacities (682a11) of stinger-tongues. On either view, polymorphic animals exhibit less doubling up of "dissimilar" functions (683a20). Thanks to Lennox for questions.

[37] Cf. the *Politics'* claim that each tool is made best when it is made for a single use (1252b1-5). Still, in *small* cities—like lower animals?—several offices may be combined in one person (1299b1-10). Thanks to Gligorijevic. For discussion, see Karbowski 2019: 224-7; Gottlieb and Sober 2017: 258-60; Leunissen 2011, 43. Cf. *Juv*'s claim that user and used should be distinct in capacity and place (IV, 469b1-2); thanks to Korobili.

[38] Humans can choose their weapons (*PA* IV.9, 687a19-b9). Because hands *adapt* to all these instruments in virtue of their ability to hold them, they are "many" instruments (687a21). Beaks do not adapt.

[39] "Sometimes": human tongues are for speech as well as flavour perception (660a1). This doubling is not problematic, as the same features—softness and detachment—are serve both (660a17-23); 683a19-26 rightly emphasizes "dissimilar" functions. Cf. Leunissen 2010's "secondary teleology". My point is that for polymorphic animals, these bad consequences are less likely, which makes them a model even where doubling occurs.

[40] For application to human society, see Karbowski 2019: 225 and Karbowski 2012: 342-5.

The idea is that where there are more (distinct) parts, these parts need not combine "dissimilar" functions and so need not be subject to trade-offs. The result is that the relations of hypothetical necessity between a part's function and features can be "tighter": such parts can have not just features that make it possible for them to perform their functions, but also a degree ("most sharp") or quality of them that is particularly appropriate for doing so, perhaps in animals of this sort.[41] Moreover, they need not have "extra" features required for one function but not a dissimilar one: they need not be *both* sharp and spongy. If the features of non-uniform parts are those hypothetically necessitated by their ends, this is to say that such parts have all and only the end-promoting features appropriate for the animal they belong to.

The animals that have more parts, II.10 suggests, are the polymorphic ones. In claiming that humans are especially polymorphic, Aristotle is thus making space for the view that they need not "have the same instrument for dissimilar uses"—that their parts can be tightly adapted to and specialized for human needs. This view raises difficult questions. On the one hand, perhaps it need not require Aristotle to suppose (falsely) that polymorphic animals excel at everything they do,[42] but only that their parts are *finely tuned* to their needs, without *interference* from "dissimilar uses". At the same time, this points to a further question: whether parts that combine "dissimilar" functions really *are* poorly tuned: isn't this just the tongue these animals need? And here we might well resist: perhaps Aristotle should simply say that in parts like these, the relation between feature and function is clearest to *us,* and no more.

Difficulties aside, the present question is this: *do* these ideas play a role in Aristotle's method? There is reason to think they do: that the reasoning that establishes the causal explanation of beaks takes human parts as models, and that their fine tuning facilitates this. Before we can get there, however, we should recall what makes beaks so puzzling. Aristotle has claimed that birds do not have their channels so "clearly articulated so much so that one would say they are nostrils, unless on account of function" (*PA* II.16, 659b2-4). Apparently, being more clearly "articulated" would allow the channels to count as nostrils, for reasons beyond those "function". What might Aristotle mean?

The opening of *PA* II.16 provides a clue: in animals "with long jawbones that become progressively narrower the part consisting of the nostrils is, as far as is possible, actually present in what is called the 'snout' (*rungchei*), while in the rest the nostrils are more articulated from the jaws" (658b20-33). In long-jawed animals, there *is* a "part consisting of the nostrils"—a nose (cf.659b4)—"present in" the snout. In other animals, however, "the nostrils are *more* articulated from the jaws" (658b32-3). The implication is that in long-jawed animals there is *less* articulation of nose and nostrils from snout: they are present, but blend in. The situation is worse in birds: they have a snout/beak (*rungchos*) but no distinct nose—let alone nostrils—on it.

The question is how articulation fits into Aristotle's approach to defining parts: is it a new criterion, or an aspect of an old one? Lennox suggests that "Aristotle is unwilling to define 'nostrils' in *purely* functional terms". Instead, "[a] nostril must be a separately differentiated [i.e. articulated] part, such as a human nose" (Lennox 2001b: 237). Thus "the bird, at any rate, has them in such a way that one would not say it has a nose at all" (659b4). These remarks are along the right lines: what is needed *is* a nose, which is more articulated. However, I will argue, this need not mean that a part's defining features

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[41] I take it that an animal's way of life (*bios*) partly determines this; see n. 65.

[42] We smell poorly (*DS* IV, 440b31-441a2; cf. *DA* II.9, 421a9-13). Still, some smells support brain health and are special to humans (444a3-4), where animals smell through breathing *because* this carries smells to the brain (444a19-25). Here, humans do excel at smelling through breathing (the focus of *PA* II.16*;* cf. *GA* V.2, 781b17-9). Thanks to Diana Quarantotto and Sophia Connell for questions.

are not "functional" or that there are no connections between articulation and teleology. Indeed, *Physics* II.8 suggests there must be: "being for the sake of something" is present in plants, but "is less articulated" (II.8, 199b9-10).[43]

More specifically, Aristotle appeals to articulation because as parts become more articulated, the connection between their features and end can get tighter, in the way sketched above.[44] The reason is that articulated parts are *distinct* from others, where—*PA* IV.6, 683a18-36 suggests—distinct parts can be specialized.[45] The upshot is that barely articulated parts lack this tight connection. (By contrast, parts with tight connections—as we find in polymorphic animals—may offer good models. See Section 0.)

Relations between articulation and teleology emerge in *PA* II.17's account of unarticulated crocodile tongues (660b33; cf. IV.11, 690b23-6) and minimally articulated fish tongues (660b20, 661a2-3).[46] Less articulated tongues sometimes appear not to be "separate" tongues (660b22-3, and unarticulated ones are "fused" to the lower jaw (660b28). The first lesson is thus that *articulated* tongues are distinct and separate. Moreover, limited articulation and separation are connected to limited *function:* "just as the tongue's use is slight, so too is its articulation" (660b18-20). In fact,

> since the perception of the taste found in flavours is for the sake of nutrition, this part is tongue-like, though not in every part equally but mostly in the tip.[47] Because of this, in the fish only the tip is separated. (661a3-6)

Perhaps the tip is most perceptive, or it most of all has "tongue-like" features suitable for perception. Either way, this is why "only the tip is separated": articulation and separation promote its function, directly or by allowing features suitable for it. (Softness would be good (660a17-9), but fish tongues are in a "spinous" place (660b16, 24-5)). Indeed, unarticulated tongues have a "lame character" (660b25). Articulation may thus promote function, insofar as articulated parts are *distinct* from the place—a "spiny" one—where they are located, which can allow them features that differ from those of the place and that are tuned to their function. In other words, articulated parts better specialize.

This picture of articulation gains support from the *De Incessu,* which builds on *PA* II.10's claim that "the natural parts are disposed according to nature in this [human] kind alone" (656a10-12; cf. *HA* 494a26-b1)[48] and connects it with articulation. Here too, articulated parts are *distinct* (cf. 706a20-1): *DI* 4

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[43] *DA* II.1: their "organs" are "simple" (412b1-2).

[44] On articulation, see Quarantotto 2019, especially 350-1. I am sympathetic to her idea that a unitary substrate is "progressively articulated" into animal parts (351). Cf. Quarantotto 2022 for the claim that as embryos get more complex, "they become systems articulated into parts with a *fixed* specialization". Because more articulated parts are more unified (they are *one* part) and more distinct from other parts in a complex organization, they can have more characteristic specialization.

[45] Cf. *HA* IV.8: some animals have "very manifest" sense organs, when they have "the place of the eyes and of hearing distinguished" (533a18-21); such animals have *ears* rather than mere channels (a21-2). I take this idea to be pre-causal: in the *PA* Aristotle can add that to lack *ears* is to lack a *part* sufficiently *specialized* to have features hypothetically necessitated by the function of ears (cf. 657a19-20).

[46] Cf. *HA* IV.8, 533a25-8 on "indistinct tongues". On articulation and function more generally, *PA* II.16, 659b29-30, III.3, 667a8, *GA* IV.6, 775a2.

[47] Alternatively, supply, with Düring, *tēn d' aisthēsin*: the tonguelike part has perception, but mostly in the tip (by analogy to *HA* II.1, 492b27) (156; see Louis 52n3 for an alternative text with a similar meaning; cf. Peck 201-2).

[48] On the placement of our parts and/or their role as models, see Lennox 1985, 314-5 and 2019, 107-11; Meyer 2006, 30-2; Osborne 2007 (on "pedagogical order": 124n38). When II.10 insists the shape of our external parts is more knowable (656a9-10), I take it that it is so both to us and by nature (*Physics* I.1 184a16-18). (In *HA* I.6,

notes that left and right are "articulated more in some than in others", particularly in those with "instrumental parts" like feet or wings (705b21-2, 24-5; cf. 706a25-6).[49] Other animals may have a functional left and right (705b25-6), but less clearly (705b29)—because they lack right and left "instrumental parts" and so make the "distinctions" (*dialêpseis*) with their body (705b25-6). Moreover, such distinct parts have other appropriate features, such as being positioned "according to nature" in certain places (706a11-2; cf. 706a21-2, 706b3-10), being "detached" and easily moved (706a18-24).

V The causes of bird beaks

Here are the lessons so far. First, highly articulated[50] parts tend to be distinct, and so more able to have appropriate features for parts of their type. Beak channels, in contrast, are not clearly articulated; indeed, this appears to explain why they are not nostrils. Second, polymorphic animals (like humans, Aristotle supposes) have more distinct parts, which can likewise be more specialized. This, I suggest, is what Aristotle thinks makes them good models: because their features can be just the ones that serve their functions, articulated to the appropriate degree for human life, starting with them illuminates exactly how those features serve that function. By comparing beaks to such parts, Aristotle can identify those features and functions—and then show why the resulting causal explanation rules out the articulation that would make beaks noses.

Aristotle does just this in *PA* II.16. Indeed, his next move—after drawing our attention to the channel's lack of articulation—is to make such a comparative claim:

> […] the bird, at any rate, has them in such a way that one would not say it has a nose at all. This is a consequence of the fact that instead of jaws it has what is called a beak. (659b4-6)

This comparative claim—that the beak is "instead of" *jaws*—is Aristotle's justification (*touto de sumbebēken, hoti*) for thinking birds lack noses. In speaking of one part being "instead of" another, Aristotle is often considering whether they are analogues (645b6-10);[51] his idea here is that the beak is analogous to *jaws.*[52] Indeed, III.1 claims, it is a mouth: "the beak, as it is called, is a mouth; for birds have

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491a21-2, emphasis is on knowability to *us*.) Falcon 2018 offers a similar reading of *HA* I.15's claim that these dimensions are "confounded" in non-human animals (494a32): the issue is not that "these functional dimensions are not present" but that they are all "in the same place"; we are not necessarily *psychologically* confounded (49-50). Cf. Wein draft.

[49] I have benefitted from Lennox 2001d, 268-71 and 2010a; Carbone 2011, and especially Corcilius 2022. Corcilius also emphasizes the difference between "functionally determined bodily differentiations" and whether those differentiations are "parts of the body that are set apart"; he notes that these "match exactly the number of points that is necessary and sufficient for accomplishing their functional task" and discusses the normative status of the human in connection with its parts' articulation. Cf. Carbone 2016 on "the *convertibility* of the teleology principle and of the morphology principle" (28).

[50] As Giouli Korobili reminds me, the three parts possessed by all complete animals—cf. *PA* II.10—are "more articulated" in some (*De Juv.* I, 468a17; cf. IV, 469b1-2 on difference in capacity and place); *On Sleep* likewise identifies "three distinct places" (456a2-3). In her commentary, Korobili argues that *De Juv.*'s three "parts" are "sections of the body". These considerations support connections between articulation and distinctness (Korobili 2022).

[51] On analogy, see Henry 2014; Leunissen 2014; Wilson 1997 and 2000 (contrasting it with the *scala*); Lloyd 1996. For caution about the expression, see Wilson 1997, 347 and 2000, 70. All I require is that the uses I focus on here have parallel hypothetical necessity relations.

[52] To my knowledge, Aristotle never claims the beak is "instead of" a nose or nostrils.

this instead of lips and teeth" (662a33-5).[53] IV.12 adds: "in the birds there is a bony beak in place of teeth and lips" (692b18-9). That the beak is a mouth—analogous to jaws, teeth, and lips—is in one respect not surprising. II.10 identified the part "by which they receive nourishment" as necessary (655b29-31). Whatever else Aristotle says about beaks, it must accommodate the facts that birds need such a part and that the beak is the obvious candidate.[54] My question is simply what implications this fact has for what beaks are like—and how Aristotle goes about drawing this out.

Aristotle appears to be arguing that we are justified in denying that birds have noses (and thus nostrils) because their beak is a mouth, given what that mouth is like.[55] This reasoning will work if it entails that beaks are such that they cannot be (even analogous to) noses: that their characteristic features both make them mouths and also prevent them from being noses (and their channels nostrils). This last point is important: the spit-and-lampstand indicates that a part might be of two types (stingers and tongues). Why *does* Aristotle think beaks are not noses—what are *these* mouths like, such that they can't be noses *too*?

The key move emerges in Aristotle's account of what makes beaks mouths—and the human-first reasoning that supports it. A few lines later, he follows up his claim that beaks are "instead of jaws" (659a5) with the claim that they are "in place of teeth and lips" (659b23). Together, both claims support the claim that beaks are mouths, which contain (parts analogous to) teeth, lips, jaws, etc. (661a34-5, 662a20ff.). Aristotle then adduces a thought experiment—which harkens back to *PA* II.10's method of starting with humans:

> For the birds, as we said, for nourishment and strength their beak is bony. It has been joined together into one, in place of teeth and lips, just as if someone who had removed the lips from a human being were both to fuse the upper teeth together, and separately the lower teeth, and then were to draw them both out to a point; in fact this would already be a bird-like beak. (659b21-7)

The thought experiment identifies the human part whose components can be transformed into a "bird-like" beak.[56] This part is a *mouth*—specifically, lips and teeth—and not a nose. It explains how that transformation is achieved: by removing extra bits and accentuating the shapes of the remaining ones.

Why does Aristotle appeal to humans *here*? Notice the claim this reasoning illustrates: that "for nourishment and strength their beak is bony." This remark echoes a similar one above. Immediately after

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[53] *HA* II.12 notes that birds have an unusual *mouth*, in that they have a beak but no teeth or lips; they also have no nose, but only the channels of the nostrils (504a19-22; cf. *HA* IV.8, 533a22-4).

[54] Thanks to Mariska Leunissen and Robert Howton for emphasizing that this point functions as important background.

[55] Thanks to Robert Howton, Mariska Leunissen, and Diana Quarantotto for raising useful questions about this claim's role. I think I agree with Leunissen and Quarantotto that Aristotle's project is to show how having a "mouth" *of the sort birds do*—not just any mouth—means they cannot have articulated nostrils. I believe Leunissen also denies that Aristotle here shows that beaks are not like the spit-and-lampstand (or elephant trunk): that their mouthlike features prevent them from being parts *defined by* the nostril function. My main point, however, is how human parts help Aristotle illuminate the beak's causal structure.

[56] Kullmann 2007 also connects this thought experiment with "die vergleichende Morphologie des Aristoteles, der vom Typus des Menschen aus den Bau anderer Tiere zu verstehen sucht" (479). Carbone 2011 takes it to *rely on* the "l'analogie fonctionnelle des parties concernées" and emphasizes its "topologique" aspect (121; cf. 139-46). Wilson 2000 notes it as a puzzling case for the distinction between differing by analogy and by the "more and less" (59). On thought experiments, cf. Leunissen 2010.

noting that the fact that the bird lacks a nose "is a consequence of the fact that instead of jaws it has what is called a beak" (659b5-6), Aristotle added:

> And these things are so because nature has constituted the birds in this way. […] In order, then, that it may be useful for both physical strength and nourishment, the beak they have is bony; while it is narrow on account of the smallness of their head. And in the beak they have channels for smell, but are unable to have nostrils. (659b6-13)

Here too, Aristotle offers a causal (*aitia de toutōn,* 659b6) explanation of the beak's mouth-like nature, notably, its boniness.[57] The explanation refers to the birds' "nature" and identifies the final cause it aims at: "physical strength and nourishment" (659b9-10; cf. 659b22). Nourishment and strength, importantly, are common and differentiated functions of *teeth* (661b1-2) and sometimes *mouths*, which are constituted by the teeth (661a34-6) and are for nourishment and sometimes strength, respiration, and speech (662a20ff.).

The upshot of the thought experiment (and, generally, the comparative claim) is thus that the final cause that makes beaks *as they are* is analogous to that of human mouths—and that what it explains is likewise analogous. Indeed, its first result is that the main *explanandum* is (as at 659b6-13[58]) teeth-like *boniness* (659b22).[59] For the human parts "fused" and "drawn out"—teeth (659b24-5)—are *bony* (663b29-664a3; cf. 692b18-9). The second result concerns the explanation of those bony features: it is like that of teeth, where boniness promotes "protection" and "advantage" (663b29-664a3; cf. 655b2-13). This reveals what makes comparisons to the human so valuable. The thought experiment shows how these features and final causes "hang together" through transformation. These features are essential to the beak, if it is to be defined by the ends of strength and nourishment.

The resulting causal analysis can, moreover, be used to justify the claim that "in the beak they have channels for smell, but are unable to have nostrils" (659b12-3). A beak like *this* cannot have nostrils "clearly articulated" out of it; it cannot specialize in what nostrils do, for the features it needs for its mouth-like function (e.g. boniness) don't allow for features that promote smelling. *Those* features might include material with a different one of *PA* II.1's "distinct capacities" (646b14-8): cartilage.[60] Parts are cartilaginous "where there is an advantage in the hard part being soft and pulpy, […] as is the case with the ears and nostrils; for brittle appendages are quickly broken" (II.9, 655a29-32.) A nostril should be "easily moved" (*HA* I.11, 492b14); cartilage allows more "fluid" movement (II.9, 655a24). Moreover, longer, more protruding channels also promote smelling (*GA* V.2, 781b8-10). Just as ears capture far off movements (781b15-6), nostrils help us smell from a distance (781b7-13). Thus just as an ear is added to channels because it secures the movement of air through the channel (781b24-6), a nostril is presumably added to channels because it secures the movement of air in smelling.[61] Here we have a more refined statement of features that promote the nostril function. Beaks, however, don't have these features, being

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[57] For the demonstrative character of this explanation, see Kullmann 2007: 474-5.
[58] That claim that the small head explains the narrowness explains the part's differentiation.
[59] I am sympathetic to Wilson 2000's suggestion that "analogy involves not only identity of function, but also material and structural similarities" (69). Lennox has also emphasized this to me.
[60] Birds have channels but lack ears, for "they do not have the sort of matter from which ears may be formed" (II.12, 657a19-20). Cf. n. 47.
[61] Cf. *Sens.* 4 on air in smelling: 443a2.

bony and brittle rather than "soft and pulpy" (II.9 655a29-32), and having channels that do not protrude but are rather near the eyes (II.13, 657b18-9) and mouth (II.16, 659b2).

All in all, while it is *possible* to smell through a beak channel, beaks and their channels lack features that promote this end *as* noses and their nostrils do.[62] The reason is that beaks are defined by nourishment and strength, and so they have features hypothetically necessitated by these ends (of the sort appropriate for a bird's way of life: *PA* IV.12).[63] These features are not compatible with further features that promote smelling—but, the thought experiment reveals, they could not be given up without compromising the beak's mouthlike function. While it is *sometimes* possible for parts to have features that promote multiple functions, most[64] of the relevant features are not options *here:* the beak's lack of nasal articulation is inevitable. In this way, looking to humans clarifies the relations of hypothetical necessity in the beak. It does so because the comparative specialization of polymorphic parts makes these relations especially tight, allowing us to see which features serve which function—what, for instance, boniness does. When Aristotle extends this analysis to beaks, he can spell out its implications for a part's *other* features.

While my focus is Aristotle's use of human models, the present analysis may also reveal why he denies that beak channels are "clearly articulated" enough to count as nostrils, "unless on account of function" (659b2-4). He may be distinguishing *performing* a "function" (birds *do* smell by breathing) from being a *part* that essentially does so (a nostril).[65] If to be defined by a function is to have features that function explains, meeting a minimum threshold of such features—beyond simply having channels—may be necessary for being a *part* of that type. Because less articulated channels are less distinct from the beak's mouth-like features, they may struggle to pass that threshold. They are somewhat like the functional left and right in animals that lack right and left "instrumental parts" (705b21-9; cf. 709b13-4): they perform the function, but lack the *parts*.[66]

VI Concluding remarks

This is the methodological value of polymorphicity: where there are more parts, Aristotle thinks, there can be a tighter relation between their ends and features. Our accounts of that causal structure can serve as models for the explanations of other parts. In *PA* II.16, this approach allows Aristotle to identify the implications of beaks' causal structure for their other features and functions. But while this is the most vivid example, there are others.[67] *PA* II.13 remarks that hard-skinned animals lack eyelids and "in place of this safeguard […] have hard eyes, as if seeing through a fused eyelid" (657b29-35).[68] Aristotle's illustration—"as if seeing through a fused eyelid"— echoes II.16's thought experiment. And here, too,

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[62] Thanks especially to Leunissen and Quarantotto for helpful questions about this section.
[63] Beaks are for nourishment and overpowering, differing according to different ways of life, e.g. a swamp-dwelling life (*PA* IV.12, 693a10-9; cf. 662a35-b); the relevant "articulation" is tuned to *bios.* Cf. Lennox 2010b.
[64] Excluding channels.
[65] Beaks thus differs from elephant noses, which *are* nostrils (659a15), and from stinger-tongues, where there is a trade-off (but not a defeat) between the features required by the ends.
[66] Thanks to Leunissen and Quarantotto for questions and suggestions. Corcilius 2022 also emphasizes articulation of *parts*. *PA* 646b25 calls non-uniform parts, including nostrils, "instrumental". Cf. Lennox 2001b: 182.
[67] Cf. II.14, 658a11-31, 658b2-10.
[68] Hard eyes are in an analogical unity "safeguard for the eye" (II.13, 657a26). Cf. Gotthelf 2012d: 194-5 and 2012a, 210. For other such parts, see 657a35, 657a37, 657b16.

humans are in view: "the human most of all" (II.13, 657a36, b1-2) carries out the eyelid function—a "quick and membranous operation" (657b33)—by *blinking* (657a37).

PA IV.12 also presents an interesting series of comparisons: "while in elephants there is a trunk in place of hands, and in some of the insects a tongue in place of a mouth, in the birds there is a bony beak in place of teeth and lips" (692b15-9). Two of these comparisons implicitly feature humans: II.16 compared beaks to human mouths, and hands are distinctively human parts (IV.9, 687a2-b9).[69] Insect tongues are trickier. Earlier, Aristotle compared these tongues—which also function as stingers and are "intermediate between a sting and a tongue" (679b7-8)—to trunks (II.17, 661a15-29; IV.6, 682b36-83a3; cf. IV.5, 678b22-3), which also function in several ways (II.16, 659a20ff.[70]). That is, he compared them to parts themselves compared to human parts. Moreover, "the so-called sting is inside the mouth, as if the capacities of the tongue and lips were conjoined and possessed together" (IV.5, 682a10-12). The strategy is to examine a transformation of *separate* parts to make sense of the causal structure—the capacities—of *this* one.

The broader lesson, however, is that Aristotle takes humans to be models not only for causal explanations of difficult parts, but also for how to *inquire* into such parts at all: for the importance of comparative anatomy more generally.[71] And here we might have an opening, if we wish to resist his anthropocentrism. Taken seriously, his interest in the tightness of the relation between end and features ought perhaps to have led him to look elsewhere—as he seems to begin to do for insect tongues.

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[69] Cf. Meyer 2006: 32-3.
[70] Cf. Gotthelf 2012d.
[71] Cf. Tipton 2013: 148n10.

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