
Teleology, First Principles, and Scientific Method in Aristotle's Biology by
Allan Gotthelf

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Students of Aristotle may take it nearly for granted today that a rigorous study of his biological writings is worthwhile not just because of the intrinsic merits of those works but also because they can help us to acquire a deeper and more nuanced understanding of other parts and aspects of Aristotle's *oeuvre*—especially his metaphysics and natural philosophy, and his philosophy of science. This view, however, was considerably less popular just a few decades ago. David Balme, and subsequently Allan Gotthelf, James Lennox, and other influential scholars, contributed significantly to this paradigm shift in the field of Aristotelian studies. Besides his work devoted to Ayn Rand's philosophy, Gotthelf is well known as the author of many seminal articles and chapters on ancient philosophy, and as the editor or co-editor of several important books on Aristotle's biological treatises and their philosophical implications. His prominent place in the recent history of Aristotelian scholarship has been acknowledged, among other things, by the publication of *Being, Nature, and Life in Aristotle: Essays in Honor of Allan Gotthelf* [2010].

Teleology, First Principles, and Scientific Method in Aristotle's Biology gathers 16 articles (some based on conference presentations), of which four—chapters 4, 12, 13, and the concluding chapter—were not published previously. Chapter 3 has been significantly expanded. The other 11 have largely been republished here with only relatively minor updates and other modifications, including the cross-references which further accentuate the overall unity of this collection. There is no introductory chapter but the preface is a useful guide to the structure of the book and to the author's intellectual background: for example, readers will find—to their surprise, perhaps, if they are not already acquainted with Gotthelf's work—that his

exposure to Ayn Rand's thinking was instrumental in his own interpretation of Aristotle's philosophy and science.

Gotthelf's analyses are always remarkably clear and are also often infused by a sort of dramatic or quasi-dialogical element. What I mean is that, while other such studies are replete with somewhat impersonal references to earlier scholarship, this book manages to convert many references into a dialogue *sui generis* as the author would seem to engage other scholars before our eyes, as it were; the mention of this or that article or lecture is often accompanied by a vivid narrative excursus—for instance, his impressions from a symposium where a speaker's reaction to questions from the audience was tellingly foreshadowing a controversial book later published by that speaker.

The 15 plus one chapters (the last one is named a 'coda' rather than being numbered) are grouped into five parts. The first four are largely correlated with Aristotle's *Generation of Animals*, *Parts of Animals*, both these works, and his *History of Animals*, respectively.

The first part is concerned primarily with teleology. In 'Aristotle's Conception of Final Causality', which is accompanied by a 'Postscript 1986', Gotthelf aims to clarify a crucial point that Aristotle himself never quite fully elucidated (despite a few theoretical discussions, including *Phys.* 2.8). The question at the heart of this chapter is:

...what, precisely, does Aristotle mean when he asserts that the coming to be (or any stage in the coming to be) of a living organism is for the sake of the mature, functioning organism which results? [6]

This question is the preamble to an investigation into the nature of teleological explanations. The author's analysis turns on the notion of biological irreducibility and implicitly on Aristotle's main explanatory concepts in such contexts—nature (φύσις) and potential (δύναμις). The potential for the end of the development of an organism is, Gotthelf believes, not reducible to what he calls element-potentials (although, as he is careful to point out, the actualization of that potential does involve the actualization of various element-potentials). The claim, then, that earlier stages in the development of an organism are for the sake of the mature organism cannot be grounded on a mechanistic approach to nature or on a set of what we would call today physical and chemical laws. It is also important, we are told, to be mindful of the empirical character of Aristotle's firm reliance on teleology,

as reflected by a number of passages from *De gen. an.* and elsewhere (a point that will be re-emphasized in other chapters). The 'Postscript 1986' responds to interpretations offered by Sorabji and others, and reaffirms the view defended by Gotthelf 10 years earlier about the irreducibility of the potential for form and its philosophical significance.

The second chapter, 'The Place of the Good in Aristotle's Natural Teleology' addresses an aspect that was not examined in the previous chapter (and is central to several scholars' accounts of final causation), namely, the link between the corresponding notions of goal and good. Gotthelf's main point here is that Aristotle does not take a reference to the goodness of an end to be a necessary ingredient of an account of what it is to be a goal or an end. The notion of end does not hinge in biological contexts on a prior concept of good. Instead, goodness itself is to be understood by first grasping the functions of concepts such as actuality and end. The structure of this argument is quite complex and involves several segments devoted to the good, the better, the well, the honorable/valuable, and the divine. Its overall purpose is to argue for a non-normative analysis of ends which appeals systematically to potential or capacity (e.g., potential for development to maturity and for continued life) as the main explanatory tool in Aristotle's science of life. The appendix to this chapter is a response to Scaltsas' suggestion that 'teleological relations cannot be analyzed in terms of the potential-actual relation' [63].

The third chapter, 'Understanding Aristotle's Teleology', while continuing the line of thought deployed in the first two and in other chapters, is meant, among other things, to provide a more comprehensive context for an inquiry into the nature of Aristotelian final causation. Gotthelf outlines some guiding questions under the three headings:

- (1) Analysis:
 - How do natural teleology and final causation in the domain of human action compare with each other?
 - And how are 'being for the sake of' (as a part is for the sake of the whole organism) and 'becoming for the sake of' (pertaining to the development of an organism) related to one another?;
- (2) Basis:
 - Is there an ontological basis for Aristotle's handling of natural teleology, as the author believes is the case, or is it merely an indication of how we understand the workings of nature?;

(3) Extent:

- What is the scope of Aristotle's natural teleology?
- Is it all-encompassing *sub specie primi moventis*?
- Can we also talk of an anthropocentric teleology?

Gotthelf chooses to focus here on questions under the second heading and much of this chapter is a summary and assessment of several approaches to it. Towards the end, he turns his attention to the relevance of Aristotle's notions of irreducible potential and final causation to modern conceptions of directiveness in biology.

In 'Teleology and Embryogenesis in Aristotle's *Generation of Animals* II.6', in addition to studying the theory presented in *De gen. an.* 2.6, Gotthelf explores the larger significance of the scientific and philosophical enterprise in that treatise. His focus, though, is on clarifying the relation between efficient causation and final causation there, and this clarification is achieved partly by taking into account Aristotle's emphasis on the order in which the parts of an animal come to be. The position defended through a careful analysis of the text is that *De gen. an.* 2.6 does not provide a 'bottom-up' account of the early stages in the development of an organism and that it actually conveys

a single, unified account of the entire embryogenesis—an account in which the embryo's formal nature (its potential for form) is playing the central efficient-causal role by 'making use of' material-efficient agents.... [100]

"What's Teleology Got to Do with It"? A Reinterpretation of Aristotle's *Generation of Animals* V' (co-authored with Mariska Leunissen) places special emphasis on *De gen. an.* 5.1 and 8, but the conclusions reached by the authors go far beyond the confines of those two sections. The goal of this chapter is to offer an interpretation which corrects a string of misunderstandings in other studies concerned to various extents with *De gen. an.* 5. According to Gotthelf and Leunissen, this fifth book comes naturally after the investigation carried out in *De gen. an.* 1-4. Besides, it does not deal exclusively with accidental features which are materially necessitated. The analysis of ch. 1 is intended to weaken a possible reading in which Aristotle's distinction between explanations based on material and efficient factors and explanations centered on final causation renders the topics discussed in *De gen. an.* 5 irrelevant to his teleological outlook. In their examination of *De gen. an.* 5.8, the authors distinguish what they call a secondary form of

teleology. Even if certain processes, such as the differentiation of teeth, are explained in material terms (in this case, as being due to what happens with the residual stuff generated originally for the growth of the bones), they are put to work by the nature of an organism in a way that serves that organism. We should, therefore, make a distinction between vital and essential parts which are 'wholly due to form' and subsidiary parts whose causation 'begins from material by-products of the former process' and 'are formed at a later stage and then act according to their own natures' [131].

The last and shortest chapter in this first part is entitled 'Teleology and Spontaneous Generation in Aristotle—A Discussion' and is largely a critique of James Lennox's interpretation of *De gen. an.* 3.11. As Gotthelf readily admits, the theory of spontaneous generation is conceivably problematic for his understanding of Aristotelian teleology: if spontaneous generation is due entirely to element-potentials, then why would the potential for form in non-spontaneous generation be irreducible? And, if the amount of natural heat involved in spontaneous generation is species-specific, then why would teleological explanations apply only to sexual reproduction? On his interpretation, however, the 'pneumatic heat' is not species-specific in spontaneous generation and this sort of generation is likely to involve 'a non-species-specific irreducible potentiality' [145]. Finally, we are cautioned [149–150] not to rely on 'actual' instances of spontaneous generation in Aristotle's works in order to make claims about teleological accounts, since Aristotle contrasts teleology with cases that are imaginary or otherwise distinct from the sort of 'actual' spontaneous generation that he occasionally writes about.

The second part of this book is devoted to 'First Principles and Explanatory Structure in Parts of Animals'. Chapter 7 ('First Principles in Aristotle's Parts of Animals'), is an (avowedly incomplete) answer to the question whether Aristotle's theory of science, as set forth mainly in the *Posterior Analytics*, is compatible with the types of definitions and explanations used in *Parts of Animals* (and possibly elsewhere in Aristotle's biological corpus). Can we find demonstrations 'in a fairly strong sense' [174] in *De part. an.* 2–4? Is there an axiomatic structure in the explanatory apparatus of *De part. an.*? Gotthelf argues that we can detect an implicit axiomatic structure there and pays special attention to the first principles (i.e., facts 'which are not themselves explained by reference to more basic facts' [155]) incorporated in those structures. First principles that underlie the explanations offered

in *De part. an.* 2–4 involve both defining aspects of the material nature of animals or parts of animals and formal (and final) aspects. Partial definitions are also afforded ‘at all levels of generality’ [178] in *De part. an.*

Throughout this chapter and indeed throughout this book, as I mentioned at the outset, one is left with the impression that Gotthelf has been engaged in a very lively dialogue indeed, and that voices other than his are also distinctly audible in this interpretative drama. This chapter starts with a critique of Barnes’ observations about the discrepancy between the *Posterior Analytics* and Aristotle’s biology, and concludes with sympathetic reflections on Kosman’s view that the *Posterior Analytics*

should be understood as offering a formal description of proper science, not a requirement that proper science itself be formal [181]

and with a rebuttal of Lloyd’s distinction between lumpers and splitters (the debate, more appropriately put, we are told, is between integrators and fragmenters).

The topic of chapter 7 is scrutinized in the next one too (‘The Elephant’s Nose: Further Reflections on the Axiomatic Structure of Biological Explanation in Aristotle’), where the emphasis is on the use of premises in *De part. an.* 2.16. The complexity of the explanation at hand is demonstrated in part by two diagrams. The first one indicates a generic ‘linear, branching structure’; the second one is meant to show that in practice this structure is more complicated, as the number of final features is bound to be much greater than that of primitive features. We are also reminded that the overall structure of the explanation is in fact far more intricate even than the second diagram if we combine the explanations for all the distinctive features of the elephant, not just for its trunk, let alone if we also care to expand this explanatory model by taking into consideration the features of other species discussed in *De part. an.* as well. The list of premises used in this particular explanation include: material principles which echo works dealing with the so-called elements and with uniform stuffs; ‘the postulation of the existence of an elephant kind’ [190]; and two types of teleological principles (formal natures are ends; formal natures operate for the best).

In ‘Division and Explanation in Aristotle’s *Parts of Animals*’ [ch. 9], Gotthelf draws our attention to a paradox: Aristotle seemed keen on reforming Plato’s method of division—he does away with sheer dichotomy and uses, for in-

stance, multiple *differentiae* simultaneously—and elaborated on this topic at some length in the *Posterior Analytics* [e.g., 2.13] as well as in chapters 2 and 3 of *De part. an.* 1. What then, wonders the author, is the role played by the method of division in the biological works proper, that is, in *De part. an.* 2–4 and elsewhere? And, if that method is used to any significant degree, what might be the connection between its application in biology and the more theoretical passages in *De part. an.* 1 and the *Analytics*? With a modesty and a frankness that are admirably displayed on several occasions in this book, Gotthelf acknowledges that he can only try to shed more light on this issue and cannot assume in this relatively short chapter the task of answering this twofold question exhaustively and definitively. After surveying several major contributions to the study of the method of division (notably by James Lennox), Gotthelf notes the importance of division at a pre-explanatory stage in Aristotelian science. The question remains, however, whether division is involved in ‘unqualified demonstration’. On his reading, *De part. an.* 1.5 yields the following requirement: one is to

explain the differences in some generic attribute (e.g., feathers) across sub-kinds of a large kind (e.g., Bird) by reference to the differences, across these sub-kinds, in the features which explain the presence of that generic attribute in the large kind. [204]

This requirement is taken to hold of much of *De part. an.* 2–4. In the conclusion to this chapter, Gotthelf demonstrates that the differentiations of the features that are supposed to be explained and of those that are mentioned in order to explain the former amount to genuine divisions. Those divisions mirror Aristotle’s more theoretical discussions about διαίρεσις quite faithfully with respect to his ‘reformed’ method and to the functions it is supposed to fulfill. The answer to the question ‘Are divisions involved in demonstration?’ is, thus, a firm ‘Yes’.

The title of part 3, ‘Metaphysical Themes in *De part. an.* and *GA*’, announces not a new topic in this book (virtually all the chapters gathered in this collection deal to some extent with the metaphysical implications of Aristotle’s biology), but a more direct approach to those themes and a more sustained effort to explain them. In ‘Notes towards a Study of Substance and Essence in Aristotle’s *Parts of Animals* II-IV’, Gotthelf reminds us about the intrinsic importance of exploring the metaphysical content of biological works like *De part. an.*, and about the possibility that such studies could put us in a

better position to explain a number of complicated issues emerging, e.g., from *Metaphysics Z*. The task at hand is limited to answering a question about Aristotle's biology, especially his *De part. an.* 2–4: 'With what conceptions of substance and essence, if any, does Aristotle operate in the biology?' [217]. The bulk of this chapter is a succinct but illuminating commentary on 10 passages—nine from *De part. an.* (mainly from book 4) and one from *Progression of Animals*—containing partial definitions. These are the passages where Aristotle either contends that a particular feature belongs to the οὐσία or λόγος τῆς οὐσίας, and so forth, of an organism of a certain kind or makes more general methodological statements involving references to substance or essence. The 'interim conclusions' focus on the wide range of formulations used to express the definitional relation between some feature and the οὐσία of a certain type of organism, as well as on the content of those partial definitions (covering soul-functions, uniform and non-uniform parts, and the 'chemical' composition of a certain kind of organism) and on the different levels of generality at which the definition is situated, no level (e.g., the *infima species*) being granted a privileged status.

The second panel in this diptych is a chapter on 'Biological Provenance. Reflections on Montgomery Furth's *Substance, Form and Psyche: An Aristotelian Metaphysics*'. Here we are invited to consider the plausibility of Furth's strong claim that the theory of material substance as articulated in the central books of the *Metaphysics* has its ultimate source in (and was initially meant as a 'deep theoretical foundation for') his biological theories. Following a historical survey intended to underline the radical, nay 'reactionary', nature of Furth's position, Gotthelf evaluates its accomplishments as well as its somewhat surprising shortcomings. Furth resorts to a sort of intuitive argument that the overall landscape of Aristotle's biological corpus points to the origin of some of Aristotle's presumably later, more 'metaphysically' formulated concerns with material substance. Gotthelf is sympathetic to the general direction of this argument but justifiably deplores the absence of a clearer, more concrete, and deliberate examination of textual evidence for that strong claim. His own contribution to this discussion is probably clearest on pages 250–251, where he notes that 'the very same irreducibility that underwrites Aristotle's natural teleology underwrites his theory of substance' (cf. the first part of this collection). In other words, a formal nature or an animal's 'mode of action as a whole' cannot be fully explained in terms of the δυνάμεις of an organism's material constituents. This chapter ends with

a qualified encomium: perhaps Furth did not sufficiently bolster his strong thesis but he did mount a vigorous and effective defense of the weaker claim, namely, that the study of the biological corpus can help us to understand better some of the dominant and sometimes intractable aspects of Aristotle's metaphysics, as treated, e.g., in the central books of the *Metaphysics*.

The protagonist in part 4 is *Historia animalium*. Chapter 12 ('Data-Organization, Classification, and Kinds: The Place of the *History of Animals* in Aristotle's Biological Enterprise') deals with a set of baffling questions pertaining to this massive treatise:

- What are its goals?
- Is it (mainly) concerned with a classification of animals?
- Are the kinds invoked in *Hist. an.* systematically embedded in such taxonomy?
- Does *Hist. an.* reflect precepts central to Aristotle's theory of science?

The long debate surrounding the functions of *Hist. an.* within Aristotle's biological corpus was fueled in part by the perplexing organization (or apparent lack thereof) of the vast number of observations and correlations that one can find there. A succinct history of attempts to determine the goals of *Hist. an.* culminates with a series of extensive comments on David Balme's approach.

Balme rejected the notion that *Hist. an.* displays a systematic classification of animals. The 'very large kinds' (μέγιστα γένη)—fishes, birds, and so on—do not constitute an exhaustive list and there are no obvious intermediate kinds forming genuine natural kinds. The core of this chapter is an outline of Balme's positive view of the goals of *Hist. an.*, a view that has been confirmed and substantially enriched more recently by Gotthelf, Lennox, and others. Aristotle's detailed account of διαφοραί makes it possible for Aristotle to delineate 'significant groupings of *differentiae*', which in turn are a necessary condition for implicit or explicit causal explanatory accounts. This connection echoes tenets of Aristotle's theory of science and marks

a two-stage progression...that first reaches a knowledge that (ὄτι) an attribute is possessed by a subject kind and then moves from there to knowing why (διότι) it does. [278]

Gotthelf continues by elaborating on suggestions by Charles and Lennox that, although *Hist. an.* is not an attempt to build a proper classification of

animals, it may still provide evidence for how the μέγιστα γένη could be established); and on their epistemological implications.

This chapter, the text of a two-part seminar, is accompanied by a short appendix, an excerpt from a paper written with Pieter Beullens ('A Case for the Ordering of the Books of *Hist. an.* 7–9 and a Question about the Biological Study of Man that Arises Therefrom') which argues that the ordering offered by the manuscripts is preferable to Theodore Gaza's reordering.

Chapter 13 ('*History of Animals* I.6 490b7–491a6: Aristotle's *megista genē*') reads like a natural continuation of chapter 12 and, in some way, it is an expanded version of a qualification made there: although establishing animal kinds is not the principal aim of *Hist. an.*, it was nonetheless on Aristotle's mind when he wrote what we refer to today as *Hist. an.* 1.6. The passage appears to be an important methodological statement but its elliptic style and the potentially confusing transitions between its three main sections make the interpretation all the more arduous. Part of what is going on there has to do, Gotthelf suggests, with Aristotle's addition of two groups which did not have any names consecrated by tradition (live-bearing four-footed animals and egg-laying four-footed animals) to a list of seven μέγιστα γένη 'already accepted from common language' [299]: birds, fishes, cetacean, hard-shelled, insects, and so on [see 490b7–14]. The last sections of this chapter focus (in the context of the division of four-footed animals into two very large kinds, live-bearing and egg-laying) on the nature of sub-kinds or intermediate kinds.

The third chapter in part 4 ('*Historiae I: Plantarum et Animalium*') is a comparative study which contends inspiredly that Theophrastus' *Historia plantarum* is basically modeled after Aristotle's *Hist. an.* and that Theophrastus was mindful of the goals of *Hist. an.* when working on his own treatise. The analysis is confined to *Hist. plant.* 1 and *Hist. an.* 1–4. In the section about *Hist. an.*, Gotthelf sums up Balme's (re)interpretation and Lennox's 'amendment' (accepted by Gotthelf), which essentially connect the organization of data in *Hist. an.* and (implicitly) its discussion about animal differences with Aristotle's causal explanations of the natures of animals (a project actually carried out in other biological works) as well as with his theory of demonstration as outlined in the *Posterior Analytics*. In the section on Theophrastus' *Hist. plant.*, Gotthelf presents and evaluates the striking or subtle similarities between the structure of (portions of) *Hist. plant.* and of *Hist. an.*, and also between the criteria used for the division of *differentiae*

in the two *Historiae*. Theophrastus' treatment of μέγιστα γένη like trees and herbaceous plants may mirror the way in which very large kinds are circumscribed in *Hist. an.* but seems 'less sure', possibly because it betrays his inability 'fully to master the material, shaping it to the intended structure, or an inability fully to master the theoretical structure itself' [329]. To return to the goals of *Hist. plant.*: as Gotthelf argues convincingly, it is not a mere natural history where the material is arranged according to types of plants; rather, it is 'a collection, an analysis, by *differentiae*' [333], much like *Hist. an.* However, there may be more to *Hist. plant.* than one might be tempted to acknowledge after a cursory reading of its nine books. Based on his close analysis of passages from *Hist. plant.* as well as from Theophrastus' *Metaphysics*, Gotthelf suggests that the ultimate purpose of *Hist. plant.* is very likely the discovery of causes—and this is reminiscent of the ultimate goal of *Hist. an.* Both treatises set forth the *differentiae* that mark out kinds of animals or plants, while also aiming to provide the foundation for a causal explanation of the natures of living beings. If *Hist. plant.* was indeed modeled after *Hist. an.*, and if our author's interpretation is correct, this further supports the approach to *Hist. an.* defended by Balme, Gotthelf, and Lennox.

The fifth part ('Aristotle as Theoretical Biologist') could very well serve as a double introduction to the whole book, albeit it is placed at the end. Readers who are familiar with Darwin and want to learn more about earlier episodes (and their reception) in the history of the life sciences, may want to read chapter 15 first. Alternatively, readers who want to get first a bird's-eye view of some of Gotthelf's most influential views pertaining to Aristotle's biology, will find the last chapter (the coda) to be a particularly clear and helpful guide.

The chapter entitled 'Darwin on Aristotle' was motivated, as the author confesses in the preface, 'by a strong streak of hero-worship' [ix]. On 22 February 1882, Darwin wrote a letter to William Ogle, who had recently translated *Parts of Animals* and had sent him a copy of the book. Gotthelf's polemic is directed at those who attempt to demonstrate that Darwin's overt enthusiasm at realizing Aristotle's contribution to the birth of biology is but a polite expression of gratitude for Ogle's generous gesture. As Gotthelf points out, though, this is a second and unsolicited letter to Ogle, and so is likely to give the measure of Darwin's genuine admiration for an important section of Aristotle's biological corpus, admiration that—our author speculates plau-

sibly—may have been based to some extent on his partial grasp of Aristotle’s treatment of teleology.

The coda to this book, ‘Aristotle as Scientist: A Proper Verdict (with Emphasis on His Biological Works)’, is based on a paper that Gotthelf presented on various occasions between 1987 and 2001. It is chiefly an *apologia* meant to allow a wide audience to become properly acquainted with Aristotle’s biological works and with their philosophical significance. This chapter effectively dismantles traditional misunderstandings such as that Aristotle is an armchair theorist, indeed a non-scientist, that he qualifies as a pre-scientist, and that he is a scientist who distinguished himself as a careful observer of nature. This third claim is not fundamentally wrong but it is clearly insufficient. The accuracy of Aristotle’s observations is revealed here by a brief discussion of several memorable examples (including the catfish and the octopus). While those observations and insights—some of which were confirmed only rather recently—are themselves impressive, the larger scientific and philosophical project underlying the main biological treatises (as well as *Progression of Animals*, *Motion of Animals*, *On the Soul*, and *Parva naturalia*) was ‘to understand what animals are (i.e., what features they have), and why they are as they are’ [379], and to organize a vast amount of data in a way that will make such understanding and explanation possible. The remaining segments of this chapter are succinct overviews of cardinal aspects of Aristotle’s biology, such as the empirical approach that permeates his treatment of final causation and the implicit axiomatic structure of his scientific explanations. Thus, the coda gives new prominence to several major topics explored throughout the book and strengthens the symphonic unity of this comprehensive investigation. It is also a convenient reminder that these are Gotthelf’s crucial contributions to this field; indeed, the author himself notes in the preface that

...I view my interpretation of Aristotle’s natural teleology, and my account of the broadly axiomatic structure of biological explanations, as my most important work. [ix]

Gotthelf’s readers—whether they are just embarking on the study of Aristotle’s biological theories or whether they are already accomplished scholars in this field or are more generally interested in ancient philosophy—will find in this collection an eminently reliable and illuminating study of one of the most fascinating episodes in the history of science and philosophy.

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