Explanation and Teleology in Aristotle's Science of Nature

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In Aristotle's teleological view of the world, natural things come to be and are present for the sake of some function or end (for example, wings are present in birds for the sake of flying). Whereas much recent scholarship has focused on uncovering the (meta-)physical underpinnings of Aristotle's teleology and its contrasts with his notions of chance and necessity, this book examines Aristotle's use of the theory of natural teleology in producing explanations of natural phenomena. Close analyses of Aristotle's natural treatises and his *Posterior Analytics* show what methods are used for the discovery of functions or ends that figure in teleological explanations, how these explanations are structured, and how well they work in making sense of phenomena. The book will be valuable for all those who are interested in Aristotle's natural science, his philosophy of science, and his biology.

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CAMBRIDGE
UNIVERSITY PRESS

CAMBRIDGE UNIVERSITY PRESS
Cambridge, New York, Melbourne, Madrid, Cape Town, Singapore,
São Paulo, Delhi, Dubai, Tokyo

Cambridge University Press
The Edinburgh Building, Cambridge CB2 8RU, UK

Published in the United States of America by Cambridge University Press, New York

www.cambridge.org
Information on this title: www.cambridge.org/9780521197748

First published in print format 2010

ISBN-13 978-0-511-90200-0 eBook (NetLibrary)

ISBN-13 978-0-521-19774-8 Hardback

For Jeff

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Figure and tables

Acknowledgements

It is a great pleasure to acknowledge the many people who have contributed to the completion of this book.

I owe special thanks to those who read and provided detailed criticisms of the complete book in one of its various stages: Frans de Haas, Jim Hankinson, Jim Lennox, David Charles, Peter Stork, Sean Coughlin, and the readers for Cambridge University Press. Their comments have helped me to clarify and improve my arguments in countless places and have saved me from many errors. The errors that remain are solely my responsibility, and, of course, none of those mentioned above should be presumed to agree with the views expressed here. I also note my gratitude to Hilary Gaskin at Cambridge University Press for her patience and help on the manuscript.

My work has also benefited enormously from the comments I received on individual chapters and other parts of the manuscript. I particularly thank Bert van den Berg, Allan Bowen, Lesley Dean-Jones, Pieter Sjoerd Hasper, Devin Henry, Marije Martijn, Alex Mourelatos, Ineke Sluiter, David Sedley, Steve White, Christian Wildberg, my colleagues Anne Margaret Baxley, Eric Brown, Carl Craver, Dennis Des Chene, and John Doris, and all those who have participated in the discussion at the various conferences, colloquia, and classrooms where this material was presented.

The book was begun as a doctoral dissertation in the Faculty of Philosophy at Leiden University, and I am grateful for their support. Parts of the dissertation were completed while I was a visiting scholar in the Joint Program in Ancient Philosophy at the University of Texas at Austin, and I thank the Philosophy and Classics departments there for sponsoring my numerous visits, Jim Hankinson for being my advisor and friend at the same time, and the Leiden University Fund and OIKOS (the National Research School of Classical Studies in the Netherlands) for their financial support. The book has undergone its most substantial transformations since I joined the Philosophy Department at Washington University in

St. Louis. I thank my colleagues there for their encouragement, advice, and friendship.

Finally, I would like to thank my family and friends: my family whom I left behind in the Netherlands for their continuous support and encouragement; and my dearest old and new friends – in particular Carolien Trieschnigg, Maithe Hulskamp, Juliette Kars, Simine Vazire, and Emily Austin – for sharing all my laughs and tears, and for making me feel at home no matter where I am.

My deepest expression of gratitude goes to my husband, Jeff Laux, for his love, his invincible optimism, and for making everything worthwhile. You mean the world to me.

I should also like to thank Kelowna Publishers for their kind permission to reprint a slightly modified version of "Nature as a good Housekeeper: Secondary Teleology and Material Necessity in Aristotle's Biology" (forthcoming in *Apeiron*) as part of Chapter 3; Brill Publishers for their kind permission to reprint an expanded version of "Why Stars have no Feet: Teleological Explanations in Aristotle's Cosmology" (which appeared in A. C. Bowen and C. Wildberg (eds.), *New Perspectives on Aristotle's De Caelo*, Leiden, 2009, 245–271) as Chapter 5; and Oxford University Press for their kind permission to reprint an expanded version of "The Structure of Teleological Explanations in Aristotle: Theory and Practice" (which appeared in *Oxford Studies in Ancient Philosophy* 33, 2007, 145–178) as Chapter 6.

Abbreviations

ARISTOTLE'S WORKS

APo	*Analytica Posteriora* (*Posterior Analytics*)
APr	*Analytica Priora* (*Prior Analytics*)
Cael	*De Caelo* (*On the Heavens*)
DA	*De Anima* (*On the Soul*)
EE	*Ethica Eudemia* (*Eudemian Ethics*)
GA	*De Generatione Animalium* (*Generation of Animals*)
GC	*De Generatione et Corruptione* (*On Generation and Destruction*)
HA	*Historia Animalium* (*History of Animals*)
IA	*De Incessu Animalium* (*On Animal Progression*)
Juv	*De Juventute et Senectute* (*On Youth and Old Age*)
MA	*De Motu Animalium* (*On Animal Motion*)
Meta	*Metaphysica* (*Metaphysics*)
Meteor	*Meteorologica* (*Meteorology*)
NE	*Ethica Nicomachea* (*Nicomachean Ethics*)
PA	*De Partibus Animalium* (*On the Parts of Animals*)
Ph	*Physica* (*Physics*)
Pol	*Politica* (*Politics*)
Resp	*De Respiratione* (*On Respiration*)
Rh	*Rhetorica* (*Rhetoric*)
Sens	*De Sensu et Sensibilibus* (*On Sense and Sensibilia*)
Somn	*De Somno et Vigilia* (*On Sleep and Waking*)
Top	*Topica* (*Topics*)

WORKS BY OTHER GREEK AUTHORS

Euclid (Euc.)

El	*Elements*

Galenus (Gal.)
Meth Med *Methodus Medendi (On the Therapeutic Method)*
Philoponus (Phlp.)
In APo *In Aristotelis Analytica Posteriora commentaria*
Plato (Pl.)
R *Republic*
Smp *Symposium*
Ti *Timaeus*
Simplicius (Simp.)
In Cael *In Aristotelis de Caelo commentaria*
In Ph *In Aristotelis Physica commentaria*
Xenophon (X.)
An *Anabasis*
Cyr *Cyropaedia*

OTHER ABBREVIATIONS

DK H. Diels, rev. W. Kranz (1961), *Die Fragmente der Vorsokratiker*, 10th edn. Berlin.
Fr. Fragment

The texts cited in this book are all taken from the *Thesaurus Linguae Graecae Canon of Greek Authors and Works* (*TLG*), 3rd edn. (1990), Oxford. All translations are mine.

References to Plato follow the Stephanus pagination as found in the Oxford Classical Texts (OCT), J. Burnet (ed.) (1900–22), *Platonis Opera*, 5 vols., Oxford.

References to Greek Commentators are to H. Diels (ed.), *Commentaria in Aristotelem Graeca* (*CIAG*) (1892–1909), Berlin.

Introduction

Why do organisms reproduce? Why do birds have wings? Why do neither snakes nor stars have feet? And why do most of the hoofed life-bearing animals have horns (but not all of them)?

For Aristotle, questions such as these go to the heart of natural philosophy, which is the study of the coming to be and presence of beings that have their own internal principle of change and rest. Throughout his lifetime, Aristotle was deeply committed to investigating and explaining natural phenomena, which is reflected all through the surviving treatises on natural philosophy. Among these, Aristotle's *Physica* is most fundamental. In this treatise, Aristotle lays out the general theoretical framework for his natural philosophy, defining notions such as nature, motion, causation, place, and time. In the other treatises, Aristotle explores more specific problems related to the study of natural beings, such as coming to be and passing away (in *De Generatione et Corruptione*), the nature and motion of the elements (in *De Generatione et Corruptione* and the second part of the *De Caelo*), the motions and features of the heavenly bodies (in the first part of the *De Caelo*), atmospheric causes and changes (in the *Meteorologica*), the notion of soul and its dependence on natural bodies (in *De Anima*), and finally, the causes of the coming to be and presence of living beings and of their parts and motions (in the biological works).

What unites the questions explored in these natural treatises, exemplified by the questions above, is that they are predominantly questions asking for the purpose of things, or, as Aristotle puts it, questions asking for "that for the sake of which." By posing this specific kind of why question, Aristotle is inquiring after the *function* served by the presence, absence, or material and structural differentiation of a certain natural feature, or after the *goal* for the sake of which some natural process or animal motion takes place. According to Aristotle's understanding of scientific knowledge, the answers to these specific why questions constitute teleological explanations, because they pick out the final cause (in the form of a function or goal) for the sake

of which something has come to be or is present (or absent, etc.). These teleological explanations are a central feature of Aristotle's investigation of nature and reflect the importance he attributes to final causality in the coming to be and presence of regular natural phenomena. In Aristotle's view of the world, everything that exists or comes to be "by nature" comes to be or changes, unless prevented, for a purpose and towards an end, and is present for the sake of that purpose or end. This goal-directedness is an internal tendency possessed by all natural things, which means that teleology operates among all of nature, from the level of the inanimate elements, through that of living beings, and on to the eternal realm of the heavenly bodies.

Although the importance of teleology for Aristotle (and in the ancient world in general)[1] has been acknowledged widely,[2] its nature and scope have consistently been the focus of much debate.[3] These debates have progressively led to a better understanding of Aristotle's theory of natural teleology, and especially of its (meta-)physical underpinnings and its contrasts with Aristotle's notions of chance and necessity.[4] What is lacking in the literature, however, is a precise and comprehensive understanding of the role Aristotle attributes to teleology in *explaining* natural phenomena throughout Aristotle's natural scientific works. Setting aside the other issues that remain concerning the causal nature and scope of teleology, the question that this book sets out to resolve is how – granted that Aristotle has established final causality as a cause of natural phenomena – he then *uses* (e.g., refers to, draws inferences from, builds premises upon, rejects other possible explanations on the basis of) this theory of teleology in his explanations of such phenomena.

The present book, then, provides a new perspective on Aristotle's teleology by exploring and evaluating its *scientific role* in generating

[1] Hankinson (1998, 6).

[2] E.g., Caston (2006, 341); Gotthelf and Lennox (1987, 199); Gotthelf (1997b, 82); and Johnson (2005, 1–2).

[3] Cf. Quarantotto (2005, 17). For a historical overview of the trends and circumstances that shaped the earlier interpretations of Aristotle, see Johnson (2005, 15–39). On the nature of Aristotle's teleology, see in particular Bradie and Miller (1999); Cameron (2002); Charles (1988); Cooper (1982; 1985; 1987); Gotthelf (1987); Irwin (1988); Johnson (2005); Lennox (2001a); Nussbaum (1978); Sauvé Meyer (1992); Scharle (2008); Sorabji (1980); and Wieland (1975). On the metaphysics of Aristotle's teleology, see in particular Charles (1994); Mirus (2004); Pavloupoulos (2003); and Witt (1998). On the scope of Aristotle's teleology, see in particular Cooper (1982); Furley (1985); Matthen (2001; 2009); Owens (1968); Sedley (1991); and Wardy (1993).

[4] See especially Johnson (2005), who brings together many of the recent new insights concerning Aristotle's teleology in his monograph, and explicitly addresses and eliminates some of its most persistent "popular misconceptions." See also Cooper (1982, 1985; 1987) and Lennox (2001a, 225 and 251).

causal explanations of natural phenomena, both in the actual explanations recorded in Aristotle's natural treatises and more abstractly in his philosophy of science.

The core of my book, consisting of Chapters 1 to 5, investigates the function, structure, and explanatory power of Aristotle's actual teleological explanations of natural phenomena. This involves a close reading of selected texts in four of Aristotle's treatises on natural science, that is, in the *Physica* (book II), *De Anima, De Partibus Animalium* (including the practice in books II–IV), and *De Caelo* (book II). These are the treatises that are most relevant to the present investigation in that they cover the main areas of Aristotle's natural science,[5] and include texts that have often been ignored in previous studies of Aristotle's teleology.[6]

In the final chapter, which is Chapter 6, I juxtapose these findings concerning Aristotle's practice in the treatises on natural science with the theoretical picture of the structure of teleological explanations gained from Aristotle's theory of scientific demonstration.[7] For this purpose I present a new interpretation of *Analytica Posteriora* II.11, a notoriously difficult chapter in which Aristotle introduces his theory of four causes into the syllogistic framework of scientific demonstration. This study thereby contributes to recent scholarship on the interplay between Aristotle's philosophy of science and philosophy of nature,[8] while at the same time adding to our knowledge of Aristotle's theory of teleology in terms of its explanatory merits and limits.

[5] Note that although this book explores Aristotle's theory and practice of providing teleological explanations as comprehensively as possible, due to the limits of space and time I have narrowed down this study to Aristotle's *science of living nature*. On a few occasions, I have something to say about the (non-natural) teleology of deliberate action as well, but the ethical and political works of Aristotle mostly fall outside the scope of this book. My central hypothesis is that Aristotle developed his notion of "that for the sake of which" primarily in the context of his investigations of living nature and that this is where he applied the notion most successfully; a further study of the use of teleology in generating explanations in, among others, his ethics or politics, would have to start from and build upon the more "basic" uses in the natural treatises.

[6] Cf. Quarantotto (2005, 27). Quarantotto points to *Ph* II.8–9 and *PA* I.1 as the key texts on which most scholars have based their interpretation of Aristotle's notion of teleology; in her own work, she studies teleology from a more comprehensive perspective, including the whole of *Physica* book II, the whole of *De Partibus Animalium*, a few passages from *De Anima*, and *Meta* I.3–10.

[7] Although there have been quite a few studies on the nature of Aristotle's (teleological) explanations within the context of the first book of the *PA* and the second book of the *Physica*: see especially Balme (1987b); Bolton (1987; 1997); Charles (1997; 1999); Detel (1997; 1999); Gotthelf (1987; 1997a); Lennox (2001a) and Pellegrin (1986), with a few exceptions (i.e., Bolton 1997; Detel 1997; and Johnson 2005), Aristotle's theoretical remarks on the structure of teleological explanations in *APo* II.11 have been ignored.

[8] For this research program, see in particular Lennox (2001a, 1–6; 1997a; 2004a; 2006), and Lloyd (1990; 1996, 7–37).

In the course of these six chapters, I defend three main theses: first, that Aristotle postulates not one, but *two types of teleological causation* as underlying the coming into being and presence of regular beneficial outcomes in nature; second, that he uses teleological principles as *heuristic tools* for the discovery of causally relevant features to be picked out in causal explanations, where the causes that are being discovered, including the final causes, are real causes and not mere epistemic reasons why;[9] and, finally, that Aristotle never attributes *causal primacy* to final causes in his explanations (even though he believes they are "prior in nature"), but only *explanatory primacy*. This means, among other things, that his teleology resists the – in itself already anachronistic – charge of backward causation. Let me say more about these three theses in turn and indicate in which chapters I defend them.

First, I argue that a more thorough understanding of Aristotle's use of teleology in the explanation of natural phenomena requires that we distinguish between two types of teleological causation, a primary and a secondary type, which are both represented in Aristotle's explanations.

The primary type of teleology involves the realization of a preexisting, internal potential (or perhaps "potentials") for form[10] through stages shaped by conditional necessity. This is the "standard" form of teleology, according to which the form of the natural being specifies the functional features that are to be realized through the goal-directed actions of the formal nature; what is picked out as causally primary in the explanations of such features is the natural being's form. For instance, birds have wings for the sake of flying, but the need to perform this activity derives from the essential nature of birds, which is being a flyer. Wings, then, are exhibited to be the necessary prerequisites for the realization of the bird's form as flyer. Explanations of phenomena that have come to be and are present as the result of primary teleology (such as wings) thus typically include references both to the ends that constitute final causes (e.g., functions such as "flying") and to the definition of the substantial being of the organism in question (e.g., definitions such as "being a flyer"), which constitutes its formal cause.

The secondary type of teleology involves a formal nature of a natural being *using* materials that happen to be available (usually residues

[9] Note that I take Aristotle to be a realist about (final) causation – it is only his *use* of teleological *principles* such as "nature does nothing in vain" that I argue serves heuristic purposes. I do not believe that his theory of teleology as a whole is heuristic.

[10] My characterization of "primary teleology" builds on the understanding of teleological causation in the case of animal generation provided in Gotthelf (1987).

that have come to be of material necessity and that are not conditionally necessitated) for the production of parts that serve the animal's well-being. The presence of these parts is not a necessary prerequisite for the realization of the animal's form; instead, their presence is said to be "for the better." For instance, large land animals often have a surplus of earthen material, which – because of its hard potential – nature then uses for the production of horns in males, which serve the (non-necessary) function of defense. In these cases, functional features emerge as it were from the potentials of the materials that happen to be available, and the operation of the formal nature is secondary to the operation of material necessity that produced the materials. Explanations of phenomena that are the result of secondary teleology (such as horns) thus typically distinguish between the presence and the coming to be of those phenomena, where the presence is explained teleologically by reference to an end that constitutes the final cause (e.g., the function of "defense" served by the part) and the coming to be by reference to material necessity.[11]

Scholars usually try to reconstruct the causal nature of Aristotle's teleology by contrasting it to material necessity and chance, and therefore tend to reduce Aristotle's own references to material causation in teleological explanations to expressions of conditional necessity. By distinguishing primary from secondary teleology, however, it is possible to give an account of the role of necessity in teleological explanation that does not involve a reduction of material necessity to conditional necessity in all cases.[12] This interpretation also counteracts another unfortunate tendency among scholars, which is to treat all teleological explanations found in Aristotle's treatises as one homogeneous category, unified simply by the fact that the explanations all refer in some way or another to the goal-directedness of

[11] My distinction between primary and secondary teleology does not rely upon Aristotle's own distinction between two types of final causes, which are "that for the sake of which" and "that for the benefit of which" (he makes this distinction in, for instance, *Ph* II.2, 194a34–b1; *DA* II.4, 415b2–3; *DA* II.4, 415b20–21; *Meta* XII.7, 1072b1–3; and *EE* VII.15, 1249b15), and differs in that way from the interpretations of Kullmann, Bodnár, and Johnson. Kullmann (1985, 173) uses the term "secondary teleology" to indicate that an end is the beneficiary of something, but not a "that for the sake of which" in a strict sense. Bodnár (2005; 24–25) also builds upon Aristotle's own distinction: in "straightforward" teleology, the goals are not also the beneficiary of the teleological structure, while in inter-species teleology the goals are the beneficiary of the teleological structure. Finally, Johnson (2005) uses the distinction between the "that for the sake of which" and the beneficiary as one of his central tools for making sense of Aristotle's explanations. None differentiate between "primary" and "secondary" teleology in the way that I propose.

[12] My interpretation is aimed mostly against scholars who have either explained away the role of material necessity in teleological explanations (Balme, 1987c); reduced it to conditional necessity (Cooper, 1987; Johnson, 2005); or assigned to it primarily a "negative" role in constraining the realizations of function (Lennox, 2001a).

nature.[13] This tendency not only obscures the diversity and versatility of Aristotle's modes of explanation, but also leads to an impoverished understanding of the explanatory power of teleology.

I introduce the distinction between primary and secondary teleology in Chapters 1 and 2. More specifically, Chapter 1 shows how this distinction operates in Aristotle's defense of natural teleology in the famous rainfall example in *Physica* II.8. Chapter 2 demonstrates how it underlies Aristotle's conceptions of "living" versus "living well" in *De Anima*, which in their turn are used to ground the specific sets of capacities different kinds of living beings have. The causal patterns underlying the distinction between primary and secondary teleology are developed most fully in Chapter 3, which examines Aristotle's scientific theory of explanation in biology as introduced in *De Partibus Animalium* I.

My second thesis concerns the role of teleology in Aristotle's methods of discovery. There are a relatively small number of teleological explanations in Aristotle's natural treatises that do not refer directly to final causes, but that proceed through the use of teleological principles such as "nature does nothing in vain."[14] I argue that Aristotle uses these principles as *heuristic tools*. The principles are used to discover causal features, which then figure in teleological explanations, but the principles do not themselves play a causal role in the ultimate explanations of natural phenomena.

In the natural treatises, there are rare cases where the end that constitutes the final cause of some natural phenomenon is not immediately accessible for observation, or where the explanandum is otherwise particularly complicated. These are typically the contexts in which Aristotle posits a teleological principle and thereby generates the appropriate series of inferences that ultimately leads to the identification of the causally relevant

[13] Sorabji (1980, 155–174) offers an account of how according to him the various kinds of teleological explanations work, but I believe his distinctions are not subtle enough to cover Aristotle's actual practice of explaining natural phenomena in a teleological way. Johnson (2005, 1 and 7) introduces his investigations into Aristotle's teleology as a study of "how ends are used by Aristotle as explanations in natural philosophy" (2005, 1). However, the core of his monograph contains a discussion of the sorts of things that according to Aristotle behave in a goal-directed way, and of the reasons why these things behave that way (and are thus explainable by reference to teleology). He does not produce any analysis of the different types of teleological explanation Aristotle uses, or any reflections upon why Aristotle uses the types of teleological explanation he does, or what he thinks these explanations amount to, which is the sort of reflection I offer in this book. Charles (1991), who recognizes that there is a plurality of teleological models at work in Aristotle's *Physica*, faults Aristotle for not presenting a unified model.

[14] Although Lennox's work on the principle that nature does nothing in vain (2001a, 205–222) suggests that Aristotle uses teleological principles in very specific ways to explain their own set of explananda, some scholars still think that they are just "didactic mantras," to remind his students that he believes nature is goal-directed. See, for instance, Quarantotto (2005, 13).

feature, which is then picked out in the explanation of the phenomenon in question. An important part of the process of discovery in these cases is the identification of what type of teleology (i.e., primary or secondary teleology) is responsible for the presence of the natural phenomenon that needs to be explained; it is my contention that teleological principles help to make this identification, while they are not themselves part of the ultimate (syllogistic) explanation.

I argue for this thesis in Chapter 4, which examines Aristotle's heuristic strategies and actual (teleological) explanations as recorded in *De Partibus Animalium* II–IV, and trace its consequences for the possibility of understanding heavenly phenomena in Chapter 5.

My final thesis, which is perhaps the most important one from a contemporary perspective, is that for Aristotle the scientific value of final causes in natural science lies in their explanatory priority. Final causes, even though they certainly play a significant causal role in natural developments (they are, after all, one of the four types of causal factors Aristotle distinguishes in nature), nevertheless never receive causal priority *in the (syllogistic) explanation of those developments*.[15]

For Aristotle, scientific explanations or demonstrations ideally follow the pattern of a Barbara syllogism (i.e., AaB, BaC, ∴ AaC). In such demonstrations, some attribute (picked out by the major or predicative term) is demonstrated to hold always or for the most part of some subject (picked out by the minor or subject term) through some causally primary feature (picked out by the middle term). In addition, Aristotle argues that scientific demonstrations of natural phenomena – unlike those of mathematical states of affairs, which are timeless – ought to reflect the chronological order of causation in the world, moving from the start or origin of the natural development to its end. For the practice of demonstrating teleological natural processes, this means that final causes can never take the position of a middle term, which picks out the causally *primary* factor in a chain of development. For, although Aristotle repeatedly points out that final causes are prior in nature and in definition (and undeniably do have causal priority in those senses), in *generation* they are last, because the ends that constitute the final causes of natural phenomena are chronologically speaking the last to come about. Whereas the end that constitutes the final cause explains the *presence* of a given natural phenomenon, the *coming*

[15] This answers the question, addressed on a general level by Code (1997) and by Bolton (2004), why Aristotle assigns special explanatory power to explanations that pick out final causes and why he considers it to be the foremost (although not exclusive) task of natural philosophers to provide teleological explanations of the natural phenomena they investigate.

to be of that end must itself be explained further in terms of either the operation of formal-efficient causation or of material-efficient causation. These latter causes are *causally prior in generation* and they can therefore take the position of middle terms in scientific demonstrations of natural phenomena. In sum, because ends that constitute the final causes of natural phenomena can by definition never be prior in generation, and because it is priority in generation that is tracked by scientific demonstrations of natural phenomena, ends can never be identified as the causally primary fact in such demonstrations.

Thus I shall argue that the syllogistic patterns of teleological explanation that Aristotle employs in the biological practice and that he describes in his theory of science never pick out final causes as being explanatory of the conclusion, but rather include functions and ends as part of the conclusion that is being demonstrated. In other words, final causes are always picked out by the major term, in the predicative position, and never by the middle term. Under this scheme, teleological explanations are explanations in which a final cause is picked out as being responsible for the *presence* of some natural feature, where the end that constitutes that final cause is demonstrated to *come to hold* of that feature through the operation of some *other* type of cause (i.e., formal-efficient causes in the case of primary teleology; material-efficient causes in the case of secondary teleology).

Final causes thus exert no "mysterious causal pull" from the future and do not cause the coming to be of their own necessitating conditions, as some – anachronistically – have suggested. Final causes are prior in nature and in definition, and function quite literally as ends and limits of developments, which is why they function as the starting points of scientific demonstrations of natural phenomena. However, in the order of generation, final causes are last, and Aristotle does not conflate these different orders of priority.

This is the central thesis of Chapter 6, in which I present my interpretation of *Analytica Posteriora* II.11 and juxtapose this with my findings concerning Aristotle's practice of providing teleological explanations especially in the biological works.

My interpretation of Aristotle's teleology as (1) incorporating (at least in some cases) material necessity rather than opposing it, (2) allowing a heuristic use of teleological principles, and (3) resisting the charge of backward causation has important ramifications not only for the way we standardly depict the place of Aristotle in the history of science, but perhaps also for contemporary debates about the notion of biological function.

The Aristotelian worldview that came to be rejected in the sixteenth and seventeenth centuries in favor of mechanistic models of the world was in fact even less Aristotle's than is often assumed. For Aristotle, the theory of natural teleology is not an a priori assumption, but a scientific hypothesis, much like contemporary etiological or propensity theories of function are. A deeper understanding of the merits (and limits) of Aristotle's use of teleology in producing explanations might put us in a better position to reconsider notions of biological function that do not rely on the postulation of mystical forces or the existence of benevolent, intelligent gods, but rather on immanent, natural principles and laws.

CHAPTER 1

Aristotle's defense of natural teleology: setting the stage for teleological explanations in the Physica

1.0 INTRODUCTION

The *Physica* forms Aristotle's most fundamental treatise in his studies of natural science. In this treatise, Aristotle investigates the principles and causes of all things that have a nature – that is, of all things that have an internal principle of change and rest – with the purpose of generating knowledge of natural phenomena (*Ph* I.1, 184a10–16). In the course of doing so, Aristotle defines a large number of key notions of his natural philosophy, such as motion and change, space and time, matter and form, causal explanation, luck and spontaneity, teleology and necessity. The conceptual apparatus and framework laid out in the *Physica* are consequently applied and reshaped for the inquiries into the more specific and more complex segments of the natural world, written down in Aristotle's other natural treatises.[1]

Final causes and natural teleology figure especially prominently in the second book of the *Physica*, where Aristotle defines his concept of nature, introduces his theory of four types of cause or causal explanation,[2] and discusses the kinds of cause operative in art and nature. In this chapter, I shall focus on Aristotle's first argument in defense of natural teleology

[1] As Aristotle makes clear in his programmatic opening of the *Meteorologica* (I.1, 338a20–339a10), the whole investigation of nature will comprise the study of change and motion in the heavens (*De Caelo*), the elements and coming to be and perishing in general (*De Caelo*, *De Generatione et Corruptione*), atmospheric causes and changes (*Meteorologica*), and finally living beings (the biological works). On the importance of the *Meteorologica* passage for the systematic connection between Aristotle's works, see Burnyeat (2001, 118–119); Falcon (2005, 2–7); and Nussbaum (1978, 107–109).

[2] Aristotle is a realist concerning both causes and explanations, which means that the four types of causal explanations he distinguishes in *Ph* II.3 and *Ph* II.7 are grounded in four types of causal relations that obtain in the world: the four *aitiai* are the kinds of answers one gives to four different why questions, and these answers will only be explanatory and hence productive of scientific knowledge if they pick out real causes (and not merely epistemic reasons why) under their causally relevant description. Cf. Freeland (1991); Hankinson (1998, 132); Johnson (2005, 41); and Moravcsik (1991, 31). Pace Van Fraassen (1980). On Aristotle's erotetic concept of inquiry, see Hintikka (1989, 73) and Lennox (1994).

against his materialist predecessors (in *Ph* II.8, 198b16–199a8), which raises an important aporia about the role of teleology, necessity, and chance in the proper explanation of natural phenomena. The main purpose of this chapter is to provide an interpretation of this argument, which will build upon a distinction I draw between primary and secondary types of teleology. Since Aristotle's defense of natural teleology in the *Physica* is among the most disputed passages in the Aristotelian corpus, this chapter will also function as a modest *status quaestionis* of recent work on Aristotle's teleology, and as an introduction to some of the basic concepts necessary for the understanding of Aristotle's use of teleological explanations in the other natural treatises discussed in the remainder of this book.

In the sections below, I shall first, by way of background, discuss the role Aristotle assigns to final causes in teleological explanations of both art and nature, and define some of the key terms I use in this study. This is section 1.1. Next, I analyze Aristotle's first argument in defense of natural teleology in the *Physica*: section 1.2 provides a general outline of the interpretational problems pertaining to the nature and scope of Aristotle's theory of natural teleology, and section 1.3 presents my solution to these problems.

1.1 PRELIMINARY REMARKS ON FINAL CAUSES IN ART AND NATURE

The place of final causes in causal explanation

Aristotle conceives of scientific inquiry in book II of the *Physica* as a questioning procedure in which the answer to the question why provides the most fundamental knowledge, because it brings out the cause(s) of something. In *Ph* II.3,[3] Aristotle introduces four types of cause that may figure in such causal explanations: (1) the "that out of which" (*Ph* II.3, 194b24: τὸ ἐξ οὗ) or the material cause;[4] (2) the "what it is to be" (*Ph* II.3, 194b27: τὸ τί ἦν εἶναι) or the formal cause; (3) the "that from which the origin of motion or rest comes" (*Ph* II.3, 194b29–30: ὅθεν ἡ ἀρχὴ τῆς μεταβολῆς ἡ πρώτη ἢ τῆς ἠρεμήσεως) or the efficient cause; and (4) the "that for the sake of which" (*Ph* II.3, 194b33: τὸ οὗ ἕνεκα) or the final

[3] The four causes already figured implicitly in Aristotle's definition of nature in *Ph* II.1–2; note that *Ph* II.3 is virtually identical to the entry on *aition* in Aristotle's "philosophical dictionary" in *Meta* V.2, 1013a24–1014a25.

[4] The name "material cause" is somewhat misleading, since for Aristotle "matter" in the sense of physical stuff (*hulê*, literally, wood; the ancient Greeks did not have a term for matter in our modern sense) is just one sort of thing among many others that can be causative as a "that out of which" (as is evidenced by the examples Aristotle gives in *Ph* II.3, 195a16–20). Cf. Hankinson (1995a), 119n12.

cause. Below, I shall briefly discuss Aristotle's notion of the final cause as it appears in his discussions of art and nature in this book, and indicate how it is connected to the other three types of cause.

Broadly speaking, Aristotle introduces three kinds of final cause in the second book of the *Physica*:[5] these are (a) completed natural substances or artifacts as the end results of processes of generation; (b) functions performed by (parts of) natural substances, artifacts, or tools; and (c) objects of desire as the aims of (deliberative) actions. (For examples of category (a), see *Ph* II.8, 199a13–14; *Ph* II.8, 199b8; and *Ph* II.9, 200b3–4; for (b), see *Ph* II.8, 198b24–28 and *Ph* II.9, 200b4–8; for (c), see *Ph* II.3, 194b33–34.)

The first category of final causes, consisting of completed natural substances and artifacts, are the finished products of the realizations of a potential for form, where this form is being transmitted through a process of natural generation or artificial production. In natural generation,[6] the potential for form is transmitted by the father – who possesses that form in actuality and whose semen contains the initial efficient cause of the embryo in the form of vital heat – into the menstrual blood, which is the matter supplied by the mother (see, e.g., *GA* I.22, 730a32–b32). The menstrual blood is blood concocted up to a certain point: it has potentially the same species form as the mother has, and contains the source of the nutritive soul (which explains the phenomenon of parthenogenesis), but – because of its lack of heat – does not have the source of the sensitive soul (*GA* II.3–5). The source of the sensitive soul is transmitted through the motions contained in the male semen (*GA* I.21, 730a23–33): these motions have the capacity to shape and form the embryo, which – once its heart has been formed – takes over its own generation and then possesses its own internal principle of motion. Natural generation thus consists of the replication of form[7] by what possesses that form in actuality into what possesses that form in potentiality; the fully realized form constitutes the final cause of the process. Artificial production consists of a similar replication of form, but with the important distinction that here the efficient cause remains at all times *external* to the generative process (this is what ultimately differentiates art from nature: what makes something natural is that it has or develops its own *internal* source of change and rest). The art,[8] present in

[5] On the variety of final causes in the second book of the *Physica*, see Charles (1991, 102–103).

[6] For a detailed account of Aristotle's theory of natural reproduction, see Henry (2006).

[7] On this model of reproduction as "formal replication," see Gotthelf (1987); Lennox (2001a, 230–232); and Witt (1994b, 222–228).

[8] "Art" seems the most common translation of *technê*; but see Hankinson (1998, 128n.2) and Löbl (2003, 258–264), who point out that the notion of *technê* is in fact broader than that of the arts: it includes what we would call crafts, skills, and applied sciences. I use the translations "art" and "craft" interchangeably.

the soul of the craftsman and mediated through his mind, guides the hands and tools of the craftsman and thus realizes the appropriate form in a piece of material, which must have the right material potentials for receiving that form (*GA* II.1, 735a2–4; *GA* II.4, 740b25–29). As in natural generation, it is the form that guides the operation of efficient causation (note, however, that a craftsman does not reproduce his own form, but that of the art he possesses in his soul) and that – when fully realized – constitutes the final cause of the generative process.

Functions performed by natural beings, artifacts, and instruments constitute the second type of final cause invoked by Aristotle. They usually figure in the explanation of the material and structural features of their possessors. Just as completed natural beings and artifacts are the realizations of preexisting potentials for forms, so are these functions the actualizations of preexisting capacities for activities, which reside in the soul or in the material potentials of something. (For example, natural functions are the actualizations of capacities for the performance of the distinctive life functions of each kind of animal, grounded in and activated by the animal's soul.) Functions always play some contributory role to the system of which they are part, and they exist "on top of" the realized forms that constitute the first type of final cause. For instance, a completed house is the final cause and the fully realized form of the art of house-building, while "shelter" is the function and final cause of the realized house; providing shelter is thus a function that follows from and presupposes the existence of the house.

Objects of desire constitute a third category of final causes, which are picked out in the explanation of animal or human action. Actions differ from natural and artistic productions in that they do not involve a replication of form – actions are not generative processes (cf. *NE* VI.5, 1140b1–4). In addition, actions involve conscious intentionality: objects of desire operate as external unmoved movers that actualize the internal unmoved movers of self-moving agents, that is, their faculties of desire and imagination or thought (for human beings, deliberation plays a crucial role; cf. *NE* III.3, 1112b11–1113a2). Objects of desire guide our actions towards their achievement, but there is no formal identity or ontological connection between an end and the means towards that end, which explains why there is more room for mistakes in this kind of process (see, e.g., *EE* II.11, 1227b19–22).[9]

As may be clear from this brief overview, final causes *never operate in a vacuum*, but always in connection with at least one other kind of cause.

[9] Pace Charles (1991, 118–119, 127), I do not believe that this model of action is important for Aristotle's defense of natural teleology.

First, Aristotle usually explains the relation between the function of something and its material constitution as one of conditional necessity (*Ph* II.9, 200a10–15):

> Thus on account of what is a saw like this? That this may exist and be for the sake of that. It is impossible, however, that this, which is that for the sake of which, comes to be, unless it is made of iron. *It is necessary, then, that it is of iron, if there is to be a saw and if there is to be its work*. The necessary, then, is necessary starting from some hypothesis (ἐξ ὑποθέσεως δὴ τὸ ἀναγκαῖον),[10] and not as an end: the necessary is in the matter, the "that for the sake of which" in the definition.

The function something needs to perform, which is given by its definition (e.g., a saw is a sawing tool, and sawing is a kind of dividing; cf. *Ph* II.9, 200b4–8), determines the kind of material that ought to be used for its production, because it is the potentials ("hard," "dry," etc.) the material has that allow for certain functions, but not for others. Thus, if there is to be a functioning (natural or artificial) part, then it will have to be made of a certain kind of material with *the appropriate kinds of material potentials*, which will have to be present first and undergo certain changes.[11] The potentials of the material that has been used for the production of some part in their turn explain why that part is able to perform the functions it performs.

Second, the relation between efficient and final causes in art, nature, and action is one of complementariness (*Ph* II.3, 195a8–11):[12] "And some are also causes of one another (ἔστιν δέ τινα καὶ ἀλλήλων αἴτια), as training is a cause of fine condition, and this [i.e., a fine condition] of training, though [they are] not [causes of one another] in the same way, but the one as end and the other as source of motion."

The continuous operation of efficient causes during both action and generation is limited by and directed towards the final cause (cf. *DA* II.4, 416a15–18: efficient causes that act independently of final causes are like a fire that spreads without direction, end, or limit), while the end that constitutes the final cause is the outcome and terminus of this efficient causal process. In the case of generative processes this means that there

[10] On the expression *ex hypotheseôs* and the idea of conditionality, see Bobzien (2002, 363).

[11] See also *PA* I.1, 642a8–13; for the inclusion of efficient causation into the notion of conditional necessity, see *PA* I.1, 639b25–30 and *GA* II.6, 743a21–26. Cf. Lewis (1988, 87n8).

[12] Cf. *GA* II.6, 742a16-b18; 742a28–36; *EE* I.8, 1218b11–22; and *Meta* I.3, 983a31: "in a third way [we speak of a cause as] the source of the change, and in a fourth the cause opposed to this (τετάρτην δὲ τὴν ἀντικειμένην αἰτίαν ταύτῃ), that for the sake of which and the good – for this is the end of all generation and change."

cannot be an end that constitutes a final cause if it is not the outcome of some efficient causality that was directed towards producing this end.[13] In natural generation the efficient, final, and formal causes often "come to one" (*Ph* II.7, 198a24–27): "In many cases three [of these causes] come to one (ἔρχεται δὲ τὰ τρία εἰς [τὸ] ἓν πολλάκις); for that what something is and that for the sake of which it is are one, while that from which motion first originates is the same as them in kind: for man generates man."

The efficient cause of the father is not numerically the same as the efficient cause of the son, but formally they are identical, and they are directed towards the realization and maintenance of the same form,[14] which *in its fullest expression* (and only then) is identical with the final cause.

Third, the relation between formal and final causes is itself a teleological one. Aristotle conceptualizes generation as a process that is directed toward an ever fuller realization of a potential for form, which culminates in a state of full actuality, which then constitutes the final cause. The potential for form is for the sake of realizing that form in actuality (*Meta* IX.8, 1050a4–10),[15] which is ultimately for the sake of activity (see *Meta* IX.8, 1050a21–23; *PA* I.5, 645b14–20). It is in this sense that Aristotle claims formal and final causes are one or "almost one" (*GA* I.1, 715a6: ἕν τι σχεδόν): something's *realized* (but not its potential for) form is that thing's final cause. In generative processes, causal priority thus lies in the potential for form that is being realized (see, e.g., *PA* I.1, 639b13–19 and *PA* I.1, 640a17–20; cf. sections 3.2 and 4.3), whereas the end that constitutes the final cause, and which chronologically comes to be last, has priority in definition (see, e.g., *DA* II.4, 415a18–20, and 416b23–25; *Meteor* IV.12, 390a10–12 and *Pol* I.2, 1253a19–25). While we define what something is on the basis of the intrinsic[16] and non-accidental functions and activities it displays, we explain the presence of these functions and activities as being causally determined by what that thing is, "for generation is for the sake of being" (*PA* I.1, 640a17).

Finally, Aristotle sometimes groups together matter and form in the explanation of the *result* of a process of generation, i.e., of the static composition of things that are, and combines efficient and final causes in the explanation of the *dynamics* and the direction of generative processes. At

[13] Cf. Broadie (1990, 391).

[14] Moravcsik (1994, 236), calls this a "built-in schedule of development and maintenance."

[15] See Witt (1998), for Aristotle's "metaphysical teleology."

[16] I use "intrinsic" to refer to causes that are causes in virtue of themselves (*kath'hauto*), which are opposed to causes that are accidental (*kata sumbebêkos*); for the distinction, see, e.g., *Ph* II.5, 196b24–27.

other times, he joins the formal and final cause together as the basis of proper teleological explanation, while contrasting it with the pair of material and efficient causation as picking out the process of material necessity.[17] I shall say a little more about the way Aristotle pairs these different causes together in his explanations of natural phenomena in the remaining chapters of this book.

The analogy between art and nature in teleological explanations

At the very beginning of the second book of the *Physica*, Aristotle defines nature as an inner source of change and rest in that to which it belongs primarily of itself, and not accidentally (*Ph* II.1, 192b13–14; 192b20–23).[18] In this way, he distinguishes natural things from the class of artifacts, which require an external efficient cause – the art, hand, or tool of the artist – to become what they are (*Ph* II.1, 192b28–32), but are otherwise very similar to natural products. In the remaining chapters, and especially in his defense of natural teleology, Aristotle relies heavily on this assumed similarity between the causal processes that generate natural and artificial products. Even if it remains doubtful whether Aristotle's theory of natural teleology is in fact based on the etiology of artifacts,[19] the analogy between nature and art at least serves a clear didactic purpose:[20] art involves the operation of the same four causes that are operative in nature, but in a more conspicuous and differentiated way. The models of teleology involved in art and nature are similar, but not identical.

[17] See, e.g., *GA* I.1, 715a4–9; *GA* II.1, 731b18–24; *GA* V.1, 778b1–10; *GA* V.1, 778b11–19; *GA* V.8, 789b19–22; and *DA* II.4, 415b10–12. Cf. Cooper (1982, 201), and Dudley (1997, 111).

[18] Nature is also spoken of as (i) that which persists through change, i.e., the substrate or the primary underlying matter (*Ph* II.1, 193a29–30; this is presumably proximate matter: see *Meta* V.6, 1016a19–24; *Meta* VIII.4, 1044a15–25; *Meta* IX.7, 1049a24–7; and Bodnár and Pellegrin (2006, 274–275)), and as (ii) that which is generated in the change, i.e., the shape or form according to the definition (*Ph* II.1, 193a30–31), whereby the latter is *more* a nature than the former (*Ph* II.1, 193b6–12; *Ph* II.2, 194a12–27). Finally, nature is spoken of as (iii) that "towards which" processes take place (*Ph* II.1, 193b12–18; 193b17: εἰς ὅ) and as an "end" and "what something is for" (*Ph* II.2, 194a27–33; 194a28–29: ἡ δὲ φύσις τέλος καὶ οὗ ἕνεκα), where this end constitutes the culmination of a continuous change.

[19] For the view that the model of art offered Aristotle the metaphysical schema for his theory of natural generation, see Granger (1993, 168) (Granger takes Aristotle's theory of action to be the model behind his natural teleology); Matthen (2009); and Broadie (1990, 393–396). I remain skeptical as to whether Aristotle needs the model of art to justify his theory of natural teleology, especially since in his view (as opposed to Plato's; see Johansen (2004, 83–86), and Lennox (2001a, 281)) the teleology of art is itself ontologically dependent on the teleology of nature (cf. Katayama, 1999, 79–80; 101–108).

[20] Cf. Cooper (1982, 198n.2), and Wieland (1975, 151).

The analogy between art and nature usually exploits the following three aspects:[21] first, the way in which the end and the means to realize that end are complementary and adjusted to each other in art and nature, in a way that they are not in the model of animal and human action. Above, we saw that in nature, the efficient, formal, and final causes often coincide, such that the "formal nature" becomes its own internal goal-directed agent of the realization of its *own* form (and not of some other form). In the case of art, the knowledge the craftsman has acquired is the knowledge of how to produce the art-specific form in matter, and it is activated for the sake of producing precisely those art-specific products. Thus, the art of house-building is acquired for and guides the use of tools for the production of houses, and not for something else.

Second, it exploits the specialization of the arts, which resembles the ontological classification of natures: the arts are divided into different kinds of specializations, each of which aims at producing its own specific object. Things with a nature are similarly split into different kinds and species, each of which tends towards the realization of its own specific form or essence.

A third aspect exploited in the analogy is the reliability and regularity of efficient causation in both domains: because of the above-mentioned specialization of the arts, craftsmen will always or for the most part produce the objects that they are trained to produce, and they will do so almost "automatically" and usually without mistakes.[22] The experienced artist or craftsman will not have to deliberate about which object to produce (a shoemaker produces shoes, not houses), and presumably only rarely about the means to produce it: his art dictates both.[23] Nature as an internal efficient cause of change and generation operates in much the same way (*Ph* II.8, 199a20–30; *Ph* II.8, 199b26–33): it realizes on a regular basis its own form, without deliberating over the means to these ends, and realizes this form, unless something impedes it, without mistakes.

It is important to note that conscious intentionality plays no significant role in the analogy between art and nature in the second book of the *Physica*. Since art is the true efficient cause in artificial production, the psychological states of the artist only seem to matter in the sense that art cannot exercise itself and depends for its actualization on the "rational potentiality" of the artist, which is a separate psychological component.

[21] Broadie (1990, 396–397), and Lennox (2001a, 287–290).

[22] Pace Matthen (2009), Aristotle does not seem to recognize mistakes of conception or design, but only of production and of failing materials; see *Ph* II.8, 199a34–b5.

[23] Broadie (1990, 398), and Lennox (2001a, 245n.9).

In Aristotle's depiction of art as an analogue of nature, human desires and intentions appear to play no crucial causal role,[24] nor do they figure in the operation of natural teleology, where the formal nature or soul is often characterized as an *internal* instantiation of an artist working through the natural body to which it belongs.[25]

Key concepts to be employed in this study

Above I explained that final causes never operate in a vacuum, but are always connected to the operation of at least one of the other kinds of cause. Based on Aristotle's analysis of natural teleological processes (for which I shall provide more evidence in Chapter 3), I shall henceforward distinguish between two causal patterns of teleology.

The first causal pattern represents what I call *primary teleology*. This process involves the realization of a preexisting potential for form through stages shaped by conditional necessity, where the fully realized form constitutes the final cause of the process. This is the "standard" form of teleology, according to which the form specifies the functional features that are to be realized through the goal-directed actions of the formal nature, and where those functional features are intrinsic to and necessary for the natural being that has them. The relevant causal connection here is thus between a potential for form and the realized potential, which constitutes the final cause. The formal nature of the animal in these cases acts as its own internal efficient cause for the realization of its own potential for form. Features that are the result of primary teleology can be exhibited to be the necessary prerequisites for natural beings such as animals to perform the functions specified in their form. Aristotle often refers to these features as being necessary, because they are of immediate vital or essential importance for the animal: hypothetically speaking, nature could not have "designed" the animal without these features, for without them it would not have been able to live or be the kind of animal it is. For instance, the definition of the

[24] Pace Bolotin (1998, 35); Broadie (1990, 401); and Owens (1981, 145). Additionally, I do not believe that this "de-psychologized" picture of art that Aristotle employs in his analogy misrepresents the ancients' conception of art; pace Broadie (1990, 400–401), and Charles (1991, 108). The emphasis on the proficiency and specialization of the arts is present in other sources (see, e.g., X. *Cyr* VIII.2, 5; I thank Peter Stork for bringing this text to my attention), and is part of the philosophical tradition (see, e.g., Pl. *R* II, 369e-370a). See also Johansen (2004, 69–91), who argues that in Plato's depiction of the Demiurge – the ultimate philosophical model of the artist – individual psychology plays no causal role.

[25] For the characterization of formal natures as craftsmen, see, e.g., *PA* I.5, 645a9 (*hê dêmiourgêsasa physis*); *PA* II.9, 654b27–655a4; *PA* II.1, 647b5–6; *PA* IV.10, 686a12; and *IA* 12, 711a18; cf. also *GA* I.22, 730b5–32; *GA* II.1, 734b20–735a4; and *GA* II.4, 740b25–741a4.

substantial being of birds exhibits these animals as flyers, and in order for birds to be able to fly, they will have to have wings (there is no other way in which nature could have realized the function of flying). Wings are present for the sake of flying, and there can be no bird without wings, because these are the parts through which the bird's form as flyer is realized (in other words, all birds must have wings, even if those wings do not actually allow the animal to fly). In the explanation of features that are the result of primary teleology, Aristotle tends to give one explanation that accounts for both the coming to be and the presence of that feature, and uses strong teleological language (e.g., a certain feature exists *for the sake of* – *heneka* – a certain function).

The second causal pattern represents what I call *secondary teleology*. This process involves a formal nature of an animal *using* materials for something good, where those materials "happen to be available" in the animal, usually as the result of material necessity, and are not strictly speaking the result of conditional necessity. The use that is made of the materials in these cases is one that is not already specified in the animal's form and/or is not immediately necessary for the animal's survival or its identity. In these cases, functional features emerge as it were from the potentials of the materials that happen to be available, which are then – secondarily – co-opted or adapted by the formal nature of the animal. Features that are the result of secondary teleology are never themselves the necessary prerequisites for the performance of a function that is specified in the definition of the substantial being of the animal. Rather, Aristotle explains their presence as being "for the better" or for "living well," because they help some other feature perform its function better (these are what I call "subsidiary parts") or because they give rise to a function the animal could – strictly speaking – do without (what I call "luxury parts").[26] For instance, the hair on our heads is presumably a "luxury" feature: Aristotle believes that these hairs come to be by material necessity, and that the formal natures of human beings then use or co-opt them for protection (the hard and earthy constitution of hair helps to protect human heads against excessive heat and cold) – a function that living beings in Aristotle's world may well do without.[27] In cases of secondary teleology, the relevant causal connection is thus that between the available material potentials and the function or use to which the materials with those potentials are put. The actions of the formal nature in these cases are guided by the potentials the available materials have, which determine

[26] For my categorization of animal parts, see section 3.2.

[27] This is a rather liberal interpretation of *PA* II.14, 658b2–10, which I offer here purely for the sake of explaining what I mean by secondary teleology; for actual examples, see Chapter 3.

the range of uses one can make of those materials, rather than by some preexisting potential for form that is to be realized. In the explanation of features that are the result of secondary teleology, Aristotle tends to give a separate explanation for the coming to be of that feature and for its presence, and prefers "weaker" teleological language (e.g., a certain feature comes to be of necessity, but exists *for* or *with a view to* – "*pros*," "*eis*," or "*charin*" – some good).

In both cases, the causal feature that is most salient to us is the function or final cause. When explaining the presence of either wings in birds or hair on human heads, we first point to their function: wings are present for the sake of flying, hair is present for protection. This is because final causes are often simply observable – we can infer what something is for by looking at what it typically does and by observing what contribution it makes to the life of the living being in question. For this reason, final causes tend to be the first causes to be picked out in a teleological explanation: they have what I call *explanatory priority*. Identifying something's final cause is the first and most important step in generating a teleological explanation.

However, as should also be clear given the distinction between two types of teleology, just identifying the final cause of some feature is not sufficient if we want to have a *complete* explanation of that feature (which is necessary if we want to have a full understanding of it). We also need to find out whether this end that constitutes the final cause is the realization of some preexisting potential for form, or rather a use that has been made of materials that were available of material necessity. In the remainder of this book, I shall refer to this issue as one of determining whether the coming to be and presence of some end that constitutes the final cause is primarily *driven by form* or primarily *driven by matter*. In the first case, it is the presence of a preexisting potential for form that guides the actions of the formal nature and that thereby directs the teleological process of its realization. In the second case, it is the presence of certain material potentials that allows for certain teleological uses (and not for others); the actions of the formal nature in making use of these materials are secondary to the operation of material necessity that produced the materials in the first place. Both processes thus involve the goal-directed actions of the formal nature – which is why *both processes qualify as being teleological*, but in the first case, the actions are primarily "driven by form" (e.g., the form of flyer requires the production of wings), in the second, they are primarily "driven by matter" (e.g., the availability of hard materials allows for the production of protective parts like horns and hair).

Both types of teleological process involve developments over time from some initial situation to the full realization of some functional feature. In primary teleology, the initial situation is the existence of a preexisting potential for form; in secondary teleology, the initial situation is the existence of "extra" material with certain material potentials. Thus, when it comes to *priority in generation* (as opposed to priority in nature or in definition, which is a kind of priority that belongs to final causes),[28] final causes are never *causally primary*. That is, final causes never initiate, so to speak, the teleological process that leads up to their realization (even if we do not interpret final causes anachronistically as acting as efficient causes, this would still be a case of backward causation). Final causes are not "active" or "productive" in that way (cf. *GC* I.7, 324b13–15; b14: τὸ δ' οὗ ἕνεκα οὐ ποιητικόν). Instead, the causally primary factors are always some combination of formal-efficient causes in the case of primary teleology, or material-efficient causes in the case of secondary teleology. Thus, the coming to be of an end that constitutes a final cause, and which (at least partially) explains the presence of the natural feature under investigation, needs itself to be further explained in terms of the operation of chronologically prior and necessitating causes. Note that I do not claim that final causes ought to be explained by (let alone reduced to) other types of cause, but rather that the *obtaining* of an end that constitutes a final cause in a certain subject ought to be further analyzed in terms of the underlying causes that necessitate its coming to be – that is, at least, if we want to have a full understanding of that subject.

The fact that final causes never have causal priority in the sense outlined above is important, because on Aristotle's account of scientific demonstration, demonstrative syllogisms ought to track the actual sequence and the timing of the various stages in the causal chain.[29] This is not a requirement Aristotle discusses in the early chapters of the *Posterior Analytics*, which focus rather narrowly on geometric-style demonstrations that are timeless and universal, and it is therefore easily overlooked. Instead, the requirement is introduced in the lesser-known chapters in book II (i.e., *APo* II.11–12), where Aristotle discusses the question of how one incorporates causes and change into the syllogistic framework of demonstrations. I shall discuss these chapters in more detail in Chapter 6, but for now it suffices to point out that in demonstrations of natural phenomena, because they involve

[28] For Aristotle's discussion of the distinction between "priority in generation" and "priority in nature/substantial being," see *PA* II.1, 646a24–646b2; cf. *PA* I.1, 640a10–b4.

[29] Cf. Charles (2000, 198–204).

changes over time, final causes can never take up the position of the middle term. The reason is that middle terms in such demonstrations ought to pick out the causally *primary* factor in the chain of development (i.e., the factor that cannot be explained any further), and in developments causal primacy and chronological primacy coincide. For the structure of teleological explanations this means that final causes will typically be picked out by the major terms, and as such will feature as part of the conclusion that is being demonstrated. Complete teleological explanations thus specify, first, the final cause which explains the *existence* of some natural feature, and second, the cause that is responsible for the end's (that constitutes the final cause) *coming to hold* of that natural feature.

With these preliminary distinctions set out, we can now turn to Aristotle's defense of natural teleology in Chapter 8 of the second book of the *Physica*.

1.2 Aristotle's First Argument in Defense of Natural Teleology

Causation in nature: the relation between teleology and necessity

Aristotle's defense of natural teleology takes place in the context of a larger exposition in the second book of the *Physica* on what nature is, what topics the student of nature should study, how nature relates to art, and what the causal role of luck and spontaneity is in nature. The problem Aristotle sets out to answer in the final two chapters of this book is the following (*Ph* II.8, 198b10–12): "We must first state the reason why nature is among the causes that are for the sake of something (ἡ φύσις τῶν ἕνεκά του αἰτίων), and next, about necessity, how it is present among natural things."

In the preceding chapters, Aristotle had defined nature in terms of each of the four kinds of cause, but first and foremost as an internal efficient cause.[30] The question Aristotle asks now is why nature, as an internal efficient cause, is among the causes that are for the sake of something, or, as I take it, why nature acts goal-directedly. The question is important, because, as Aristotle continues to explain (in *Ph* II.8, 198b12–16), his predecessors traced back all phenomena to necessity or material causation, and waved goodbye to

[30] This conception of nature as an internal efficient cause is itself characterized as a hypothesis that belongs to the first principles of the science of nature (*Ph* VIII.3, 253b2–6). It cannot be demonstrated through a syllogistic proof, and the same holds for the proposition that the world of natural changing things exists; cf. Bolton (1991, 19–21). The fact that there are natures or natural things Aristotle claims is evident – the attempt to demonstrate this would in fact be ridiculous (*Ph* II.1, 193a1–9).

any other kind of cause, thus leaving it unclear whether there is any causal role to be played by nature as a goal-directed efficient cause in addition to nature as a material-efficient cause.[31]

The way Aristotle introduces the issue here pertains directly to one of the most pressing problems in the scholarship on Aristotle's teleology: how exactly does Aristotle think teleology and necessity in nature are related to each other?[32] Recent scholarship has proposed the following four different interpretations for the way Aristotle perceives this relationship:

Based on the way Aristotle contrasts his own teleological view of nature with the views of his predecessors who explain everything in terms of material necessity, some scholars argue that Aristotle believes that the two views are incompatible with each other, and that he ultimately denies that there is such a thing as material necessity operative in nature that is independent of the operation of teleology.[33]

Others think that for Aristotle the two "forces of nature" are compatible, but that the operation of material necessity and the actualizations of element potentials as such are *not sufficient* to produce regular, good, or complex results. According to these scholars, natural phenomena could not come about without the operation of a final cause, and therefore explanations in terms of formal and final causation cannot be reduced to explanations in terms of efficient and material causation.[34]

Still others agree that necessity and teleology are compatible in Aristotle's worldview, but do so on the grounds that the theory of natural teleology has no ontological consequences. They claim that the theory of teleology is an explanatory framework that has the sole purpose of making things intelligible for us humans. Accordingly, these scholars believe that teleology is merely used by Aristotle as a heuristic device in his attempt to explain natural phenomena. It is argued that on the level of causation, material and efficient causes are all that is needed to bring about natural phenomena; on the level of explanation and understanding, however, we need the language of ends and functions in order to make sense of the natural phenomena.[35]

[31] Cf. Sauvé Meyer (1992, 792–793).

[32] I shall return to the question of the relation between teleology and necessity in section 3.3. For the present purposes, an outline of the problem and possible interpretations will suffice.

[33] See, e.g., Balme (1965; 1987a).

[34] Stronger and weaker versions of this so-called "irreducibility thesis" have been defended by amongst others Bradie and Miller (1999, 75); Charles (1988, 1–53); Cooper (1982, 197–222); Gotthelf (1987, 204–242); Irwin (1988, 109–112); Lennox (1982; 2001b); and Waterlow (1982, 69).

[35] Stronger and weaker versions of this pragmatic viewpoint have been defended by Charles (1988); Irwin (1988); Nussbaum (1978); Sorabji (1980); and Wieland (1975).

All three views discussed above focus on the question of the compatibility and ontological reducibility of teleology and necessity. However, the position I adopt myself, and for which I shall offer further evidence in my discussion below, is the view first introduced by Sauvé Meyer (1992).[36] She argues that we should dismiss the question of whether or not teleology and necessity are mutually compatible or reducible to each other as not being the main point for Aristotle, and focuses, conversely, on the issue of intrinsic versus incidental causation.

Following this approach, I believe that the reason why Aristotle contrasts his own teleological worldview with that of his materialist predecessors is that the latter deny that high-order natural phenomena, such as animals and plants, have a privileged ontological status. According to the materialists, only the material elements are natures in a true sense, which means that the things that are constituted from them are mere accidental qualities or arrangements of these elements. The materialist view of nature eliminates those very things that Aristotle takes to be ontologically basic, and which in his view are in particular need of explanation, namely complex natural wholes such as living beings. In short, for Aristotle an animal is the primary example of a natural substance, whereas for the materialist an animal is merely a coincidental conglomeration of elements. The heart of the debate does not pertain (or at least not directly) to the question of reductionism, but rather to that of eliminativism: the mistake of the materialists is not just that they reduce plants and animals to their material elements, but more that, as a consequence of this reductionism, they deny that plants and animals are substances at all.[37]

Aristotle thus does not want to subsume all forms of material necessity under conditional necessity (he is not against all forms of reductionism),[38] nor does he require teleological explanations for all natural phenomena (he is also not a panglossian). He agrees that material necessity on its own may account for the coming to be of some low-level natural phenomena that have regular good outcomes (see, e.g., the production of eyebrows to be discussed in section 3.2), but denies that the presence of such outcomes

[36] Versions of this view are also defended by Bolton (1997, 122); Judson (2005); and Matthen (2009).

[37] Sauvé Meyer (1992, 794–795; 820–825); Johnson (2005, 98–99).

[38] Chapters that are traditionally read as endorsing an anti-reductionist view (e.g., *PA* I.1, *Ph* II.9, *GA* V.8) in fact make a more subtle point about what the appropriate modes of explanation are for what kind of natural phenomena: some natural phenomena cannot be explained in terms of material-efficient causes alone and require the *additional* assumption of formal-final causes. Aristotle's point is not that we should substitute conditional necessity for material necessity in all cases, but rather that we should *expand* the types of cause we invoke in our natural explanations.

on a regular basis[39] can be merely accidental. Instead, materially necessitated structures are "actively" co-opted or adapted in animals by their formal natures *because they are good for that animal*; their explanation thus requires references to teleology as well as to material necessity. High-level natural phenomena, such as the coming to be of complex natural wholes like (most) living organisms, are never due to an accidental combination of material elements, but are always the product of intrinsic causation involving teleology and conditional necessity.

In both low-level and high-level generations of natural products, Aristotle holds that these products can only be explained satisfactorily by reference to the goal-directed actions of nature as an internal efficient cause. Such a formal nature acts – always or for the most part – for the sake of something by either (i) realizing an internal, preexisting potential for form or (ii) by using materials produced by material necessity for the good of the natural being. The first causal pattern is what I characterized above as "primary teleology"; the second pattern is that of "secondary teleology." An important difference between the two types of teleology not mentioned above is that while primary teleology only pertains to the actions of *internal* formal natures working within the confines of the individual animal, the causal pattern underlying secondary teleology can also be extended to include what has been called "inter-species" teleology. In the latter case, it describes the causal pattern of any agent – internal or external – making use of things available by nature for its own good, such as living beings using each other as food.[40]

Bearing these distinctions in mind, I shall now resume my discussion of Aristotle's first argument in defense of natural teleology.

A first outline of the aporia and of Aristotle's solution

Aristotle's first answer to why nature is among the causes that are for the sake of something consists of a puzzle or aporia concerning the causal

[39] See Nielsen (2008, 397–398), on the normative connotation of Aristotle's notion "for the most part": the notion need not always indicate actual frequency, but rather frequency *in ideal circumstances*.

[40] In inter-species teleology the perspective of the user becomes important; see Judson (2005, 356–357). Things that are present for whatever reason can be used by a goal-directed agent, because of the material potentials these things have, either *within* natural beings (e.g., earthy material, because of its defensive potentials, can be used by the formal nature of deer for the production of horns), or *among* natural beings (e.g., the branches of a tree, because of their resistance against water, can be used by the shipbuilder for the production of ships). The outcomes of these processes of "using" have genuine functions or final causes (e.g., defense or floating), even though it would not be right to say that the constitutive materials that are used *came to be* for the sake of these functions or final causes.

relation between natural processes and the goodness or badness of their outcomes. In the hypothetical objection, raised by an imaginary materialist predecessor, Aristotle draws an analogy between the falling of rain and the growth or spoilage of crops on the one hand and the generation of animal parts and complete animals and their functions on the other hand (*Ph* II.8, 198b16–32). The base domain of the analogy runs as follows (*Ph* II.8, 198b16–23):

> There is a difficulty: what prevents nature not to act for the sake of something or because it is better, but in the way Zeus rains, not in order to make the crops grow, but of necessity (for it is necessary that that which has gone up cools down, and what cools down becomes water and falls down: when this has happened, it turns out that crops grow), and in the same way also that if someone's crops are ruined on the threshing floor, it does not rain for the sake of this, in order that they be spoiled, but that it happened to come about.[41]

Aristotle has his opponent suggest that instead of saying that a beneficial outcome, such as the growth of crops, is the result of nature acting for the sake of something (i.e., being the result of primary teleology) *or* of nature acting that way because it is better (i.e., the outcome being the result of secondary teleology),[42] we might as well say that the natural process took place of material necessity, in virtue of water elements acting according to their material natures, and that the outcome – whether good or bad – just happened to result in that way.

As Sedley points out,[43] the expression "Zeus rains" indicates that Aristotle portrays his opponent as a materialist who tries to provide a materialist explanation for something that is popularly viewed as an act of a providential god. This latter view, representing a naïve, religious, and anthropocentric assumption about the supposed providential teleology of the world, is ridiculed and rejected in favor of a naturalistic explanation in terms of the interactions of material elements. The materialist account interprets the relation between natural processes and their outcomes as an accidental one: the meteorological phenomenon of rainfall can be explained fully by reference to the mechanical cycle of evaporation, and the agricultural

[41] ἔχει δ' ἀπορίαν τί κωλύει τὴν φύσιν μὴ ἕνεκά του ποιεῖν μηδ' ὅτι βέλτιον, ἀλλ' ὥσπερ ὗει ὁ Ζεὺς οὐχ ὅπως τὸν σῖτον αὐξήσῃ, ἀλλ' ἐξ ἀνάγκης (τὸ γὰρ ἀναχθὲν ψυχθῆναι δεῖ, καὶ τὸ ψυχθὲν ὕδωρ γενόμενον κατελθεῖν· τὸ δ' αὐξάνεσθαι τούτου γενομένου τὸν σῖτον συμβαίνει), ὁμοίως δὲ καὶ εἴ τῳ ἀπόλλυται ὁ σῖτος ἐν τῇ ἅλῳ, οὐ τούτου ἕνεκα ὗει ὅπως ἀπόληται, ἀλλὰ τοῦτο συμβέβηκεν.

[42] Pace Scharle (2008, 169–170), who reads these two propositions conjunctively as exhibiting one and the same kind of natural teleology. For my reading of "because it is better" as a reference to secondary teleology, see sections 3.2 and 4.2.

[43] Sedley (1991, 185).

outcomes – whether they are good or bad – are unrelated and coincidental to the event of rain itself. The end result does not explain the occurrence of rain (rather, material necessity does), nor does the occurrence of rain intrinsically necessitate a particular outcome (rather, as the use of the verb συμβαίνειν suggests, the outcomes are by chance and accidental).[44]

Next, the hypothetical opponent applies this causal scheme to the biological realm, starting with the generation of parts of animals and their functions. The first half of the target domain of the analogy runs as follows (*Ph* II.8, 198b23–29):

> So what prevents also parts in nature from being this way, for example that teeth shoot up of necessity, the ones in the front sharp, with the fitness for tearing, the molars broad and useful for grinding down the food – not because they came to be for the sake of this, but because they turned out that way. And similarly about the other parts, in as many as "that for the sake of something" seems to be present.[45]

The materialist again conceptualizes the causal relation between biological parts and their function as an accidental one: teeth grow of material necessity, and their functional differentiation is a matter of chance, resulting accidentally from the material potentials of teeth and from the structure in which they happened to grow, and not because of teleology. The same is said to hold of as many parts as seem to be for the sake of something: they all come to be due to material necessity, and their functional features are mere accidents.

The materialist then extends this causal scheme to the coming to be of complete living beings (*Ph* II.8, 198b29–34):

> Wherever then all [the parts] turned out in a way they would also [have done] if they had come to be for the sake of something, those survived, having been organized in a fitting way by spontaneity. As many as did not [turn out] in such a way perished and continue to perish, as Empedocles says about the man-faced ox progeny. This then is the argument, about which one might be puzzled, and there may be others just like it.[46]

[44] I translate *hê tuchê* with "luck" and *to automaton* with "spontaneity"; I use "chance" as a general term covering both luck and spontaneity.

[45] ὥστε τί κωλύει οὕτω καὶ τὰ μέρη ἔχειν ἐν τῇ φύσει, οἷον τοὺς ὀδόντας ἐξ ἀνάγκης ἀνατεῖλαι τοὺς μὲν ἐμπροσθίους ὀξεῖς, ἐπιτηδείους πρὸς τὸ διαιρεῖν, τοὺς δὲ γομφίους πλατεῖς καὶ χρησίμους πρὸς τὸ λεαίνειν τὴν τροφήν, ἐπεὶ οὐ τούτου ἕνεκα γενέσθαι, ἀλλὰ συμπεσεῖν· ὁμοίως δὲ καὶ περὶ τῶν ἄλλων μερῶν, ἐν ὅσοις δοκεῖ ὑπάρχειν τὸ ἕνεκά του.

[46] ὅπου μὲν οὖν ἅπαντα συνέβη ὥσπερ κἂν εἰ ἕνεκά του ἐγίγνετο, ταῦτα μὲν ἐσώθη ἀπὸ τοῦ αὐτομάτου συστάντα ἐπιτηδείως· ὅσα δὲ μὴ οὕτως, ἀπώλετο καὶ ἀπόλλυται, καθάπερ Ἐμπεδοκλῆς λέγει τὰ βουγενῆ ἀνδρόπρῳρα. ὁ μὲν οὖν λόγος, ᾧ ἄν τις ἀπορήσειεν, οὗτος, καὶ εἴ τις ἄλλος τοιοῦτός ἐστιν·.

In a final move, the materialist claims that even the coming to be of entire natural beings can be explained by reference to the same causal model: the fact that some animal parts formed matching wholes is the result of spontaneity, not of nature acting for the sake of something. The view that is being ascribed to someone like Empedocles is thus that the present biodiversity is to be explained as the accidental result of a mix-and-match process of animal parts that is guided by chance and not by the goal-directed actions of nature.

Immediately following this aporia, Aristotle presents his own solution (*Ph* II.8, 198b34–199a8):

> It is impossible that things are that way. For those things, and all things that are by nature, come to be that way either always or for the most part, and none of them belongs to things that are due to luck or spontaneity. For it does not seem to be due to luck or spontaneity that it rains often in wintertime, but [it does] when [it rains] during the dog days. Nor do heat-waves [seem that way] during the dog days, but [they do] when they occur in winter. If, then, it seems that [these things] are either by accident or for the sake of something, [and] if it is not possible that these things are by accident or by spontaneity, they are for the sake of something. But that such things are by nature, even the people who make this argument would claim that. There is thus that for the sake of something among the things that come to be and are by nature.[47]

The structure of the counter-argument Aristotle provides is quite complex, so let me offer a brief paraphrase.[48] What is at stake in the argument is the nature of the causal relation between natural processes and their outcomes: the materialist presented three examples of natural cases in which this relation was one of chance. Aristotle's counter-position is that it is impossible that the outcomes of natural processes mentioned by the materialist are due to chance. It is impossible because natural processes produce such outcomes as described by the materialist either always or for the most part – their regularity excludes (by Aristotle's definition of chance as discussed in *Ph* II.4–6)[49] the possibility that they are due to chance.

[47] ἀδύνατον δὲ τοῦτον ἔχειν τὸν τρόπον. ταῦτα μὲν γὰρ καὶ πάντα τὰ φύσει ἢ αἰεὶ οὕτω γίγνεται ἢ ὡς ἐπὶ τὸ πολύ, τῶν δ' ἀπὸ τύχης καὶ τοῦ αὐτομάτου οὐδέν. οὐ γὰρ ἀπὸ τύχης οὐδ' ἀπὸ συμπτώματος δοκεῖ ὗειν πολλάκις τοῦ χειμῶνος, ἀλλ' ἐὰν ὑπὸ κύνα· οὐδὲ καύματα ὑπὸ κύνα, ἀλλ' ἂν χειμῶνος. εἰ οὖν ἢ ἀπὸ συμπτώματος δοκεῖ ἢ ἕνεκά του εἶναι, εἰ μὴ οἷόν τε ταῦτ' εἶναι μήτε ἀπὸ συμπτώματος μήτ' ἀπὸ ταὐτομάτου, ἕνεκά του ἂν εἴη. ἀλλὰ μὴν φύσει γ' ἐστὶ τὰ τοιαῦτα πάντα, ὡς κἂν αὐτοὶ φαῖεν οἱ ταῦτα λέγοντες. ἔστιν ἄρα τὸ ἕνεκά του ἐν τοῖς φύσει γιγνομένοις καὶ οὖσιν.

[48] For alternative reconstructions of the argument, see Quarantotto (2005, 90–95).

[49] For Aristotle, luck and spontaneity indicate the causes of irregular and unexpected outcomes. These are outcomes that *typically* come to be due to thought, choice, or nature, but whose cause in this

This is clear from the following two examples (the use of δοκεῖ in *Ph* II.8, 199a1 indicates that Aristotle assumes that even his opponent would agree to this): nobody would say that frequent rain in the winter is due to chance (only rain in the summer is), nor would he say that frequent heat-waves in the summer are due to chance (only heat-waves in the winter are). If, then, these frequently occurring natural processes are either due to chance or for the sake of something (Aristotle again uses δοκεῖ in *Ph* II.8, 199a3 to suggest accordance),[50] they must be for the sake of something: the relation between natural processes and their outcomes must be teleological.

Although the general purport of the passage is clear enough (i.e., that nature is among the causes that act for the sake of something), there are three problems in Aristotle's response to the puzzle that I shall need to address in the next section.

First, Aristotle couches the dispute over which causes are operative in nature exclusively in terms of spontaneity and teleology; the notion of necessity is not mentioned in his response to the puzzle raised by the materialist.[51] This "disappearance" of the notion of necessity seems suspicious, for Aristotle usually counts material necessity among the causes of natural events that happen always or for the most part.[52] He often uses examples of meteorological phenomena such as the evaporation cycle that produces rain to illustrate the regularity of materially necessitated processes.[53] The mechanical explanation offered by the materialist for the

particular case is either: (i) an indeterminable cause; the event (e.g., "a falling stone that hits a person") *seems* to have been for a purpose (e.g., "someone throwing that stone with the purpose of hitting that person"), but the expected corresponding action that typically leads to this outcome did not take place (e.g., nobody actually threw the stone). The event must therefore be the result of some other action that from our perspective is indeterminable; the outcome is called a case of good or bad luck. Or (ii) a determinate cause (e.g., "going to the marketplace in order to litigate as a plaintiff") that has incidental and unforeseen results (e.g., "meeting his debtor and getting his money back"), possibly in addition to having a proper result and final cause (e.g., "litigating as a plaintiff"). The unforeseen result is also called a case of good or bad luck. Cf. Boeri (1995, 87–96), and Lennox (2001a, 250–258). For Aristotle's interpretation of the notion of luck in Empedocles, see *Ph* II.4, 196a17–24 and *GC* II.6, 334a1–9.

[50] A materialist might well have disagreed with Aristotle's dichotomy: Waterlow (1982, 77).

[51] Sauvé Meyer (1992; 797) suggests that Aristotle focuses solely on chance and teleology in order to frame the problem in terms of accidental causation on the one hand and intrinsic causation on the other: if the outcomes of natural processes are either accidents or the products of the goal-directed actions of nature, then on the basis of their regularity we should conclude that they are the result of teleology. This shift in terminology might also reflect the type of causation that the materialist claims is operative in the coming to be of complete living beings in the final part of the analogy: spontaneity is said to produce the same results one could expect from teleology.

[52] Cf. Charlton (1970, 120).

[53] The key passage is *GC* II.11, 338a14–b19, which will be discussed in more detail in section 3.3. See also *APo* II.12, 96a2–7 and *Meta* VI.2, 1026b27–35.

coming to be of rain matches Aristotle's own view:[54] rainfall is due to the circulation of material elements in the atmosphere, depending on the orbit of the sun and the change of seasons, and is therefore a regular natural phenomenon. Nowhere does Aristotle claim that rain is for the sake of something.

This brings us to the second problem in Aristotle's solution to the aporia: Aristotle seems to argue that if winter rain and summer heat are regular natural phenomena, they cannot be due to chance but must be for the sake of something. What, then, does Aristotle think winter rain is for? Traditionally, scholars have denied that Aristotle endorses the view that winter rain is for the sake of something.[55] However, more recently, other scholars have pointed out that the latter interpretation would make the solution to the aporia incomprehensible,[56] and I believe this is right. The text itself presents only one possible goal of winter rain: the growth of crops. Certainly, this need not be the only purpose served by winter rain, but if the argument is to be rhetorically effective, it seems that there must be some non-accidental way in which Aristotle thinks winter rain (even if not itself caused teleologically) serves the growth of crops and thus proves the materialist to be wrong.[57]

In the next section, I shall in fact argue that Aristotle believes that winter rain is for the sake of growing crops, where the type of teleology at stake is an external form of *secondary* teleology. The coming to be

[54] For Aristotle's discussion of rain in terms of material and efficient causes, see *Meteor* I.9, 346b16–36; *Meteor* I.11, 347b12–33; and *GC* II.10, 337a1–7; in the biological works, Aristotle uses the mechanical explanation of rain as an analogy for physiological processes in the body: see *Somn* 3, 457b31–458a9 and *PA* II.7, 653a2–7.

[55] See, e.g., Charlton (1970, 120–123); Gotthelf (1987); Irwin (1988, 102–107); Nussbaum (1978, 94), and, more recently, Pellegrin (2002, 309); Johnson (2005, 149–158); and Judson (2005, 345–348).

[56] See Code (1997); Cooper (1982); Furley (1985); Sedley (1991; 2007); and Wardy (1993).

[57] Most recently, Scharle (2008) has argued that winter rain is indeed teleological, but not for the sake of the growth of crops, since it is not *the nature* of winter rain to be for the sake of this, nor the nature of the cosmos to direct winter rain to this. She holds that winter rain is teleological because the motions of the water elements are fitted to the circular motions of the sun (which is the efficient cause of water motions) in a way that when they fall in the winter the rain is teleological, because it is properly due to the retraction of the sun and thus due to intrinsic causation, whereas when they fall in the summer, the rain is accidental, because it is not a proper result of the closeness of the sun. Although this presents an interesting and elegant alternative, I take it that the crux for Aristotle in *Ph* II.8 is to show that regular natural phenomena have regular beneficial outcomes due to the fact that *nature is an efficient cause that acts for the sake of something*. Under Scharle's interpretation, however, it is the retraction of the sun in the winter that is the efficient cause that makes the water return to its natural place, but this efficient cause itself never – neither in the winter, nor in the summer – acts for the sake of this outcome. In fact, the motions of the sun are an accidental cause of the entire water cycle, which Aristotle characterizes as a materially necessitated process, whereas the return of water elements to their natural place is always a case of primary teleology for Aristotle, regardless of what season it is. Cf. Sedley (1991, 184); Wardy (1993, 22), and Morison (2002, 26–28).

of crops is not a realization of an internal potential for form through the actions of winter rain (i.e., crops are not an outcome of primary natural teleology), nor is it an accidental outcome of winter rain (i.e., crops are not a spontaneous by-product of a materially necessitated natural process). Rather, the coming to be of crops is due to the goal-directed actions of human beings who make use of the natural material potentials of regular winter rain (and seeds) and impose the art of agriculture on what is naturally available, in order to secure the regular coming to be of beneficial outcomes (i.e., coming to be as crops is an extrinsic function of a certain kind of plant). It is thus an example of human beings using art to complete the goal-directedness present in nature in a way that resembles formal natures using extra materials for the production of subsidiary animal parts: both are cases of "using" what is naturally available, and in both the "goods" produced reveal the perspective of the user, rather than a feature intrinsic to the thing used. Of course, under this interpretation the causal connection between winter rain and the growth of crops is thus hardly a *natural* teleological one. However, it does illustrate the necessity of there being goal-directed efficient causes for the production of regular, beneficial outcomes, which is the main point Aristotle is making against his materialist opponent.

However, if we grant, then, that winter rain is for the sake of something, perhaps even for the growth of crops, we face a third problem, concerning the scope of Aristotle's natural teleology. The standard view is that Aristotle restricts the operation of natural teleology to the individual natures of substances,[58] but if rain comes to be to serve a function that is distinctly anthropocentric, then perhaps we ought to conclude that Aristotle's teleology itself is anthropocentric (i.e., that the goal-directedness of nature is *ultimately* for the benefit of man)[59] or even cosmic (i.e., that the goal-directedness of nature is *ultimately* for the sake of preserving the existing balance in the cosmos).[60] Below, I shall argue that these conclusions are not necessary if we interpret Aristotle to understand the coming to be of crops (just like the coming to be of teeth) as being a form of secondary, rather than of primary teleology. Serving an anthropocentric goal is something that is imposed on natural processes from the outside, not something that is intrinsic to their internal natures.

[58] See especially Gotthelf (1987).

[59] This controversial but thought-provoking interpretation is defended by Sedley (1991; 2007).

[60] A cosmic view of Aristotle's teleology is assumed or defended by Cooper (1982); Furley (1985, 115–116); (1996, 75); Kahn (1985); Matthen (2001; 2009); Sedley (1991; 2007); and Wardy (1993, 19).

1.3 THE NATURE AND SCOPE OF NATURAL TELEOLOGY

Empedocles and Aristotle on the coming to be of teeth

The debate on Aristotle's first argument in defense of natural teleology traditionally focuses on the rainfall example, which is arguably the most problematic part of the argument, while much less attention is paid to the Empedoclean account of natural generation.[61] However, since the Empedoclean account forms the target domain in the analogy, we can use it for our interpretation of the rainfall example.

Let me start by briefly outlining Empedocles' zoogony as it can be reconstructed from the fragments that have been preserved.[62] According to the testimony by Aetius (*DK*31A72), Empedocles distinguishes four stages in the generation of animals and plants. The first two stages probably occur under the increasing influence of Love, in which animal generation is explained "bottom-up," as moving from parts to wholes (see in particular *DK*31B17; B57, B59, B60, B61, B96, and B98). First, the coincidental interactions amongst the four Empedoclean elements produce animal tissues such as flesh and bone. Next, similar interactions between these tissues produce separate animal parts, such as foreheads and arms. Finally, the random interactions between such isolated parts roaming the earth lead to the coming to be of different kinds of animals. Once Love's influence is strong enough, the parts will randomly stick together, forming all kinds of hybrids. Stages 3 and 4 probably occur under the increasing influence of Strife, in which complete plants, animals, and human beings come to be spontaneously from the earth (see *DK*31B62 and Strasbourg fragment d). They are said to rise up like shoots of plants, grow limbs, and then mature naturally to the point where they are able to reproduce themselves sexually (Strife pulls the uniform masses apart and thereby creates the extremities). Presumably, this is the world in which we live now. Ultimately, Strife will break up the organisms into their four elements again and soon Love's influence will make itself felt.

Empedocles' account of the biological past is thus cyclical,[63] and draws from two conceptually different models of the origin of species. The

[61] The passage is usually quoted to applaud Empedocles for offering a pre-Darwinian theory of natural selection; see, e.g., Bostock (2006, 50); Ross (1936, 78); Sedley (2003, 2, 11; 2007, 43).

[62] The exact details of Empedocles' zoogony have been the subject of much debate, especially after the publication of the Strasbourg papyrus by Martin and Primavesi (1999), which revealed some interesting new materials. I claim no originality or comprehensiveness in the overview I present here – my purpose is merely to put the *Physica* passage into context.

[63] On the nature of this cycle and the continuity between the phases of Love and Strife, see Sedley (2007, 39–40).

zoogony under Strife follows a mythological model according to which living beings come to be spontaneously from the earth. The first generation is explained as a transition from the stage of spontaneous generation of both males and females, growing out of the moisture due to fire, to a stage of sexual reproduction, thus resembling a botanical process of the growth and maturation of plants (without undergoing some kind of transformation of species). The zoogony under Love, on the other hand, seems to be an original invention by Empedocles and offers a fully naturalistic account of the growth of more complex organic compounds, resulting from random collisions of organic parts. The examples of creatures thus produced are rather fantastic hybrids, like the man-faced ox progeny mentioned by Aristotle, but the fragments do not rule out the possibility that these combinations also resulted in living beings like the ones that are alive now, such as, for example, ox-faced ox progenies. The reference to Empedocles we find in Aristotle's defense of natural teleology fits this second kind of zoogony.

Crucial for the understanding of the Empedoclean passage in *Ph* II.8, 198b23–34 is the distinction in the materialist account of generation between the two levels of "incidental fitness." The first level pertains to the "incidental fitness" of parts of animals: material necessity causes the coming to be of parts such as teeth that turn out to have the right potentials and structure for the performance of biological functions such as biting and grinding. The second level pertains to the "incidental fitness" of complete living beings: spontaneity causes animal parts to combine "in a fitting way," and the animals that result from these "matches" make up the present diversity of animal species (those combinations of parts that do not "fit" constitute the monsters that died and continue to die). For Aristotle, both causal accounts are mistaken, but as I shall expound below, they are not mistaken to the same degree.

Aristotle's biological treatises are full of references to teeth, so let me start by presenting his own explanation of the coming to be and presence of these parts (*PA* III.2, 663b22–35):

> We must say what the character of the necessary nature is, and how nature according to the account *has made use* of things present of necessity for the sake of something . . . For the residual surplus of this sort of [earthen] body, being present in the larger of the animals, is *used* by nature *for* protection and advantage, and [the surplus, which] flows of necessity to the upper region, it *distributes* in some animals to *teeth* and tusks, in others to horns.[64]

[64] πῶς δὲ τῆς ἀναγκαίας φύσεως ἐχούσης τοῖς ὑπάρχουσιν ἐξ ἀνάγκης ἡ κατὰ τὸν λόγον φύσις ἕνεκά του κατακέχρηται, λέγωμεν . . . Τὴν γοῦν τοιούτου σώματος περισσωματικὴν

In this passage, Aristotle exhibits teeth to be paradigmatic products of secondary teleology. Just like his materialist opponent, Aristotle believes that the *coming to be* of teeth is primarily due to material necessity[65] and that the functionality of the teeth follows from the material potentials the constitutive materials of teeth happen to have. The terms "useful" (*chrêsimos*)[66] and "suitable for" (*epitêdeios*)[67] that are put in the mouth of the materialist to describe the incidental fitness of parts perfectly reflect Aristotle's own usage of these terms, indicating the "fitness" something has – not in virtue of being conditionally necessitated for that purpose, but in virtue of the material potentials a part or residue happens to have of material necessity. However, the *presence* and functionality of teeth must ultimately be explained by reference to the goal-directed actions of the formal nature of animals with teeth. The formal natures of these animals make use of these materials and "assign" a function to them in accordance with the potentials the materials have of necessity. Since in this case the materials are earthen and hard, which constitute the right potentials for the function of defense, the formal natures use them to make parts such as teeth, tusks, and horns (see *PA* II.9, 655b4–15). So even though the coming to be of teeth is not primarily driven by form (Aristotle never suggests that there is a preexisting potential for form that is being realized by the production of teeth; strictly speaking, he believes animals could nourish and defend themselves without teeth), Aristotle does not deny that natural, materially necessitated processes can have beneficial outcomes. He only denies that they can have such beneficial outcomes on a regular basis *without the intervention of goal-directed efficient causes*, which (actively)

ὑπερβολὴν ἐν τοῖς μείζοσι τῶν ζώων ὑπάρχουσαν ἐπὶ βοήθειαν καὶ τὸ συμφέρον καταχρῆται ἡ φύσις, καὶ τὴν ῥέουσαν ἐξ ἀνάγκης εἰς τὸν ἄνω τόπον τοῖς μὲν εἰς ὀδόντας καὶ χαυλιόδοντας ἀπένειμε, τοῖς δ' εἰς κέρατα.

[65] Other relevant passages are *GA* II.6, 745a18–745b9, in which Aristotle explains that teeth are made from the residues conducive to growth assigned to bones, and *GA* V.8, in which he explains the differentiations of teeth by reference to both material necessity and teleology. I discuss these passages in a separate paper, co-authored with Allan Gotthelf (2010).

[66] *Chrêsimos* usually characterizes the potentials residues have for something; see, e.g., *GA* I.15, 720b34–35; *GA* I.18, 725a3–7; *GA* III.3, 754b6–7; *GA* III.10, 760b13–14; *GA* IV.8, 776a23–26; *GA* V.2, 781b26–28; *HA* II.1, 500a15; *HA* VI.22, 576a14–16; and *IA* 1, 704a4–5.

[67] *Epitêdeios* is used to designate foodstuffs, natural places, and even thoughts that have certain "function-inducing" characteristics that these things just happen to have. For instance, Aristotle uses it with respect to certain areas in the sea that "are favorable for spawning"; see *HA* VIII.13, 589b3–6; cf. *HA* III.21, 522b22–23; *HA* III.21, 523a3–4; *HA* V.13, 544b8–9; *HA* X.5, 636b21–23; and *MA* 8, 702a17–19. Aristotle also uses the term to indicate the suitability of material mixtures for certain functions (*PA* IV.10, 686a8–11): "And nature placed some of the modes of perception on the outside of it [i.e., the head] as well, on account of the blend of the blood being well proportioned and *ensuring* both the warmth of the brain and the quietness and accuracy of perception." For this use of the term, cf. *Pol* VII.4, 1325b40–1326a4.

adapt or (passively) co-opt such features in order to support the animal's well-being.[68]

For Aristotle, it is the materialist account of the "fitness" of complete living beings that is most problematic. For Empedocles, animals that are "composed in a fitting way" and that therefore survive seem to be animals that are quite literally combinations of matching parts (i.e., of ox faces combined with ox bodies, etc.).[69] Aristotle, on the other hand, understands the well-adaptedness of each particular kind of animal primarily in terms of its being able to perform all its necessary vital and essential functions within its own specific natural environment. The regularity of animal species exhibiting this kind of fitness cannot be fully accounted for by reference to spontaneity or even to formal natures using what happens to be available for something good. The regular presence of functioning living beings requires, according to Aristotle, the assumption of a *stronger* form of teleology, i.e., of formal natures acting always or for the most part for the sake of realizing a preexisting potential for form (while thereby regulating the various necessary interactions of material-efficient causes), where this form is eternal in species in virtue of being continuously transmitted from father to offspring.

The failure of materialists such as Empedocles to recognize the operation of primary teleology is also highlighted in the following passage (*PA* I.1, 640a17–26):

> For generation is for the sake of being, but not being for the sake of generation. This is why Empedocles did not speak well when he said that many things belong to animals because they turned out that way during generation – for example that the backbone is such, because it happened to get broken when it was being twisted; he failed to see, first, that the seed previously constituted must already possess this sort of potentiality, and, next, that the producer was prior not only in definition but also in time; for it is a human being who generates a human being, such that it is because the one *is* such, that the other's coming to be happens in that way. (Cf. *GA* II.1, 735a3–4)

As Aristotle explains here, the core of his theory of primary teleology in natural generation is the fact that whatever organism comes to be already

[68] See also Aristotle's criticism of Democritus in *GA* V.8, 789b2–15, where Democritus is rebuked for failing to acknowledge the operation of (secondary) teleology in the differentiation of teeth.

[69] Empedocles' notion of fitness thus hardly foreshadows fitness in a Darwinian sense. For instance, in Empedocles there is no selection for the fittest, but only for the fit (where this selection procedure is a purely negative force eliminating the unfit); and "fitness" does not refer to a relation between the animal and its environment (pace, most recently, Nielsen 2008, 387), but only to an internal match of parts being mixed in the same ratio. Also, the concept of chance invoked by Empedocles is one of randomness, not one of statistical probability: all homogeneous hybrids survive, all heterogeneous hybrids die.

possesses its corresponding form in potentiality (where the process of generation is for the sake of realizing that form or the being of that animal), and receives it from something that possesses that form in actuality.[70] The process of primary teleology involves the eternal replication of form,[71] which can only be explained through the assumption of nature operating as an internal efficient cause that acts for the sake of realizing those forms. It is only at the level of the coming to be and presence of complete and functioning living beings that Aristotle claims that the goal-directed actions of nature as an efficient cause are always primarily driven by form (i.e., it is the potential for form that guides the actions of nature as an efficient cause): where Empedocles mistakenly believes that their presence can be explained bottom-up, as the coincidental outcomes of spontaneous combinations of material elements, Aristotle grounds his explanations of animals in their form and explains their necessary parts and material constitutions top-down.[72]

In sum, what Aristotle tries to establish in arguing against the puzzle raised by the materialist is not the priority of form as such (the notion of conditional necessity is not explained until the following chapter, i.e., *Ph* II.9), but the necessity of postulating goal-directed actions of natural efficient causes to account for regular beneficial outcomes *also* in those cases where material necessity is the primary cause in the coming to be of a part or structure. Aristotle is thus not trying to present a unified account of (natural) teleology here, but is rather making the more general claim that for the explanation of whatever level of "fitness" or functionality can be found in natural beings, one needs to assume the operation of an efficient cause acting for the sake of producing that functional feature, regardless of whether this goal-directedness is primarily driven by form or by matter.

The rainfall example and the scope of natural teleology

We now have a clearer picture of the analogy between the rainfall example and the Empedoclean theory of generation: according to the materialist, both kinds of "generations" are due to material necessity, where the beneficial (or detrimental) outcomes are spontaneous and incidental, rather than due to the actions of an intentional agent (such as Zeus) generating things for the sake of those outcomes. The materialist thus refutes the providential, external, and anthropocentric teleology of Zeus in favor of a purely material form of causation. Aristotle's own solution to the aporia

[70] Witt (1994b, 222–228). [71] Lennox (2001a, 231). [72] Cf. Furley (1996, 77).

must be sought to lie somewhere in the middle: material necessity may certainly play a role in the generation of some natural phenomena, but if the relation between natural processes and their good outcomes is to be explained in terms of intrinsic causation, we must – rather than assume divine providence – postulate immanent natural teleology. That is, we must postulate the existence of internal natures that operate as efficient causes for the sake of such good outcomes, where this teleology is primarily driven either by form or by matter. This much at least must be the implication of Aristotle's statement and subsequent argument that it is "impossible for things to be that way" (*Ph* II.8, 198b34). What remains is to explain how Aristotle's account of rain fits into this picture and what the implications are for the scope of natural teleology.

In the sections above, I have argued that for Aristotle's solution to the aporia to be effective we need to attribute to Aristotle a teleological explanation of winter rain, but that this teleology need not be of the primary, natural type. Aristotle's own explanations of teeth and living beings suggest that he has the materialist come up with examples that in his own view represent increasingly stronger cases of teleology. The examples move from secondary to primary teleology, with the most dubious teleological example of rainfall producing crops functioning as the base domain in the analogy. In order to reconstruct Aristotle's teleological account of winter rain, I thus propose to treat the rainfall example as a weaker analogue of his account of teeth, i.e., as a weaker version of what I have called secondary teleology.

I have already suggested that Aristotle would agree with the materialist explanation of the coming to be of rain as a materially necessitated process. He identifies the sun and the obliquity of its orbit as the overarching cause responsible for the circularity of the seasons and the regularity of winter rainfall: the simple elements imitate this circular motion, and this is what causes rain to fall regularly during the wintertime.[73] Following the pattern of secondary teleology, we now need to identify something for which the availability of winter rain can be used. In my discussions above, I already assumed the coming to be of crops to be a plausible final cause of rain. The anthropocentric character of this final cause (the materialist reference to the growth of crops, rather than to that of plants in general, reveals a strictly human agricultural perspective)[74] need not be a problem, since we do not have to postulate that according to Aristotle winter rain comes to be for the sake of producing crops in the strong sense, nor that by producing crops

[73] Cf. Matthen (2009). [74] Sedley (1991, 185–186).

rain is realizing some preexisting natural form that is anthropocentrically defined,[75] for neither of these conclusions hold for the example of teeth. Instead, what is needed for a teleological interpretation of winter rain is the identification of some overarching goal-directed natural efficient cause that guarantees the intrinsic causal connection between winter rain and some regular beneficial outcome of winter rain, such as the growth of crops.

In the case of teeth, the goal-directed efficient cause is represented by the animal's own internal formal nature, which uses what is available of material necessity for something that is good for that specific kind of animal, thus illustrating Aristotle's claim that "nature is among the causes that act for the sake of something." In the case of crops, however, the goal-directed efficient cause is represented by *external* agents, that is, by human performers of the art of agriculture. Crops come to be through the intervention of human beings who impart the art of agriculture on the water, which due to material necessity is regularly available in the winter for the irrigation of seeds: humans use what is naturally available for what is *good for them*.[76] Agriculture thus takes place in the winter because that is when it regularly rains; it does not rain regularly in the winter for the sake of agriculture.

The fact that human beings are the beneficiaries of the coming to be of crops does not imply that *all* goals in nature are anthropocentric. As Aristotle argues in the second part of his defense of natural teleology (see *Ph* II.8, 199a8–20), art is ontologically secondary to nature, which means that the ends of artistic production are subsidiary to what happens in nature. The ontological priority of nature forms the crux of the whole second argument: if art is limited to the imitation and completion (or "perfection") of natural goals, which it achieves through means congenial to nature, and if artistic processes are for the sake of something, then evidently (*Ph* II.8, 199a17: δῆλον) natural processes, too, are for the sake of something (cf. *PA* I.1, 639a19–21) – evidently, because the relations of priority and posteriority are the same in natural and artistic processes.[77]

[75] There is no form or nature of winter rain; cf. Johnson (2005, 156), and Wardy (1993, 25), who draws an analogy with Aristotle's notion of the city: the city *is* by nature, but that does not entail that it also *has* a nature.

[76] Cf. Matthen (2001, 183–184), who explains winter rain as an instance of "instrumental teleology." Note also that in this respect the example of winter rain is similar to the example of the light shining through a lantern in *APo* II.11, 94b27–37: light, consisting of relatively small particles, passes through larger pores of material necessity, but human beings make use of the potential of light by making lanterns, which will prevent them from stumbling in the dark. The use to which light is put is anthropocentric and secondary to the nature of light itself. Cf. Byrne (2002, 43).

[77] The analogy between the processes of artistic production and natural generation for which Aristotle argues in this second argument is twofold: (i) if there is a sequence of which there is an end, the

However, it would be false to think that because the arts borrow their ends from nature and because artistic ends are (by definition) anthropocentric ends, therefore the ends in nature must be anthropocentric, too.[78] Instead, art imposes an anthropocentric outlook on natural entities that come to be and are present for the sake of realizing their own internal ends.

It is thus important to realize that *all art* is in some sense a form of secondary teleology (i.e., one that involves external, human agents), as we as goal-directed agents make use of what is present by nature for our own benefit (*Ph* II.2, 194a33–36):

> Indeed,[79] the arts too make their material: some [arts make it] without qualification, others [make it] good to work with, *and we use it as if everything exists for the sake of us* (καὶ χρώμεθα ὡς ἡμῶν ἕνεκα πάντων ὑπαρχόντων). For we, too, are in some sense ends: for that for the sake of which is double; this has been said in *On Philosophy*.[80]

In this passage, Aristotle indicates that the final cause in artistic productions (as opposed to final causes in natural generations) lies outside the performance of the art, and is always relative to what is beneficial to us: our desires and needs determine what will be the end results of art, building upon what is already available or happening in nature.[81] The structures and uses we impose upon natural things through the application of art are always – although the product of intrinsic causation – accidental to those things and secondary to their own proper natural ends.[82] Nature is not itself anthropocentric; we just *use* natural things to our own benefit.

previous motions leading up to this end must have been for the sake of this end; the sequence is organized and teleological (*Ph* II.8, 199a8–9); (ii) the temporal ordering of the various steps in the sequence leading up to the end is determined by this end (and is thus to be explained teleologically; *Ph* II.8, 199a18–20). See Charles (1991, 114–115).

78 Pace Sedley (1991, 187).

79 Ἐπεὶ picks up on the conditional sentence in *Ph* II.2, 194a21–22 "if art imitates nature."

80 Sedley (1991, 189; 2007, 203n.72) uses this text in support of his anthropocentric interpretation of Aristotle's natural teleology. He argues that the construction of *hôs* plus the participle of *huparcheô* should be read as "on the ground that everything exists" rather than as "as if everything exists"; however, according to Rijksbaron et al. (2000, 100), constructions like these indicate a "subjective reason" for which the narrator does not want to be held responsible (cf. X. *An* IV.2.5). Aristotle thus makes a concession to popular thought in claiming that we are *in some sense* (*pôs* should be read in a conciliatory way) an end, too.

81 Cf. Broadie (1990, 400–401).

82 Cf. Aristotle's discussion of Antiphon's example of a bed (*Ph* II.1, 193a11–17): "If someone planted a bed, and the decomposition acquired the ability to send up a shoot, what would come up would not be a bed but wood: this seems to show that the arrangement in accordance with habit and art belongs accidentally (τὸ μὲν κατὰ συμβεβηκὸς ὑπάρχον), while its substantial being is that which persists continuously while being affected in these ways (τὴν δ' οὐσίαν οὖσαν ἐκείνην ἣ καὶ διαμένει ταῦτα πάσχουσα συνεχῶς)." In the absence of external efficient causes and under the right conditions, artifacts behave according to the natures of their constitutive material and realize their natural, primary ends, such as wood growing into a tree.

In short, the three examples of natural products put forward by the materialist (i.e., crops, teeth, complete living beings) represent for Aristotle increasingly stronger versions of the operation of the goal-directedness of nature. The point Aristotle is trying to make in his solution to the puzzle is that none of these natural phenomena with their beneficial outcomes can be explained satisfactorily (i.e., in terms of intrinsic causation) without the postulation of efficient causes acting for the sake of something. The coming to be of crops exhibits a form of external, secondary, artificial teleology: the growth of crops involves the intervention of *human* agents who impose the art of agriculture on what is available by nature, and thus produce something that is good from a human perspective. The coming to be of teeth exhibits immanent, secondary, natural teleology: the growth of teeth involves the intervention of the *formal natures* of individual animals on materials and structures that come to be of material necessity; the formal natures thereby make use of what is available by nature for what is good for their own specific substantial being. Finally, the coming to be of complete animals exhibits immanent, primary, natural teleology: the generation of animals involves the formal natures of individual animals realizing a preexisting potential for form by conditionally necessitating all the required materials and by organizing them in the appropriate way.

Further reflections on the scope of natural teleology

The distinction between primary and secondary teleology also allows us to make sense of other passages in the Aristotelian corpus that reflect an anthropocentric perspective on teleology. All natural beings, while being primarily and intrinsically realizations of their own form and existing for their own sake, can be used as matter by other natural beings, either as food and constitutive material, or (exclusively by human beings) as the underlying matter in artistic production. This appropriation of other natural beings as food or underlying matter is to be understood as a form of secondary teleology. Both the internal form of secondary teleology and the external appropriation of other beings are characterized by the presence of goal-directed efficient causes that make use of what is naturally available. In both cases, the material (which is either internal or external to the living being) is used for what is good *from the perspective of the user*; and the potentials of the available materials are causally primary. In neither case is the end that constitutes the final cause a realization of a preexisting potential for form.

A crucial and notorious passage in this context is Aristotle's description of how nature provides food for all living beings as part of an attempt to establish the naturalness of the art of acquisition and warfare (*Pol* I.8, 1256a19–21; b7–22):

> But there are many kinds of food, and therefore also many ways of life, both of animals and of human beings . . . Such property seems to be given by nature herself to all, in the same way as it does immediately following their birth, so too when they are being completed. For some animals generate at the moment of childbirth at the same time also sufficient nutriment to last until the offspring can supply itself – for example as many animals as produce larvae or lay eggs. As many as bear live young have up to a certain time nutriment within themselves for their offspring, namely the stuff called milk. Hence it is equally clear that we should suppose that also for those that are coming to be, that plants are for the sake of animals and that the other animals [i.e. non-human animals] are for humans – domesticated animals *for both use and food* (διὰ τὴν χρῆσιν καὶ διὰ τὴν τροφήν), and if not all, at least most wild animals *for food and for other benefit* (τῆς τροφῆς καὶ ἄλλης βοηθείας ἕνεκεν), such that from them both clothes and other kinds of tools come to be. If, then, nature makes nothing incomplete or in vain, it is necessary that nature has made them all for the sake of human beings.

Aristotle explains that since there are many kinds of food and all living beings need food, there are many ways of life: nature has adapted each way of life (both of animals and of human beings) to the living being's preferences for food and to the ease with which it can acquire it (*Pol* I.8, 1256a26–28). However, the property of food itself is provided by nature to all things alive, both directly in the form of (for instance) milk or egg-white at the moment of birth, but also by extension during maturation, in the form of other natural beings. The passage ends with a hierarchical picture of the food chain, according to which nature has made plants to serve as food for animals, and animals as food for human beings; Aristotle claims that ultimately nature has made everything for the sake of human beings. The teleology Aristotle defends here is unmistakably anthropocentric.[83]

However, it is important to recognize that Aristotle's focus here is on the existence of natural beings *qua food*; plants and animals are for the sake of human beings *qua* being the foodstuffs without which humans would not be able to live. The teleology that accounts for the use human beings make of other living beings is therefore secondary: it reveals the perspective of the user, who makes use of what is provided by nature for his or her own

[83] Sedley (1991, 181).

good.[84] This perspective is even more apparent in Aristotle's concluding remarks about the question of the naturalness of acquiring wealth (*Pol* I.10, 1258a19–24; 34–38):

> And the question about which we were puzzled in the beginning, [namely] whether it is the task of household management and of political science to acquire wealth or not, is also clear: it is necessary that [wealth] is present. For just as political science does not make men, but receives them from nature and uses them (ἀλλὰ λαβοῦσα παρὰ τῆς φύσεως χρῆται αὐτοῖς), so too is it necessary that that nature provides the earth or sea or whatever else for food . . . Most of all, as was said earlier, it is necessary that [wealth] is present by nature. For it is a task of nature to provide food to that which is born:[85] because for each living thing its food is what remains from that from which it comes into being. That is why the art of getting wealth out of crops and animals is natural for all people.

Just as nature produces human beings for politics to use, so too it is necessary that nature provides food for humans, in the form of other living beings, for humans to use.[86] The environment to which a living being naturally belongs is rich in other living beings that may serve as its food, but it is the predator that is adapted to use and digest the food that is available, not the food to the predator (cf. *Pol* I.8, 1256a19–22). As Pellegrin points out,[87] a camel (discussed in *PA* III.14, 674a28–674b18) has the kind of tongue and the number of stomachs it has to be able to digest the thorny bushes that are available in its habitat as a potential source of food. The thorny bushes are not the way they are (that is, bristly, woody, and fibrous), and do not grow when and where they do, because there are camels in their neighborhood that can only eat such food. Aristotle mentions no examples of plants or animals that are the way they are for the sake of becoming the right kind of food for some other being, and the fact that formal natures of animals – if possible – develop means for protection or defense indicates that natural teleology is restricted to the life and well-being of the individual animal.

[84] Cf. Scharle (2008, 162): "plants are for the sake of animals in the sense that it is part of animal nature to make use of plants, and animals are for the sake of humans in the sense that it is part of human nature to make use of animals."

[85] Cf. *GA* II.6, 744b17–25 where nature is compared to a good housekeeper who provides food to everyone, but according to a strict hierarchical pattern; for a discussion of this image, see section 3.2.

[86] Cf. Lloyd (1996, 191–192).

[87] Pellegrin (2002, 312); Scharle (2008, 164–165) makes the same point; pace Sedley (1991, 191; 2007, 202n.69). The direction of causality is important, because it shows that the formal nature of each kind of living being produces that living being *with a view to its own individual substantial being* (i.e., it adapts the camel in such a way that it can nourish itself from what is naturally available in its habitat), not with a view to the substantial being of other living animals (i.e., it does not adapt the bushes to the needs of camels).

So even though Aristotle seems to speak of a universal nature when he says that nature provides food for all, the *individual* formal natures of each kind of living being are what appropriate other kinds of (living) beings as their food and sustenance. In other words, the individual formal natures make sure that each individual kind of living being is able to benefit from the foods in its environment, which amounts – generally speaking – to "nature providing food for all."

Just as in the case of winter rain, plants and animals only have a potentiality for a secondary function *from a certain perspective*[88] or *relative to* other beings elsewhere in the food chain. The food chain imposes a hierarchy of conditional necessary relations between members of the present animal diversity, according to which the existence of the one is conditionally necessary for the coming to be and existence of the other.[89] Humans are on top of this food chain in virtue of having mastered a wide variety of arts and thus of being able to make the best use of what nature provides. Only humans move freely through different habitats and invent tools to increase their success in using things for their own advantage (and in protecting themselves against being eaten by others). Nature has made plants and animals for human beings to use as food or to benefit from them in other ways, but, I submit, the use human beings make of them is a secondary purpose (which is thus not part of the substantial being of plants and animals), and one that is imposed by human beings through the application of some kind of art.

In other words, the fact that human beings are often beneficiaries of natural processes does not reveal an essential characteristic of *natural* teleology (Aristotle's natural teleology is not in itself anthropocentric), but rather of *human art* that appropriates those natural processes to serve human ends.

A final passage that is relevant for the interpretation of the kind of teleology at stake in the natural food chain is Aristotle's discussion of the placement of the mouth in dolphins and selachians and the reason why they turn around while eating (*PA* IV.13, 696b25–34):

> In some [fish] the mouth is placed straight across, and towards the front, but in others on the underside, as for example in dolphins and selachians; and they grasp their nourishment after having turned belly up. And it appears that nature does this not only for the sake of the preservation of 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

[88] See Judson (2005, 356–357). [89] Cf. Simpson (1998, 49).

owing to being quickly sated. And in addition, being curved and narrow the nature of the snout is unable to open widely.[90]

The explanandum in this passage is not the existence of the mouth as such in a particular group of fish (which is presumably the result of primary teleology: a mouth is a necessary part for the intake of food in all animals), but rather its peculiar placement, which appears to be the result of secondary teleology.[91] Aristotle gives three – related – explanations for the peculiar positioning of the mouth and eating habits of dolphins and selachians. The final two explanations resemble a common pattern of explanation in Aristotle's biology (see sections 4.2–3) in which a feature is explained both by reference to the better (i.e., to how the feature contributes to the well-being of the animal) and to material necessity. Not being able to eat *easily* – obviously, dolphins and selachians still need to be able to catch some food – prevents these animals from eating themselves to death, but is also a necessary consequence of the structure of the snout they have, which is unable to open widely. However, the intrinsic function that is being served by the position of the snout and the turning around – i.e., the preservation of such animals as dolphins and selachians – is closely connected to a second, extrinsic function, which Aristotle mentions first (perhaps because this explanation is immediately accessible to observation, or because it is popular among the people of his time): the only way in which nature can prevent these animals from overeating is by allowing their food to escape. Since all dolphins and selachians eat fish, their peculiar eating habits serve *as a corollary* also to preserve the life of (some of) these fish (cf. *HA* VIII.2, 591b23–30). The direction of the hierarchy in the food chain is the reverse from the one outlined in the *Politics*: here the "lower" animals benefit from the eating habits of "higher" animals. This indicates that there is no absolute subordination of the good of one living being to that of another.[92]

Even if there is no need for an anthropocentric interpretation of Aristotle's natural teleology, the passages discussed above still leave room for a *cosmic* interpretation of this teleology. The examples of an eternal cycle of rainfall without which no plant could grow (let alone crops) and of formal

[90] Τὰ μὲν γὰρ κατ' ἀντικρὺ ἔχει τὸ στόμα καὶ εἰς τὸ πρόσθεν, τὰ δ' ἐν τοῖς ὑπτίοις, οἷον οἵ τε δελφῖνες καὶ τὰ σελαχώδη· καὶ ὕπτια στρεφόμενα λαμβάνει τὴν τροφήν. Φαίνεται δ' ἡ φύσις οὐ μόνον σωτηρίας ἕνεκεν ποιῆσαι τοῦτο τῶν ἄλλων ζῴων (ἐν γὰρ τῇ στρέψει σῴζεται τἆλλα βραδυνόντων· πάντα γὰρ τὰ τοιαῦτα ζῳοφάγα ἐστίν), ἀλλὰ καὶ πρὸς τὸ μὴ ἀκολουθεῖν τῇ λαιμαργίᾳ τῇ περὶ τὴν τροφήν· ῥᾷον γὰρ λαμβάνοντα διεφθείρετ' ἂν διὰ τὴν πλήρωσιν ταχέως. Πρὸς δὲ τούτοις περιφερῆ καὶ λεπτὴν ἔχοντα τὴν τοῦ ῥύγχους φύσιν οὐχ οἷόν τ' εὐδιαίρετον ἔχειν.

[91] The correct interpretation of this passage is highly contested: see Balme (1980, 9; 1987b, 279); Johnson (2005, 209); and Lennox (2001b, 341–342).

[92] Pace Bodnár (2005, 23–4).

natures of dolphins constructing their eating habits such that their prey may escape suggest that there exists a natural tendency in all individual things towards the regularity and goodness of the cosmos as a whole. Some suppose that this regularity exists over and above the one inherent in the individual natures of living beings and that it ensures the preservation of the cosmos as it is. Under a cosmic interpretation of Aristotle's natural teleology, the harmony, interaction, and well-adaptedness between individual natural entities is derived from or is an expression of an overall nature, i.e., the nature of the cosmos, which has its own form.[93]

There is no doubt that Aristotle on occasion conceptualizes the cosmos as a unity in which beings contribute to the existence and well-being of other beings,[94] and we should certainly expect him to provide a teleological explanation of this order (see *PA* I.1, 641b10–23[95] and section 5.4). The crucial question is thus not whether there is *a* form of cosmic teleology in Aristotle, but whether he explains the cosmic order in terms of a *separate* teleology in which everything is a realization of one underlying cosmic form, or rather in terms of *natural* teleology in which the actions of the individual formal natures of everything natural also account for order on a cosmic or global level. The key passage quoted in support of the cosmic reading is *Meta* XII.10, 1075a11–25:[96]

> We must also consider in which way the nature of the whole (ἡ τοῦ ὅλου φύσις) contains the good and the best – whether as something separated and by itself, or as its arrangement. Or [is it] in both ways, as an army does? For the good [of an army] is in its order and is also the general; but it is mostly the latter: for he is not due to the order but the order is due to him. All things are ordered together in some way, but not in the same way – even swimming animals and flying animals and plants. And it [i.e., the order] is not such that there is no relation between one thing and another – there is one: for all things are ordered together towards one (πρὸς μὲν γὰρ ἓν ἅπαντα συντέτακται), but it is as in a household, where for the free people it is least possible to act at random, but all or most [of their actions] are arranged, while it is possible for slaves and animals – their contribution to what is communal being little – much to act as they chance: for that is the kind of principle that nature is of each of them (τοιαύτη γὰρ ἑκάστου ἀρχὴ αὐτῶν ἡ φύσις ἐστίν). I mean, for example, that it is necessary for everything to come to

[93] See Sedley (1991, 192).

[94] Furley (2004, 83); Hankinson (1998, 147); Matthen (2009).

[95] In this passage, I take Aristotle to make the a fortiori argument that if sublunary natural beings are the product of natural teleology, then the more so should we consider the heavenly order to be the product of such teleology (even if the heavens did not come to be in a chronological sense). The fact that nature is for the sake of something is picked out as the cause for *both* sublunary and heavenly order; I see no evidence for Sedley's claim (2007, 195–196) that Aristotle here prioritizes cosmic teleology over that of individual natural processes.

[96] See Sedley (1991, 192–194; 2007, 198–200); Cooper (1982, 213). Cf. also Matthen (2001), who argues for the existence of a cosmic nature on the basis of *De Caelo* book I; however, Bodnár (2005, 10–17) offers convincing arguments that undermine such a reading.

be dissolved, and that there are likewise other things in which everything shares in the whole.

This passage forms the opening of a chapter in which Aristotle discusses the place of the good in "the whole." He first presents his own view and then continues with a discussion of the *endoxa* of his predecessors. Aristotle's own account – which I shall discuss only in outline – makes use of two analogies. First, comparing the "nature of the whole" to an army, he indicates that the good of the cosmos is exhibited most by the Unmoved Mover (who is analogous to the general), because he is the cause of the good of the order of the cosmos (which is analogous to the order of the army). Next, he compares the order of the whole to a household, thus illustrating what seems to be the necessity involved in the movement of the stars and planets on the one hand, and the passing or deconstruction of bodies in the sublunary world on the other hand.[97] The "one," towards which everything else is ordered, is again the Unmoved Mover, who – as Aristotle explained in *Meta* XII.7–9 – is the final cause that drives all motion in the cosmos.

Defenders of the cosmic reading interpret Aristotle's expression "the nature of the whole" (perhaps picked up in 1075a22–23: "for that is the kind of principle that nature is of each of them") as a reference to a separate cosmic nature with its own form that underlies the order of everything. However, the fact that Aristotle picks out the Unmoved Mover as the cause of the good of the order and of the joint arrangement of the constitutive parts in both the images speaks against this interpretation:[98] the goodness and interrelations of things in the cosmos are not an expression of the nature of the cosmos itself,[99] but rather of all individual natures trying to approximate as much as possible the *same* ultimate final cause (cf. *Cael* II.12,

[97] Cf. Balme (1987b, 278) and *Cael* II.12, which I discuss in section 5.3.

[98] See Bodnár (2005, 17–21) for a discussion of the philological and interpretational problems of this cosmic reading of the expression.

[99] The nature of the city does not provide a good parallel for a universal nature here: the city comes to be by nature for the sake of living and *is* in that sense a nature (since it is the endpoint of a process, just as a house is: *Pol* I.2, 1252b27–1253a4), but it does not *have* a nature that is being realized by this natural development. Rather, the city *receives* a form through an act of lawgiving, where the lawgiver is similar to a craftsman who makes use of what is naturally available to create a social structure for the sake of living well (see, e.g., *Pol* I.2, 1253a29–31; I.10, 1258a21–22; II.12, 1273b30–33; VII.4, 1325b39–1326a4). The natural priority of the city to the household and individual human beings pertains to the fact that separated from the city nobody is able to achieve the *good life* (see, e.g., *Pol* I.2, 1253a18–22; III.6, 1278b15–30; III.9, 1280b29–1281a4). I believe that the "ethical" city, as opposed to the "natural" city, is a product of secondary teleology, and that there is therefore no natural form of the city. For my interpretation of Aristotle's account of the city, see Leunissen (in progress).

292b20–25). That is, the goodness, order, and joint arrangement of the cosmos as a whole *emerge* from the goal-directed actions of the individual parts of the cosmos towards the same end, the Unmoved Mover.[100] This goal-directedness is *usually* explained as being steered by the *individual* natures acting as efficient causes for the sake of something (see *DA* II.4, 415a25–b7; *GA* II.1, 731b24–732a1 and *GC* II.11, 338b6–19), and presumably this is also the cause identified in the expression "for such is the kind of principle that nature is of each of them." I do not see what explanatory work would be left to do for a cosmic nature.[101] The expression "the nature of the whole" may simply be periphrastic for the universe.[102]

In short, I believe that cosmic teleology is ultimately grounded in natural teleology, and that natural teleology in its primary form is limited to individual natures that act as efficient causes for the sake of something.

1.4 CONCLUSION

Aristotle's defense of natural teleology in *Ph* II.8 lays the foundations for the use of teleological explanations in the other natural treatises. His theory of natural teleology is presented as the better alternative to the materialist mode of explanation of nature, which explains beneficial outcomes in nature as the accidental results of materially necessitated processes and therefore cannot explain the regularity of such outcomes in terms of intrinsic causation. Aristotle proposes instead that natural efficient causes act – either always or for the most part – for the sake of something, which means that natural processes and their outcomes are intrinsically connected, and that we thus should explain the beneficial outcomes of natural processes teleologically.

At the level of complete natural beings, this teleology is always primarily driven by form: natural generation of complete organisms consists in the realization of a potential for form, transmitted by something that possesses that form already in actuality. The teleology exhibited is primary teleology. At the level of natural parts, this teleology may primarily be driven by either form or matter (and thus be a form of either primary or secondary teleology): whereas form is the primary cause for the development of necessary parts, the availability of extra matter – often due to material necessity – is the primary cause for the development of subsidiary parts, such as teeth. (Aristotle thus does not replace material necessity by natural teleology: for

[100] Cf. Bodnár (2005, 10, 21) and Scharle (2008, 158–161); pace Kahn (1985, 203).
[101] Cf. Johnson (2005, 276n.44) and Scharle (2008, 167).
[102] Bodnár (2005, 18); Sedley (2000, 329).

Aristotle, material necessity is a genuine cause in nature, but the incorporation of the results of material necessity in complex natural beings can only be accounted for by reference to the goal-directed actions of the formal nature of those beings.) At the inter-species level, the teleology at stake is always secondary: the formal nature of one natural being appropriates the potentials available in another natural being in order to use it for its own benefit. The systematic appropriation of natural materials by human beings is called art: artists act as the external efficient causes in "informing" materials for the sake of completing natural goals (such as the growth of crops) or of producing artifacts, both of which serve some human good. The perspective of artistic production (but not that of natural teleology) is inherently anthropocentric. Finally, the harmony, interaction and well-adaptedness among natural beings seem to follow from the internal and individual striving of these natural beings towards immortality and the First Unmoved Mover: cosmic teleology can thus be explained in terms of natural teleology, without the postulation of a cosmic form that is being realized.

According to Aristotle's defense of natural teleology, its operation is restricted to the actions of the individual formal natures of natural beings, but its scope ranges from the generation of low-level biological parts such as teeth to high-level cosmological phenomena such as the motions of the heavenly bodies. In the next chapters, I shall pursue Aristotle's actual use of teleological explanations in these domains.

CHAPTER 2

Aristotle's bio-functional account of the soul: establishing the starting points of teleological explanation in the De Anima

2.0 INTRODUCTION

Aristotle introduces his investigation of the soul in *De Anima* as being among the primary kinds of knowledge, on account of both its accuracy and its dealing with better and more wonderful things (*DA* I.1, 402a1–5). Knowledge of the soul contributes especially to natural philosophy (*DA* I.1, 402a6–7; cf. *DA* I.1, 403a27–28), because the soul is "a sort of[1] principle of living beings" (*DA* I.1, 402a8: ἔστι γὰρ οἷον ἀρχὴ τῶν ζῴων) and living nature represents Aristotle's concept of nature in the fullest sense.[2] For Aristotle, then, the study of the soul and its embodiment is the starting point of biology,[3] and as such forms an important part of his broader investigation into nature.

The issues Aristotle sets out to address in *De Anima* are, first, the nature and essence of the soul and, second, the soul's attributes – both the ones proper to the soul and the ones living beings have in virtue of having a soul (*DA* I.1, 402a8–11). This program leads Aristotle, among others, into investigations of the ontological status of the soul and its parts, of the relation between the body and the soul, and of the various capacities of the soul that living beings share. In this chapter, sidestepping many of the difficulties in the interpretation of this treatise, I shall focus rather narrowly on Aristotle's bio-functional analysis of the soul, i.e., on his study of the soul as a non-aggregative unity[4] of teleologically organized

[1] Aristotle's qualification of the soul as "a sort of principle of living beings" might indicate that it remains to be seen in what sense the soul is a principle, i.e., that there are some senses in which the soul is a principle of living beings (i.e., in the sense of formal, efficient, and final cause), but that in others it is not (i.e., not in the sense of material cause); cf. *DA* II.4, 415b8–10; Ross (1961, 176). Lennox (2006, 308) proposes that the qualification foreshadows Aristotle's thesis that the soul is also a principle of *plant* life, a view that is perhaps not immediately shared with his contemporary readership.

[2] Lennox (2006, 294).

[3] Cf. Cohen (1992, 58); Lloyd (1992, 148–149); Sorabji (1974, 65–66); and Van der Eijk (1997, 231–232).

[4] On the unity of the soul, see *DA* II.3, 414b28–32 and *DA* III.9, 432a22–b6.

functions that make the natural body in which they are realized alive.[5] Of particular interest in this context is Aristotle's distinction between the concepts of "living" and "living well" in his teleological explanations for why different kinds of living beings have the kind of soul functions they have. I shall first, in section 2.1, by way of background, outline Aristotle's use of teleological notions in his account of the soul as a principle of life (in particular in *DA* I.1–3 and *DA* II.1–4), and then, in section 2.2, turn to his teleological explanations for why different living beings possess the specific soul functions they do (in *DA* III.9–13). These latter explanations show, I believe, some interesting resemblances to and deviations from the patterns of explanation to be found in the – methodologically later – biological works.

My purpose in this chapter is to show how Aristotle, in establishing a bio-functional conception of the soul, provides the starting points and the foundations for explanations in the biological works. Since for Aristotle the soul is the first actuality and the final cause of a natural body that potentially has life, the various parts and features living beings have will be explainable in terms of the kind of soul (or combination of capacities for the performance of life functions) they possess;[6] and part of what Aristotle does in *De Anima* is to define and teleologically ground the different kinds of soul.

2.1 TELEOLOGY IN THE ANALYSIS OF THE NATURE OF THE SOUL

Teleological notions in the preliminary characterizations of the soul in DA *I.1*

Aristotle presents two accounts of the nature of the soul as a principle of life in *De Anima*: one (in *DA* II.1) that defines the soul as the first actuality of a natural body that is instrumental; and one (in *DA* II.4) that identifies the soul as the formal, efficient, and final cause of a living being. As I shall indicate below, teleological notions play an important role in both these characterizations of the nature of the soul.[7]

However, the framework for both these approaches to the study of the soul, one in terms of definition, the other in terms of a causal analysis, is laid down in *DA* I.1. In this opening chapter of the treatise, Aristotle

[5] Rorty (1992, 7), calls this Aristotle's "philosophical bio-psychology."
[6] Lloyd (1992, 149).
[7] Pace Code and Moravscik (1992, 132, 134–135, and 138).

tries to determine the appropriate method for the study of the soul,[8] while taking three assumptions about the soul as starting points.

The first of these assumptions is that the soul is a principle of life – not only of human beings, but of *all* living beings, including animals and divine beings (*DA* I.1, 402b7; plants are included among things that have souls in *DA* II.2, 413a25–b1). In this way, the soul operates for Aristotle also as a principle of individuation: different kinds of living are coextensive with different kinds of soul, which makes living beings be what they are in virtue of having the specific kind of soul they have.[9]

Second, Aristotle assumes that the soul is a combination of "parts" that perform different kinds of life functions and that have their own objects (*DA* I.1, 402b9–14). For instance, the faculty of the soul that perceives (τὸ αἰσθητικόν) performs the function of perception (τὸ αἰσθάνεσθαι), and has as its object the perceptible (τὸ αἰσθητὸν). This conception of the soul is teleological, for it defines and explains the existence of each aspect of the soul in terms of the specific work it performs: souls are essentially capacities that exist for the sake of the performance of a wide variety of life functions, which are explored more fully in *DA* II–III.[10]

Third, Aristotle claims that the affections[11] of the soul are "enmattered structures" (*DA* I.1, 403a25: δῆλον ὅτι τὰ πάθη λόγοι ἔνυλοί εἰσιν).[12]

[8] The methodological questions Aristotle raises pertain to: (i) the genus of the soul (is the soul a *tode ti* and *ousia* or one of the other categories?); (ii) the ontological status of the soul (is it in potentiality or is it rather a kind of actuality?); (iii) the structure of the soul (does the soul have parts or not?; is every soul *homoeidês* or not?; if it is *homoeidês*, is the difference one of genus or species?); (iv) the definition of the soul (is there one definition only, or is there a definition for the soul of each separate kind of ensouled being?). On the programmatic importance of *DA* I.1, see Menn (2002, 102–103) and Rorty (1992, 7–8).

[9] *DA* II.2, 413b32–414a1: "Moreover, some animals have all of these [functions of the soul], others have only some of them, and still others have only one – and this causes a differentiation between living beings (τοῦτο δὲ ποιεῖ διαφορὰν τῶν ζώων)." Cf. Everson (1997, 3–4) and Sorabji (1993, 163–165).

[10] The terminology Aristotle uses in his discussions might require some brief clarification. Aristotle speaks of the *dunameis* of the soul (e.g., *DA* II.2, 413a22), which I translate as the capacities of the soul. Sometimes Aristotle calls them *môria* (parts) of the soul, but this should not be taken too literally (perhaps "aspects" would be a better translation). The *energeia* or *praxis* (activity) of these *dunameis* (a *dunamis* is a capacity or potentiality for an activity) is what Aristotle equates with the performance of *erga* (functions). The individual functions are usually rendered by the use of the substantive form of the infinitive (*to -ein*; e.g., *to noein*), or with an action noun (*-sis*; e.g., *noêsis*), while the *adjectivum verbale* (*to –ikon*; e.g., *to noêtikon*) refers to either the capacities of the soul or to that which has these capacities. The *supinum* (*to –on*; e.g., *to noêton*) refers to the objects of the capacity.

[11] In the first book of *De Anima* Aristotle uses the term *pathê* rather loosely to refer to emotions, pleasures and pain, and functions (see, e.g., *DA* I.5, 409b14–19).

[12] The expression is obscure; on the problems involved, see Everson (1997, 234–236). My translation follows Caston (2006, 318).

Concerning the relation between the soul and its affections (this problem is raised in *DA* I.1, 403a3–b19), Aristotle believes that he has evidence (*DA* I.1, 403a19: μηνύει; *DA* I.1, 403a22–23: ἔτι δὲ μᾶλλον τοῦτο φανερόν) that the affections of the soul – with the exception perhaps of the function of thinking – are always "with body," and that they are therefore ontologically inseparable from the body. The affections of the soul are not just realized in matter, but the matter itself is also a constitutive part of what the affections are (*DA* I.1, 403a25–27): "[Affections are enmattered structures] such that their definitions are such as, for instance, 'being angry' is a certain change, belonging to a distinct kind of body or bodily part or capacity, originating from this, for the sake of that."

As the example of anger makes clear, a proper definition of an affection of the soul must include references to all four Aristotelian causes, including the *specific* kind of body to which the change belongs as the material cause. The fact that the affections of the soul involve body makes the study of the soul "immediately" part of the field of the natural philosopher (*DA* I.1, 403a27–28; but see *PA* I.1, 641a29–b10 for the exclusion of the rational part of the soul from the field of natural philosophy). And, as Aristotle's subsequent discussion of the task of the natural philosopher makes clear (*DA* I.1, 403a27–403b16), the relation between body and soul is ultimately one of conditional necessity. Form and matter cannot be separated in a definition of the affections of the soul, because if the affection is to be what it is, it needs to be realized in a particular kind of body (*DA* I.1, 403b2–3): "For the one is an account of the thing, but it is necessary for that [i.e., craving for revenge] to be in a particular kind of body, if it is to be."

The affections of the soul are inseparable from the body, because being realized in an appropriate material constitution is itself a necessary condition[13] for the existence of these affections. Aristotle concludes the chapter by pointing out that the true natural philosopher needs to study

[13] For the implicit reliance on the notion of conditional necessity, see also Aristotle's criticism of his predecessors for not further specifying the body that receives the soul in *DA* I.3, 407b20–26: "But people put their effort into saying what sort of thing the soul is, while they determine nothing further (προσδιορίζουσιν) about the body that receives it, just as though, in the manner of the Pythagorean myths, any random soul were to be clothed *in any random body* (τὴν τυχοῦσαν ψυχὴν εἰς τὸ τυχὸν ἐνδύεσθαι σῶμα). For while each body seems to have its own proper (ἴδιον) shape and form, they talk as if one were to say that carpentry is to be clothed in flutes; but the art has to use tools and the soul has to use the body." Aristotle believes that just as each art needs its *own proper and befitting* instruments, so the soul needs its *own proper and befitting* body – proper and befitting, that is, for the functions it is to perform; cf. Hett (1936, 43); *DA* II.2, 414a22–25 and *DA* II.2, 414a27.

the functions and affections of the soul as the products of both matter and form, and not as abstractions (*DA* I.1, 403b16–19).[14]

In sum, the implicit assumption in this chapter seems to be that the relation between soul and body is a teleological one: living beings have the kind of bodies and bodily parts they have for the sake of performing all their characteristic life functions.

The definition of the soul as the first actuality of a natural instrumental body in DA *II.1*

Aristotle's discussion of the soul in *DA* II.1 builds mainly upon the first and the third of these assumptions. His purpose in this section is to provide a definition of the soul that is as comprehensive as possible (*DA* II.1, 412a3–6): "But let us go back and, as though from the beginning, try to distinguish what the soul is and what would be its most common definition."

Aristotle carries out this program in different stages. He offers two intermediate definitions before stating – cautiously – his final common definition, which characterizes the soul as "the first actuality of a natural body that is *organikon*" (*DA* II.1, 412b4–6). The first definition, characterizing the soul as "a substantial being in the sense of the form of a natural body which potentially has life" (*DA* II.1, 412a19–21), follows from an analysis of the genus of substantial being and the identification of living beings as composite substances: the soul is form and the natural body is matter that has life in potentiality. The second definition gives a specification of the kind of substantial being the soul is as being a "first actuality"[15] (*DA* II.1, 412a27–28), which means that the soul is like a *hexis* or disposition for life functions, rather than the *energeia* or exercise of them (which would be the "second actuality"). For a natural body to be properly called alive, then, it needs to possess all the relevant life functions by way of a fully developed disposition, such that they can be exercised or activated at any given time. The third and final definition follows from a specification of what it means for a natural body to have life potentially as being "instrumental"[16]

[14] Hamlyn (2001, 80) and Ross (1961, 200). Although I cannot defend my position in full here, I believe that passages such as these give reason to doubt functionalist readings of Aristotle's theory of the soul; for an overview of the functionalism debate, see Caston (2006, 320–322).

[15] The term *entelecheia* was coined by Aristotle, and designates a completed state resulting from an internal movement towards this state; see Ritter (1932; 1934) and Johnson (2005, 88–90).

[16] The traditional reading of *organikon* as "having organs" or "being composed of organs" (see, e.g., Ross 1961, 51, 313; Hamlyn 2001, 85) must certainly be wrong: elsewhere in the Aristotelian corpus the term *organikon* (coined by Aristotle; see Byl 1971, 132) always means "instrumental" and there is no reason to assume it means something different here. The new reading is defended most notably

(*DA* II.1, 412a28–b1: τοιοῦτον δὲ ὃ ἂν ᾖ ὀργανικόν). In this way, Aristotle characterizes the natural body living beings have as the instrument of the soul,[17] presumably in the sense that the whole body – including all its constitutive parts (cf. *DA* II.1, 412b1–4) – is present for the sake of the performance of all the characteristic life functions that make up that being's life,[18] making the unity of body and soul explicitly a teleological one (see *DA* II.1, 412b6–9).

Aristotle illustrates his general definition of the soul with the following analogy (*DA* II.1, 412b12–17):

> Just as if one of the instruments, for example an ax, were a natural body: for being an ax would be its substantial being, and that would be its soul. If this were separated from it, it would no longer be an ax, except in name, but in fact it is an ax. For the soul is not what it is to be and the structure of *such* a body, but of *a particular kind of natural body* – one that has a principle of movement and rest within itself.

Just as what it is for an ax to be an ax is determined by the function it performs (i.e., cutting), which would be its soul, so too for natural bodies their being is determined by the kind(s) of functions they perform, which in fact is their soul. Take away something's capacity to perform its characteristic function, and it will no longer be what it is, except homonymously, that is, the name will be used inappropriately to refer to something that is no longer what it is.[19] Because for Aristotle what something is is determined by the function(s) it performs, the soul constitutes the essence of the living beings that have it (instruments do not have souls, because they lack an internal principle of movement and rest, and always require an external source of movement). The same holds for the parts of living beings

by Bos (2001, 187, 190–192; 2003, *passim*; 2008, 12, 177), but see also Everson (1997, 64–65); Kosman (1987, 376–377, 381–382); and Menn (2002, 108–117).

[17] Cf. *PA* I.1, 642a11–13: "So too, since the body is an instrument (ἐπεὶ τὸ σῶμα ὄργανον) – for each of the parts is for the sake of something, and likewise also the whole – it is therefore a necessity that it be of such a character and constituted from such things, if that is to be." On this passage, see Lennox (2001b, 149–150). See also *DA* I.3, 407b25–26, quoted above in n.13.

[18] This is how, e.g., Kosman (1987, 376) and Lennox (2001b, 142) interpret it. However, this is not the only possible interpretation: Bos (2001, 188–190), argues that "the natural body that potentially has life" and that is "instrumental to the soul" must be one of the elemental bodies, namely pneuma (for animals and human beings; the instrumental body for plants is vital heat); Everson (1997, 63–69) argues that the natural body to which Aristotle refers is not the whole animal body, but rather a part of it, so that the animal would not have one soul, but as many souls as it has instrumental parts – a view that is strongly criticized by Barnes (1999, 121).

[19] For Aristotle's use of the principle of homonymy for things that have lost their capacity to perform their characteristic function, either in virtue of having died or in virtue of being constituted from the wrong kind of material (in e.g., *PA* I.1, 640b33–641a5; *Meteor* IV.12, 389b28–390a13; and *GA* II.1, 734b24–25), see Furth (1987, 37) and Shields (1999, 131–154). It is possible that death also involves a material change of the body: see *PA* I.1, 641a17–21 and Lennox (2001b, 138).

(*DA* II.1, 412b17–22): the substantial being or soul of, for example, an eye would be sight, which is its function. On this account, living beings are a unity of a natural body that has life potentially (and not that has lost it) and of the soul as first actuality, which is the capacity for the performance of that living being's characteristic life functions, in which the body exists for the sake of the soul (*DA* II.1, 412b27–413a4).

Aristotle's "common" definition of the soul (cf. *DA* II.1, 412b10: καθόλου), then, exemplifies both in what way the soul is a principle of life and how it is related to the natural body: having life is the possession of life functions (i.e., a soul) by a natural instrumental body, which is able to exercise those functions through its instrumental parts. For Aristotle's explanatory program in biology this means that at least the majority of bodily features a living being possesses will be explainable by reference to the life functions for which these features are instrumental (and hence conditionally necessary) and the possession of which constitutes the living being's substantial being. However, as Aristotle repeatedly indicates, this "rough" definition will only be helpful to a certain extent (*DA* II.1, 413a9–10):[20] since the soul is an essence, rather than being something that has an essence, it would be "ridiculous" to define the soul properly in abstraction from the living beings that have soul (*DA* II.3, 414b20–28; 414b25: γελοῖον). Therefore the natural philosopher must try to establish what the soul of *each kind of living being* is (*DA* II.3, 414b32–33; *DA* II.3, 415a12–13): he must determine what the particular set of life functions is that defines each kind of living being (this is where Aristotle's second assumption of the soul as a set of life functions comes in), and these functions will provide the most appropriate starting points for explanations of biological phenomena.

Aristotle's conception of the soul as a final cause of natural bodies in DA *II.4*

In defining the soul as the first actuality of a natural body that is instrumental, Aristotle characterizes the soul as the form of a living being, where its instrumental body is its matter (cf. *DA* II.2, 414a14–19). In a later discussion of the nutritive and generative faculty of the soul, Aristotle claims that as the cause and principle of the living body (*DA* II.4, 415b8), the soul – in addition to being that body's formal cause – is also an efficient and final cause (*DA* II.4, 415b8–12). Aristotle then explains why the soul is also a "that for the sake of which" (*DA* II.4, 415b15–21):

[20] Cf. Everson (1997, 174–175).

It is apparent that the soul is a cause also as that for the sake of which. For just as the intellect acts for the sake of something, in the same way, too, does nature, and that is its end. Such is among living beings the soul according to nature: for all natural bodies are instruments of the soul, just as the bodies of living beings, so too also the bodies of plants, because they are for the sake of the soul. And that for the sake of which is double, there is the "of which" and the "for which" (διττῶς δὲ τὸ οὗ ἕνεκα, τό τε οὗ καὶ τὸ ᾧ).

Nature – just like intellect – acts for the sake of something, and among living beings "that for the sake of which" is the soul (cf. *PA* I.1, 641a19–21). Aristotle explicitly restates the teleological relationship between natural bodies and soul: natural bodies are instruments of and exist for the sake of the soul. This means both that the soul *operates* through the natural body and that the natural body with (at least most of) its features is the *conditionally necessary prerequisite* for the realization of the capacities for the performance of a living being's life functions that constitute its soul. Aristotle adds, however, that there exists an ambiguity concerning the kind of end the soul is, since there are two kinds of ends: there is the "that for the sake of which" or the final cause properly speaking, and there is the "for which" or "beneficiary of which," which plays no causal role.[21] He does not make clear whether he conceives of the soul as an end in the sense of a final cause or of the beneficiary of a natural body, or of both, but his explicit characterization of the soul as a "that for the sake of which" in *DA* II.4, 415b15 seems to indicate that Aristotle only mentions the two possibilities in order to limit his conception of the soul to an end in the proper, causal sense.[22]

[21] Cf. Kullmann (1985, 172) and Judson (2005, 358). Johnson (2005, 65–69), for whom the distinction between the two senses of *to hou heneka* is central to resolving "the problems of Aristotelian teleology," offers an alternative interpretation, characterizing the distinction as "a difference between the aim of something and the beneficiary of the achievement of that aim," using for the latter the formula "for the sake of which for which beneficiary." He takes *to hou heneka – hou* to refer to the end proper and *to hou heneka – hôi* to refer to the beneficiary of (the realization of) the end, and believes that sometimes both senses are simultaneously operative. Applying this distinction to the characterization of the soul as a final cause, Johnson explains that "The body exists for the aim of the soul's functioning, and the soul's functioning exists for the benefit of the individual organism that lives through the soul and with the body." Despite the interesting parallels Johnson offers to illustrate his reading of *to hou heneka hôi* (2005, 67n.8), I am not convinced that this is the most natural reading of the expression. See also *Ph* II.2, 194a34–b1: when Aristotle states that "we also are in a sense an end" he means that we benefit from what is naturally available without being the proper end of natural processes.

[22] Cf. *Meta* XII.7, 1072b2–3, *EE* VII.15, 1249b15, and *DA* II.4, 415b2–3, where Aristotle first introduced the distinction in the *De Anima* only to indicate that becoming as divine as possible through reproduction is something living beings do for their own sake, not for some god's benefit. See also Gotthelf (1987, 210) and Polansky (2007, 205–207).

In short, although Aristotle does not define the soul itself teleologically (the soul is not itself characterized as being for the sake of something, although, taken as the combination of capacities, the soul can be understood as being for the sake of the actualization of those capacities), by identifying it as a final cause, he establishes that the characteristic activities living beings for the most part perform are in fact their natural functions in a technical sense. For the activities living beings perform are the exercise of the capacities they have in virtue of the kind of soul they possess, and their bodies are thus to be exhibited as the conditionally necessary instruments for the performance of these capacities.

2.2 TELEOLOGY IN THE ANALYSIS OF THE CAPACITIES OF THE SOUL

The hierarchy of the capacities of the soul: living versus living well

Since for Aristotle soul is coextensive with life, and since life is one of those things that are "spoken of in many ways," one of the main purposes of *De Anima* is to demarcate both living from non-living and each particular form of living from the other forms. As is to be expected from our introductory remarks above on the nature of the soul, Aristotle carries out this program of demarcation by identifying those functions that are characteristic for life in general and for the different forms of life in particular.

In *DA* II.2–4, Aristotle distinguishes the living from the non-living broadly in terms of the presence of at least one capacity for a life function (*DA* II.2, 413a20–25):

> So we say, taking this as a starting point for the inquiry [i.e., that definitions should not only state the fact but also reveal the reason why], that what is ensouled is distinguished from what is soulless by living. But living is said in more than one way, and if any one alone of the following is present in something, we say that it is alive, such as for example intellect, perception, motion and rest with respect to place, and in addition motion with respect to nutrition and decay and growth.[23]

The one capacity for a function in virtue of which all living things are alive (at least in the sublunary realm: Aristotle's general characterization of life as the presence of at least one life function leaves open the possibility for the existence of a divine form of life, characterized by the function

[23] Sometimes Aristotle also adds appetite (ὄρεξις) and imagination (φαντασία) to the list of characteristic life functions. On this list of life functions for Aristotle's conception of life, see also Matthews (1992, 185–193).

of thinking only) is the capacity of nutrition, which involves both self-nutrition (τὸ θρεπτικὸν) and reproduction (γεννήσις).[24] The particular combination of life functions that each sublunary kind of living being is able to perform (cf. *DA* II.3, 414a29–32) presupposes the presence of this most basic function of life (it is the only function – except for maybe thinking – that is ontologically independent[25] from the other functions, whereas all other functions depend on it: *DA* II.2, 413a31–32) and builds up from there to more complex forms of life.

The most basic form of sublunary life is exhibited by plants, which have no other capacity of the soul except the capacity of nutrition (which demonstrates that this capacity can exist independently of the other capacities for life functions).[26] For this reason, the ability to perform the function of nutrition is both what demarcates something as a living being (it constitutes both a necessary and a sufficient condition for life) and what – if found alone – constitutes the defining or essential function of plants (*DA* II.2, 413a25–b1; *DA* II.3, 414a32–33). The essential function of animals, which represent a more complex form of life, is the perceptive function of touch (ἁφή; *DA* II.2, 413b2–10; cf. *DA* II.3, 414b1–4). Aristotle uses perception as a collective term encompassing a number of perceptive functions for which an animal may or may not have the capacity (i.e., touch, smell, hearing, and vision). Touch is the first and most basic one among them, for it is the only perceptive capacity that can exist independently of the other perceptive capacities, whereas they cannot exist without it (*DA* II.2, 413b5–7; *DA* II.3, 415a4–5). For human beings, who represent the most complex form of life, the essential capacity that marks off their specific kind – although it is possibly also shared by "more honorable beings" – is thinking (*DA* II.3, 414b18–19), the highest capacity of all.[27]

Each form of life is thus characterized by its own specific combination of capacities for life functions, but none of these combinations is random. Each particular set of life functions that different kinds of animals and human beings have represents a strict hierarchy of higher functions that are ontologically nested in lower ones. Aristotle explains this relation between different life functions through an analogy with complex rectilinear figures (*DA* II.3, 414b28–415a5):

[24] See, e.g., *DA* II.2, 413b2–3 (nutrition is the principle of life) and *DA* II.4, 415a22–25 (nutrition is the first and most commonly possessed capacity of the soul); cf. also *GA* I.23, 731b5–7.

[25] Aristotle uses the verb χωρίζεσθαι to describe the "ontological separability" of one life function from another; see Broadie (1996, 163–164) and Polansky (2007, 169–170, 197).

[26] See *DA* II.2, 413a33–b1; *DA* II.3, 414a33–b1; *DA* II.3, 415a2–3; and *DA* II.4, 415a23–26.

[27] In human beings, this function seems to be dependent on the capacity of imagination (*DA* III.8, 432a8–9), but presumably it exists independently in divine beings.

What applies to the soul is almost the same as what applies to geometrical figures. For in both figures and things that are ensouled, that which is prior always exists potentially in that which follows in order, for instance, the triangle in the quadrilateral, and the nutritive capacity in the perceptive. Such that we must investigate concerning each kind what the soul is of each, for instance what [the soul is] of plant and what of human being and what of animal. What the explanation is for why they are in such state of arrangement, we must investigate. For without the nutritive capacity there is no perceptive capacity, but the nutritive capacity is present in separation of the perceptive capacity in plants. Again, without the sense of touch none of the other perceptive capacities is present, but touch is present without the others.[28]

Aristotle claims that what is prior in complexity is present in potentiality in what is more complex: just as more complex rectilinear figures contain in themselves the more basic ones in potentiality (four-sided figures divide into three-sided figures, etc.), so do more complex capacities of the soul contain in themselves the more basic ones in potentiality. The unity between the capacities of the soul is one of order (*taxis*),[29] which is here rendered as being ontological in nature: whereas the lower capacity can exist separately and does not need the higher capacities, the higher cannot exist without the lower ones (the existence of the "basic" capacities is a necessary condition for the existence of the more complex ones).[30]

Aristotle investigates the question (announced in *DA* II.2, 413b9–10; 413b32–414a1; and *DA* II.3, 414b33–415a1) of why living beings possess the precise sequence of nested capacities they have in *DA* III.9–13. As we shall see in more detail below, the ontological hierarchy of nested capacities is there shown to be in fact a "taxonomical" hierarchy[31] in which the more basic capacities constitute a necessary prerequisite for the existence of the higher and in which the realization of the more complex capacities contributes to the goals pursued by the basic ones.[32]

[28] παραπλησίως δ' ἔχει τῷ περὶ τῶν σχημάτων καὶ τὰ κατὰ ψυχήν· ἀεὶ γὰρ ἐν τῷ ἑφεξῆς ὑπάρχει δυνάμει τὸ πρότερον ἐπί τε τῶν σχημάτων καὶ ἐπὶ τῶν ἐμψύχων, οἷον ἐν τετραγώνῳ μὲν τρίγωνον, ἐν αἰσθητικῷ δὲ τὸ θρεπτικόν. ὥστε καθ' ἕκαστον ζητητέον, τίς ἑκάστου ψυχή, οἷον τίς φυτοῦ καὶ τίς ἀνθρώπου ἢ θηρίου. διὰ τίνα δ' αἰτίαν τῷ ἑφεξῆς οὕτως ἔχουσι, σκεπτέον. ἄνευ μὲν γὰρ τοῦ θρεπτικοῦ τὸ αἰσθητικὸν οὐκ ἔστιν· τοῦ δ' αἰσθητικοῦ χωρίζεται τὸ θρεπτικὸν ἐν τοῖς φυτοῖς. πάλιν δ' ἄνευ μὲν τοῦ ἁπτικοῦ τῶν ἄλλων αἰσθήσεων οὐδεμία ὑπάρχει, ἁφὴ δ' ἄνευ τῶν ἄλλων ὑπάρχει·

[29] See *Meta* V.11, 1018b26–29; 1019a2–4.

[30] For the ontological interdependency among the various capacities of the soul, see *DA* II.2, 413b23–25 and *DA* II.3, 414a32–b19.

[31] Cf. Caston (1996, 184–186) on the conception of *chôristos* as "taxonomical separability."

[32] *Pace* Johnson (2005, 9), who thinks that the simpler functions exist for the sake of the more complex ones.

The crucial distinction Aristotle draws within this hierarchy is between capacities whose realization is necessary to make possible a specific way of *living* itself and capacities whose realization is rather for the sake of *living well*. In the first case, the realization of a certain capacity is of *immediate* vital or essential importance for all the subspecies within the same widest form of life as considered in *De Anima*, i.e., plants, non-human animals, and human beings. Without the possession of and the means to realize that capacity, the living being could not have existed at all or would not have been able to be the specific kind of being it is. For instance, having the capacity of touch is both a necessary and sufficient condition for being an animal, and *all* animals therefore will have touch; without it, no animal can exist or could have been an animal. In the second case, which pertains only to non-human and human animals, the possession of and means to realize a certain capacity is not of immediate vital or essential importance for all subspecies (and therefore not necessary in a strict sense), but it does serve the well-being of *some* of them: the capacity seems to be present for the sake of *optimizing* the living being's performance of the essential and vital life functions, rather than for the sake of the basic performance of such life functions. For instance, having the capacity of voice is not necessary for all animals: hypothetically speaking, nature *could* have "designed" animals that are currently able to produce sounds in such a way as to be able to function without this ability. For Aristotle, this is evidenced by the observation that there are in fact animals that lack this capacity and that are nevertheless perfectly able to live and reproduce. The capacity is present only in those animals that take in air, and its function is to express pain and pleasure (see *Pol* I.2, 1253a8–18), which as Aristotle indicates contributes to the well-being of these animals (I return to this example below). Of course, this does not mean that taking away this capacity from *actual* animals that are "designed" to have the capacity for voice would not harm or kill them; the idea is just that *in other possible worlds* these animals too could have existed without the capacity for voice.

The strategies Aristotle uses to determine whether a capacity is necessary for living or rather for the sake of living well are remarkably similar to the ones he uses in the biological works to determine the ontological status of parts. In the biological works (which I shall discuss in Chapters 3 and 4), we shall see that Aristotle often makes use of the "rule" that if a part can be observed to be present in all members of a particular kind, it must be a necessary prerequisite for the performance of a vital or essential

function of that kind.[33] If a certain part is present only in some members of a particular kind, whereas the whole kind can be observed to be able to perform the function that is associated with that part, Aristotle infers that its possession cannot be necessary for all the members of that kind, but that the part must rather have a contributory or subsidiary function serving the well-being of some subspecies. (In Chapter 3, I shall submit that the first category of "necessary parts" is the result of primary teleology, whereas the second category of "subsidiary parts" is the result of secondary teleology.) In using this kind of reasoning, Aristotle seems to build on the same pattern of investigation as he applies here in *De Anima* with regard to the two categories of capacities: if the capacity is present in all members of a widest kind it must be conditionally necessary for that kind; the kind could not have existed or be the kind it is without it. The capacity must be a basic one, shared by all members of that kind. If it is present only in some members of that widest kind, it must be for the sake of the well-being of those members of the kind only and the capacity must be a more complex one.

It is important to note here that these distinctions are not supposed to work as *descriptive* accounts of actual, realized living beings: as I suggested earlier, it is usually not the case that we can simply remove a capacity or part that contributes to the animal's well-being without also severely harming or even killing that animal, and so de facto many if not most parts or capacities turn out to be necessary (in this immediate sense) for the living beings that have them. Rather, I believe that these distinctions operate at a more theoretical level – in "design space," so to speak, where nature is still metaphorically speaking "deciding" what parts and capacities a certain kind of animal can and should have, how many of those parts it should have, and where the parts should be placed, etc.[34] (Cf. Aristotle's explanation of the footlessness of snakes in *IA* 8, 708a9–20: here it appears that the "initial design" of snakes includes the possession of four feet, but nature then "takes away" those feet in the actual realization of snakes, because their presence would inhibit their swift motion; I discuss this example in more detail in sections 4.2 and 5.4.) At this level, the relevant question is not whether a particular, actual species can continue to live on when we remove its

[33] See, e.g., *GA* I.4, 717a12–31; I discuss this example and Aristotle's use of teleological principles in section 4.2.

[34] Even though species are eternal for Aristotle, he sometimes appears to offer quasi-genetic accounts for why a particular species "turned out" the way it is; I say more about these personifications of nature and the thought experiments Aristotle employs in Chapters 3–5.

subsidiary capacities or parts, but whether nature hypothetically speaking *could have* "created" a certain kind of living being without a certain part or capacity. If the answer is "yes" – for instance, because we observe among the present biodiversity that there are in fact members of the same kind that do not possess the part or capacity in question – then that feature must be for the sake of living well, rather than a necessary prerequisite for the life of that kind. Accordingly, it is not "among the natural possibilities" for nature to design *any* kind of animal without the sense of touch – for such beings would simply not qualify as being an animal. However, nature could have – and has, based on the empirical evidence Aristotle is using – created animals without voice, which means that this capacity cannot be a necessary one for all animals. The "thought experiment" about whether or not nature could have "created" a certain living being without a certain part or capacity helps to determine the status of that feature as either being necessary for a specific widest kind ("nature has to include this feature in the design of the animal") or rather being subsidiary for a specific subspecies within that widest kind (the feature is an optional feature at the design level – nature implements it where possible and where the possession of this feature would be for the better).

The distinction between living and living well can therefore be used by Aristotle to determine the position of a certain capacity in the hierarchy of soul capacities. The more kinds of living beings have a certain capacity, the more basic that capacity must be to life; "necessity" thus refers here to the extent to which a capacity is required for the basic survival or being of the living being and is thus conditionally necessary for it. Capacities that are less widespread (among and within kinds) must be less basic to that form of life and must therefore predominantly contribute to living well, where the "well" indicates a more complex performance of the being's life functions. The *scala naturae* that Aristotle sketches here and in the biological works (see *HA* VIII.1, 588b4–22; *PA* IV.5, 681a10–15 and *PA* II.10, 656a3–13; 656a5–6: "And there is still greater variety among those whose nature partakes not only of living but, in addition, of living well") is thus functionally defined: he calls those forms of life "higher" or "more honorable" that display greater organic and functional complexity on top of their basic survival activities.[35]

In short, living beings have the capacities of the soul they have for the sake of living and living well, where the capacities that serve living are first in order in the hierarchy and most basic, and the capacities that serve living

[35] Cf. Lennox (1999, 6–7) and Polansky (2007, 541–542).

well are later in order and are more complex, with the capacity of thinking serving the ultimate, highest purpose of living well in an ethical sense (see, e.g., *NE* X.7, 1178a5–8 and *NE* X.8, 1178b21–23). Ultimately, Aristotle explains the ontological hierarchy and the specific sequence of nested soul functions found in living beings in terms of teleology and conditional necessity,[36] while building upon the functional analyses of each capacity.[37]

In the next sections, I shall provide an analysis of the specific explanations Aristotle provides for the capacities of nutrition, perception, and – more indirectly – locomotion; the capacity of thinking – perhaps because it is not necessary for life as such and therefore not strictly speaking a biological capacity – is left undiscussed.

Teleological explanations for why living beings have the capacities of nutrition and perception

The nutritive capacity is, as we saw above, the ultimate principle of life and the one capacity that is common to all living beings (*DA* II.4, 415a23–25). Aristotle defines it as the capacity for both reproducing and using food (*DA* II.4, 415a25–26), which are the "most natural functions" among living beings (*DA* II.4, 415a27: φυσικώτατον γὰρ τῶν ἔργων τοῖς ζῶσιν; cf. *Pol* I.2, 1252a28–30). The capacity for reproduction has as its final cause "the production of another just like itself" (*DA* II.4, 415a28: τὸ ποιῆσαι ἕτερον οἷον αὐτό; cf. *GA* I.4, 717a21–22), such that sublunary living beings – which as individuals are perishable – can participate in the eternal and the divine by eternally replicating themselves in form (*DA* II.4, 415a29–b7). Participation in the divine is, according to Aristotle, the ultimate goal of all actions, for being is better than not being, and living is better than not living (*GA* II.1, 731b24–732a1; *GC* II.11, 338b6–19; cf. Pl. *Smp* 207c–208b), and formal replication is the only way for sublunary living beings to achieve this. Note that individual living beings are not themselves concerned with the preservation of their species; rather it is the individual's striving for participation in the divine for its own individual good that is the true final cause of reproduction.[38]

[36] Cf. Hankinson (1998, 154).

[37] Note that each capacity is defined by reference to the function of the activity it is the capacity for (where this function constitutes the proper final cause of that activity), but that the teleological explanation for why certain living beings have this capacity will refer to the (necessary) contribution this function makes to the life of that living being as a whole. For instance, the capacity for perception is for sight, where the function of sight is for the sake of the detection of food, sexual mates, and potential predators.

[38] Balme (1987c, 279–80) and Lennox (2001a, 133–137).

The use of food, on the other hand, is ultimately for the sake of self-preservation of the living being: by nourishing itself, the living being "saves its substantial being, and exists as long as it also feeds itself" (*DA* II.4, 416b14–15: σώζει γὰρ τὴν οὐσίαν, καὶ μέχρι τούτου ἔστιν ἕως ἂν τρέφηται). The nutritive capacity also prepares food for activity – without food, a living being is not able to exist (*DA* II.4, 416b17–20) or reach sexual maturity and reproduce itself. When – in a later chapter – Aristotle explains why living beings have the nutritive capacity and why it is most basic to life, he refers primarily to the role of the use of food in living beings (*DA* III.12, 434a22–26):[39]

> It is necessary for everything that lives and has a soul to possess the nutritive soul (τὴν μὲν οὖν θρεπτικὴν ψυχὴν ἀνάγκη πᾶν ἔχειν ὅτι περ ἂν ζῇ καὶ ψυχὴν ἔχῃ), from birth until death; for it is necessary that what comes to be has growth, maturity, and decline, and these things are impossible without nourishment. It is thus necessary that the capacity for nutrition is present in all growing and declining things.

Aristotle stresses the necessity of metabolism as a basic principle of life: the ability to use food and to regulate the flow of matter is a first prerequisite if living beings are to complete a life cycle of coming into being, growing, thriving, and perishing (cf. *PA* II.10, 655b30–2: "it is not possible to be or to grow without food"). The presence of the nutritive capacity is thus a conditional necessity for living. There is no justification for why the nutritive and generative capacities are considered to be one and the same "part" of the soul; however, both serve the preservation of life, the one of the individual animal itself through the process of metabolism, the other – indirectly – of the whole animal kind through the process of formal reproduction. Self-preservation of a particular kind of life is the most basic end Aristotle picks out in teleological explanations of biological phenomena.[40]

The perceptive capacity, to which Aristotle turns next, is defined as a form of alteration or as a kind of being moved and affected (*DA* II.5, 416b32–417a2). Aristotle explains that it is not necessary for all living beings, but that it is necessary for all animals (*DA* III.12, 434a30–32):

> For an animal it is necessary to have perception, <for without that it would not be able to be an animal>, if nature does nothing in vain. For all things that are

[39] I treat the accounts in *DA* II.4–5 and *DA* III.12–13 as thematically continuous. For the hypothesis that *DA* III.12–13 was in fact originally placed in between *DA* II.4 and *DA* II.5, see Hutchinson (1987, 373–381) and its critique by Burnyeat (2002, 30n6).

[40] Cf. Johnson (2005, 171–178).

according to nature are for the sake of something, or are accidents of those things that are for the sake of something.[41]

Sense perception, in the sense of touch, is not only an essential or defining capacity of animals (cf. *DA* III.13, 435b16–17); Aristotle also wants to argue that it is a *vital* capacity. He explains, first, that a full range of sense perception is necessary for all *locomotive* animals and, second, that the capacity of touch by itself is of vital necessity for all animals.

Aristotle's explanation that the capacity of sense-perception is present in the locomotive animals that have it, because it is necessary for living, starts from the principle that nature does nothing in vain. In the biological works, Aristotle often invokes this principle to explain "paradoxical" absences of parts (see my discussion of this principle in section 4.2): by imagining the part in question to be present it is possible to detect what other feature the animal has that would have interfered with the functionality of the now missing part, and the presence of this (typically more necessary) feature explains why the part is absent in the actual animal. The part's presence would have been in vain, and nature – so it is posited – does nothing in vain. It thus seems that in the biological works Aristotle uses the reversed form of the same heuristic strategy he uses in *De Anima*: for here we are to imagine the *absence* of a capacity that is in fact present in order to detect the cause for its presence.

Specifically, Aristotle proposes that we imagine the existence of locomotive animals without the capacity of sense perception and then "observe" what the consequences of this absence would be: clearly, the animal "would be destroyed and would not reach the end which is the function of its nature" (*DA* III.12, 434a33–b1: φθείροιτο ἂν καὶ εἰς τέλος οὐκ ἂν ἔλθοι, ὅ ἐστι φύσεως ἔργον; cf. *Ph* II.6, 197b22–29). The reason why the animal would die is that it would not be able to find its food (*DA* III.12, 434b1–8):

(For how would it be nourished? For in those living beings that are stationary that [i.e., food] is available from that out of which they have been born, and it is not possible for a body to have a soul and an intellect that can distinguish things, but not to have perception, if it is not stationary and has been generated – and even if it were not generated – for why would it not have it [i.e., perception]? For it is either better for the soul or for the body; but now neither is the case (ἢ γὰρ τῇ ψυχῇ βέλτιον ἢ τῷ σώματι, νῦν δ' οὐδέτερον): the soul will not think better, nor will the body exist more because of it.) Therefore no body that is not stationary has a soul without sense perception.

[41] τὸ δὲ ζῷον ἀναγκαῖον αἴσθησιν ἔχειν, <οὐδὲ ἄνευ ταύτης οἷόν τε οὐθὲν εἶναι ζῷον,> εἰ μηθὲν μάτην ποιεῖ ἡ φύσις. ἕνεκά του γὰρ πάντα ὑπάρχει τὰ φύσει, ἢ συμπτώματα ἔσται τῶν ἕνεκά του.

Sense perception (although Aristotle does not state this explicitly, he clearly has the full range of capacities for sense perception in mind here)[42] is thus ultimately present for the sake of enabling locomotive animals to gather food after birth: without this capacity, they would die and would certainly not be better off in any way (apparently, the absence of a capacity is justified if and only if the animal's functioning benefits from this absence). Since nature never produces living beings that are not sufficiently equipped to achieve their natural ends (such beings would be in vain), it does not produce locomotive animals without the capacity of sense perception.

The presence of the capacity of touch is equally explained teleologically as being ultimately necessary for the sake of the self-preservation of *each* kind of animal, including the stationary ones (*DA* III.12, 434b10–14): "And it is necessary that it has it [i.e., the capacity for touch]. This is clear from the following. Because, since an animal is an ensouled body and every body is tangible, it is necessary that the body of an animal is able to touch, if the animal is to survive" (εἰ μέλλει σώζεσθαι τὸ ζῷον).

Aristotle believes that touch is necessary for survival, because anything that touches something else without sensing or registering it (i.e., undergoing some kind of change by being affected by the object), will not be able to flee from some things (e.g., predators) or catch others (e.g., food or possible mates); and "in that case, it will be impossible for the animal to survive" (*DA* III.12, 434b16–18: εἰ δὲ τοῦτο, ἀδύνατον ἔσται σώζεσθαι τὸ ζῷον).[43] This ultimate function of the capacity of touch to preserve the animal through enabling it to seize (or to flee from) things when sensing their presence also leads Aristotle to the conclusion that taste is a kind of touch (*DA* III.12, 434b18). Taste is the touching – or the perceiving – of what is tangible and nutritive, i.e., food, without which the animal cannot be (*DA* III.12, 434b22–24): "So these [i.e., touch and taste] are necessary for an animal, and it is manifest that without touch it is impossible for an animal to be."[44]

The capacity of touch, then, and its subcapacity of taste, both presuppose and contribute to the performance of the nutritive capacity, and as such are present for the sake of the preservation of the animal (cf. *DA* III.13, 435b17–18). However, in terms of hierarchy, touch is more necessary and therefore more universal than the other perceptive capacities (*DA* III.12, 434b24–27):

[42] Cf. Polanski (2007, 536–537).

[43] Note that by connecting touch to the appetitive capacities, Aristotle is able to explain the basic "flee and chase" behavior of animals. See Freeland (1992, 236–237).

[44] αὗται μὲν οὖν ἀναγκαῖαι τῷ ζώῳ, καὶ φανερὸν ὅτι οὐχ οἷόν τε ἄνευ ἁφῆς εἶναι ζῷον.

The others [i.e., smell, hearing, and sight] are for the sake of the good and come to be not in whichever of the animals; but in some, such as in the locomotive kind, their presence is necessary. For if it is to be preserved, it needs to perceive not only what it touches but also what is far away.[45]

Whereas touch is necessary for the existence of *all animals*, without qualification (cf. *Sens* 1, 436b12–15), the other perceptive faculties are necessary *only for those animals that are capable of locomotion*. In stationary animals, the other perceptive faculties, if present (and there are stationary animals without these additional perceptive faculties), are "not for the sake of their existence but for the sake of the good" (*DA* III.13, 435b19–21: οὐ τοῦ εἶναι ἕνεκα ἀλλὰ τοῦ εὖ).[46] The higher sense perceptions thus constitute a hybrid category: they are necessary and for the sake of living for all locomotive animals, but subsidiary and for the sake of living well if present in stationary animals.

This is, in the first place, because Aristotle believes that touch is the only capacity for sense perception that, if destroyed, destroys the animal with it, whereas excesses in color, sound, flavor, or smell only destroy the organ of perception, but not the animal itself (*DA* III.13, 435b4–19): this shows that touch is more basic to life than the other perceptive capacities are. Second, touch is more basic because the other senses are subsidiary to the achievement of *its* goal (i.e., detection of food and predators, and ultimately the preservation of the animal; cf. *DA* II.3, 414b6–9). For an animal has sight in order to see changes or effects in the transparent medium, be it air or water; taste (or perhaps rather smell)[47] to experience what is pleasant and painful in food and to adjust its desires accordingly; and hearing and voice for the sake of communication (*DA* III.13, 435b19–25) – which are all for the sake of enabling animals to detect objects at a distance.

The presence of the higher perceptive capacities expands in a way the capacity for touch and thereby allows even stationary animals to live a more complex life in terms of their activities, i.e., to live well in addition to living at all. As Aristotle explains in the introductory chapter of *De Sensu*, the higher senses (and especially hearing) contribute to the growth of intelligence and what has intelligence has the capacity to achieve higher

[45] αἱ δὲ ἄλλαι τοῦ τε εὖ ἕνεκα καὶ γένει ζῴων ἤδη οὐ τῷ τυχόντι· ἀλλὰ τισίν, οἷον τῷ πορευτικῷ, ἀνάγκη ὑπάρχειν· εἰ γὰρ μέλλει σώζεσθαι, οὐ μόνον δεῖ ἁπτόμενον αἰσθάνεσθαι ἀλλὰ καὶ ἄποθεν.

[46] Cf. Polanski (2007, 540–541).

[47] It is odd that Aristotle here lists taste among the capacities for sense perception that are for the sake of living well, rather than as being necessary, while leaving out smell: Hutchinson (1987, 377n.2) suggests that instead of γεῦσιν we should read ὄσφρησιν at *DA* III.13, 435b22, which would conveniently solve both problems.

perfection beyond mere self-preservation and reproduction (*Sens* 1 436b10–437a16; cf. *EE* I.7, 1217a21–29). Here he reiterates that for animals that are capable of locomotion, the higher senses are necessary for their preservation (*Sens* 1, 436b20: σωτηρίας ἕνεκεν), but adds that for those that also have intelligence, the higher senses serve their well-being (*Sens* 1, 437a1: τοῖς δὲ καὶ φρονήσεως τυγχάνουσι τοῦ εὖ ἕνεκα).

Voice, which is mentioned as one of the higher capacities that are for the sake of living well (in *DA* III.13, 435b24–25), is a special form of producing sound that belongs uniquely to animals (*DA* II.8, 420b5–6). Aristotle gives a more elaborate teleological explanation of why animals have this capacity in the following text (*DA* II.8, 420b13–22):

> Voice is sound made by an animal not with any chance part [of his body]. But since everything that makes a sound does so because something strikes something else in something else again, and this is air, it is reasonable that the only creatures to have voice should be those which take in air. For nature then uses the air already breathed in for two functions; just as it uses the tongue for both tasting and articulation, and of these tasting is necessary (and so is found in a greater number [of living beings]), while expression is for the sake of well-being, so also nature uses breath both for the inner warmth, as something necessary (the reason will be stated elsewhere) and also for voice so that there may be well-being.[48]

In explicating the purpose of voice, Aristotle again draws a distinction between two types of ends: some capacities are necessary for life, but others serve the animal's well-being. The first are present because they are conditionally necessary for the animals that have them (i.e., they are the product of primary teleology); the second are present because *nature uses* what is already present – here: what is already present for the sake of performing a necessary function – for the performance of a second function that serves the animal's well-being (i.e., they are the product of secondary teleology; see sections 4.2–3). As Aristotle makes clear, voice performs a secondary function: just as tongues are present because they are a necessary prerequisite for the realization of the function of taste, and nature makes use of tongues for articulation (that is, if the tongues that are already present

[48] φωνὴ δ' ἐστὶ ζῴου ψόφος οὐ τῷ τυχόντι μορίῳ. ἀλλ' ἐπεὶ πᾶν ψοφεῖ τύπτοντός τινος καί τι καὶ ἔν τινι, τοῦτο δ' ἐστὶν ἀήρ, εὐλόγως ἂν φωνοίη ταῦτα μόνα ὅσα δέχεται τὸν ἀέρα. τῷ γὰρ ἤδη ἀναπνεομένῳ καταχρῆται ἡ φύσις ἐπὶ δύο ἔργα – καθάπερ τῇ γλώττῃ ἐπί τε τὴν γεῦσιν καὶ τὴν διάλεκτον, ὧν ἡ μὲν γεῦσις ἀναγκαῖον (διὸ καὶ πλείοσιν ὑπάρχει), ἡ δ' ἑρμηνεία ἕνεκα τοῦ εὖ, οὕτω καὶ τῷ πνεύματι πρός τε τὴν θερμότητα τὴν ἐντὸς ὡς ἀναγκαῖον <ὄν> (τὸ δ' αἴτιον ἐν ἑτέροις εἰρήσεται) καὶ πρὸς τὴν φωνὴν ὅπως ὑπάρχῃ τὸ εὖ.

have the right material potentials),[49] in the same way air is present in those animals that have it because it is a necessary prerequisite for the realization of the function of cooling, which preserves the vital heat within an animal, and nature makes use of air for the sake of voice. This explains both why only animals that cool themselves through air have voice (only they possess air that nature can use for voice), and why those animals have voice: its presence serves the animal's well-being.

In other words, if an animal does not require the possession of the primary function to stay alive or to be the kind of animal it is, and therefore lacks the parts that are the necessary prerequisites for the performance of that function, it will also lack the secondary, non-necessary function. This is why, for instance, fish have no voice (*DA* II.8, 421a3–6): "It is manifest, too, why fish have no voice; for they have no larynx.[50] They do not have this part because they do not take in air or breathe in."

As Aristotle explained earlier, throats are organs for breathing, and they exist for the sake of the lung (i.e., throats are subsidiary parts; *DA* II.8, 420b21–24), which implies that only animals that breathe air have throats. The primary function of throats is to contribute to the function of cooling which is primarily and properly performed by the lungs; the secondary function of the throat is communication. Now, fish do not breathe air (they cool themselves through water), and therefore do not have lungs; animals without lungs lack throats, and without a throat, the materially necessary condition for the production of voice is lacking, too. Fish lack the necessary physiological requirements to produce voice, because their primary essential and vital functions do not require the presence of those organs (and, of course, the presence of air itself), which nature then can use (and needs) for the realization of a function that serves the well-being of the animal. As we shall see in Chapters 3 and 4, Aristotle provides many more teleological explanations in his biological works that are similar to this one in building upon the fundamental distinction between something being necessary for living or being subsidiary to the animal's well-being.

[49] Secondary functions may not obtain if a part lacks the right material potentials: for instance, human beings have tongues that are "the most detached, softest, and broadest, so that it may be useful for both its activities – the soft and broad tongue being useful both for the perception of flavors (for man is the most keenly perceptive of animals, and his tongue is soft, for it is most tactile, and taste is a sort of touch); and for the articulation of words and speech" (*PA* II.17, 660a17–22), whereas four-footed animals that are blooded and live-bearing are hardly capable of vocal articulation because "they have a tongue that is hard, undetached, and thick" (*PA* II.17, 660a34–5).

[50] For the complexities involved in translating the word *pharunx*, see Lennox (2001b, 252).

Finally, Aristotle also provides a teleological explanation for why there are several capacities for perception, rather than just one (*DA* III.1, 425b4–11):

> One might ask for the sake of what we have several senses and not just one. Is it perhaps in order that the common objects which accompany [the special objects], e.g., motion, size, and number, may less escape our notice? For if there were only sight, and this [sight] was of white, they would escape our notice more and they would all seem to be the same, on account of color and size invariably accompanying each other. Now, since the common objects are present in another perceived thing too, this makes it clear that each of them is something distinct.

The five senses combined are for the sake of enabling animals to detect the common objects of perception, which would otherwise escape our notice. If we were only able to see a white ball, it would be difficult to distinguish the whiteness in color from the magnitude in shape, because the two necessarily come together. Once we are also able to touch the ball, and feel a hard shape, we are able to recognize that the magnitude is something different from the color and from the hardness of the ball, and thereby get a clearer perception of its magnitude and of the nature of magnitude in general.

In sum, the presence of all five perceptive capacities in locomotive animals is for the sake of perceiving common objects and thus for the perception of everything that Aristotle believes is possible to be perceived.[51]

A teleological explanation for why animals have the capacity for locomotion

Aristotle's discussion of what locomotion is for and why it is present in the animals that have it is intimately connected to his discussion in *DA* III.9–11 of the nature of locomotion, the capacity of the soul that is responsible for it, and its physiological realization. I shall therefore closely follow Aristotle's analysis in these chapters.

Since locomotion appears to be different from such "automatic" motions as growth and decay (which all living beings have on account of their nutritive soul), respiration and expiration, and sleeping and waking, Aristotle first sets out to determine what capacity of the soul moves animals in respect of place and whether this is a separate capacity (*DA* III.9, 432a19–20; *DA* III.9, 432b7–8). His method is one of elimination.

First, Aristotle rules out the nutritive capacity, which is responsible for movement with respect to growth and decay, as being responsible for

[51] Polansky (2007, 378–379).

locomotion. Aristotle takes it as a given that locomotion is always for the sake of something (as a progressive motion it is itself an intrinsically teleological activity) and that it can only be voluntary and according to nature if it involves imagination and desire (*DA* III.9, 432b14–16). Since the nutritive capacity does not involve imagination or desire, it cannot be the cause of locomotion. Besides, Aristotle adds, if the nutritive capacity were responsible for locomotion, plants would also have had the capacity for locomotion and hence the parts instrumental for this kind of movement, which is not the case (*DA* III.9, 432b18–19). The underlying teleological principle at play here is that no living being lacks the instruments that are the necessary prerequisites for the realization of a necessary function. If a particular kind of living being lacks the instruments that are typically used for the performance of such a function, then it is reasonable to assume that it also lacks that function (presumably, because that function is not vital or essential to it).

Next, Aristotle eliminates the perceptive capacity as a candidate for producing locomotion: since there are many perceptive animals that are stationary and motionless (*DA* III.9, 432b20–21) – which indicates that perception and locomotion do not correlate universally – perception cannot be responsible for locomotion either. Aristotle refers again to the absence of locomotive parts as evidence for the absence of the capacity for locomotion, this time while positing the teleological principle that nature does nothing in vain (*DA* III.9, 432b22–26):

> If nature does nothing in vain and never leaves out any of the necessary [parts], except in those beings that are maimed and incomplete, while such living beings are complete and not maimed (and a sign of this is that they are able to reproduce themselves and they have maturity and decline [of life]) – then they too would have instruments for locomotion.[52]

If nature indeed never produces living beings that lack the means to realize their capacities, the only plausible explanation for why stationary animals – that are otherwise complete – lack instruments for locomotion is that these parts are not the necessary prerequisites for the realization of perception and that thus the presence of the capacity for perception is not the (sufficient) cause of locomotion.

[52] εἰ οὖν ἡ φύσις μήτε ποιεῖ μάτην μηθὲν μήτε ἀπολείπει τι τῶν ἀναγκαίων, πλὴν ἐν τοῖς πηρώμασι καὶ ἐν τοῖς ἀτελέσιν τὰ δὲ τοιαῦτα τῶν ζώων τέλεια καὶ οὐ πηρώματά ἐστιν (σημεῖον δ' ὅτι ἐστὶ γεννητικὰ καὶ ἀκμὴν ἔχει καὶ φθίσιν) – ὥστ' εἶχεν ἂν καὶ τὰ ὀργανικὰ μέρη τῆς πορείας.

Finally, Aristotle considers the intellective or calculative capacity, which he defined earlier as "that by which the soul both knows and understands" (*DA* III.4, 429a9–10). However, this capacity cannot be the mover either (*DA* III.9, 432b27–28): "For the intellective capacity thinks of nothing practical and it says nothing about what is to be avoided and pursued." Since the intellect is concerned with abstractions and not with the avoidance or pursuit of something, it cannot as such be the source of locomotion.[53] Merely thinking about something that is to be avoided or pursued does not bring about the emotional state necessary for the initiation of locomotion. Even if the intellect were to tell the animal to avoid or pursue something, the animal would not be moved; instead, the animal acts in accordance with desire (*DA* III.9, 433a1–3). Aristotle uses an analogy with the art of healing to point out that the intellective capacity is not sufficient as a cause of locomotion, because there is a difference between having knowledge and acting according to that knowledge. On the other hand, desire on its own is also not sufficient to cause locomotion: the case of continent people shows that although they may have the cravings and the desire for things, "they do not do those things for which they have a desire, but follow reason" (*DA* III.9, 433a7–8). Both intellect and desire seem to be involved in locomotion, but on their own they are insufficient.

From these considerations Aristotle draws the preliminary conclusion that desire and imagination *together* produce locomotion, given that imagination is some kind of thinking and that it is the only intellectual capacity that human beings and animals have in common (*DA* III.10, 433a9–13). He indicates that the capacities of the practical intellect and desire are equally goal-directed (*DA* III.10, 433a15–17): in contrast with the theoretical intellect that (typically) finds its end in its own activity, the *practical* intellect and desire are both directed towards an (external) end. The practical intellect starts from the object of desire, which is the end of the capacity of desire, and the endpoint of reasoning is what initiates locomotion towards that object.[54] The *primary* cause of locomotion is desire and ultimately the object of desire (*DA* III.10, 433b10–13).[55]

[53] Cf. *PA* I.1, 641a29-b10, where Aristotle argues that the natural philosopher need not speak about all parts of the soul, but only about those parts that are a source of movement; because intellect is not a source of movement (at least not on its own), that part of the soul does not belong to the domain of the natural philosopher. See Lennox (2001b, 143–145).

[54] See Charles (1984, 89–96) for the view that the conclusion of the practical syllogism is not an action, but *becomes* an action; the conclusion is a proposition, which – when accepted – by the activity of desire explains the action as an efficient cause. On the purpose of practical syllogisms, see Natali (2001, 61–67); cf. Charles (1984); Cooper (1975); Corcilius (2008a–c); Hardie (1968); Nussbaum (1978); and Santas (1969).

[55] This object of desire may be either the good or the apparent good (where good means the practical good, which is capable of being otherwise); *DA* III.10, 433a28–31.

Within this framework, Aristotle distinguishes three constituents of locomotion (*DA* III.10, 433b13–31). The first constituent is the mover or the moving cause (*DA* III.10, 433b13: ἓν μὲν τὸ κινοῦν), which is "double": there is a moving cause that is itself unmoved and one that both moves and is moved (*DA* III.10, 433b14–15). The unmoved moving cause is the practical good, which is the object of desire, external to the animal that is capable of locomotion. The moved moving cause is the capacity of desire, a part of the soul internal to the locomotive animal. Thus, the practical good, without being moved itself, initiates movement towards it in the capacity of desire; the capacity of desire is thereby itself moved, and in its turn moves the animal. The second constituent is that with which the moving cause produces movement (*DA* III.10, 433b14: δεύτερον δ' ᾧ κινεῖ). These are the "bodily instruments" that are conditionally necessary for animals to effect movement, such as feet, wings, and fins, which are to be "investigated among the functions common to body and soul" (*DA* III.10, 433b19–21: διὸ ἐν τοῖς κοινοῖς σώματος καὶ ψυχῆς ἔργοις θεωρητέον περὶ αὐτοῦ). The third and last constituent involved in locomotion is that which is moved (*DA* III.10, 433b14: ἔτι τρίτον τὸ κινούμενον), which is the animal or human being that is moved towards an end.

This, then, implicitly yields the teleological explanation of why some living beings are capable of locomotion: locomotion is progression towards (or away from) an object of desire (or of dislike) initiated by imagination for the sake of pursuing (or avoiding) that object of desire (or of dislike) perceived at a distance. The goal-directedness of locomotion itself is crucial for why animals have this capacity: locomotion would be of no use if it were merely progression in just any direction – the actualization of the capacity for locomotion is progression *towards* or *away from some (non-)desired object*. This may also explain why the locomotive capacity is not a separate part of the soul that is realized by its own object, in the way that the capacity of hearing is actualized by some object producing sound. Rather, the capacity for locomotion is concomitant to the capacity of desire that is present in an animal that also has imagination (*DA* III.10, 433b27–29): "In general then, as we have said, insofar as the animal is capable of desire, to that extent it is capable of moving itself; and it is not capable of desire without imagination."

The capacity for locomotion emerges, as it were, from the capacities of desire and of imagination, and is therefore present only in those animals that have these two capacities. The reason why animals that only possess the most basic capacity for perception, i.e., touch, are incapable of locomotion follows from this: these animals also only have imagination and appetite in

a very rudimentary form,[56] and are therefore unable to identify objects of desire or to focus on such objects – which would be necessary while moving towards them (*DA* III.11, 433b31–434a10).[57] This makes their motions "indeterminate" (*DA* III.11, 434a4–5: κινεῖται ἀορίστως) and random – they will eat only when they happen to touch upon something edible.

In sum, Aristotle does not explain the presence of locomotion in animals that have desire and imagination by reference to the contribution the function of locomotion makes to either living or living well; rather, he seems to treat the level of desire and imagination present in an animal as explanatorily basic, and uses this to explain why some animals have locomotion and why others do not, and then explains the number of perceptive capacities these animals have by reference to whether or not they have locomotion. Roughly, there are thus two main kinds of animals. Some animals have (nutrition and) touch and a rudimentary form of desire and imagination. They are not capable of locomotion and therefore do not need any of the higher perceptive capacities (if they do possess some of these, they are for the sake of living well). Other animals have (nutrition and) touch, desire and imagination, and therefore also locomotion. They possess the higher perceptive capacities for the sake of this latter capacity. The more capacities a living being has, the more complex its life and the more it partakes in well-being (cf. *Cael* II.12, 292b1–19 and my analysis of this passage in section 5.3). Plants, which only possess the capacity for nutrition, only partake in living; and human beings, who possess – in addition to all the other capacities that are present in the most complex animals – the capacity of thinking, have the highest share in living well.

2.3 CONCLUSION

Following the methodological order of the natural treatises of Aristotle, we have shifted from Aristotle's defense of the teleology of nature as an internal principle of motion and rest in the *Physica* to his teleological analysis of *living* nature in *De Anima*, where living is identified with the realization of soul capacities in a natural, instrumental body.

The teleological framework that Aristotle sets out in the *Physica* seems to be presupposed in the explanatory strategies of *De Anima*. For instance, in order to gain knowledge about the nature of the soul, Aristotle invokes his theory of four causes, and subsequently defines the soul as the efficient, formal, and final cause of the living being, and its natural body as the

[56] Cf. Schofield (1992, 272n.55). [57] Frede (1992, 290); Richardson (1992, 384).

material cause. In order to gain better understanding of the soul's operation on and interaction with the natural body, he uses his analogy between nature and art, and thereby establishes a functional conception of the soul and the instrumental and conditionally necessary character of the body. In order to explain why certain kinds of living beings have the soul capacities they have, he frequently posits the teleological principle that nature does nothing in vain, and then shows how the capacities they have are necessary for their living or rather contribute to their living well.

From the very outset, Aristotle's analysis of the soul is teleological in nature: the soul is that for the sake of which the bodily aspects of the living being are as its instruments. The soul constitutes a hierarchical and non-aggregative unity of capacities for the performance of functions in virtue of which a natural, instrumental body has life – and, in some cases, also well-being. The complete body with its main parts and features is conditionally necessitated by or subsidiary to (and therefore explainable by reference to) these life functions. Because of this, the characteristic activities and physical realization of each form of life – whether of a widest kind or of an individual subspecies – becomes explainable by reference to the particular combination of interdependent soul capacities that specific form of life has as its final cause.

The different capacities of the soul are themselves teleologically grounded as well: their presence in the living beings that have them is either necessary for those beings in terms of their basic survival and/or identity, or is rather for the sake of the living being's well-being. Not all capacities are thus equally necessary for life as such: the most basic capacities such as nutrition and reproduction are those that are most common among all living beings because they are most necessary for life; the higher capacities – which, except perhaps for the capacity of thinking, all presuppose the presence of the basic ones – are less prevalent, because they are less necessary for staying alive and reproducing, but rather serve the living being's well-being by allowing it to live a more complex life.

We shall see in the next two chapters that the teleological explanations for why animals have the parts they have in the biological works reflect this gradual scale of necessity and thus build upon the foundations laid down in *De Anima*.

CHAPTER 3

Introducing biology as a demonstrative science: the theory of teleological explanation in the De Partibus Animalium *I*

3.0 INTRODUCTION

Aristotle's theory of natural teleology applies in particular to living natural substances: their coming to be and existence, their change and development, and many of their differentiations are the result of the goal-directed actions of their formal natures. In the following two chapters, I discuss the role of teleology in the explanations Aristotle provides of the presence, absence, and differentiations of animal parts in *De Partibus Animalium*.

In Chapter 4, I shall present an analysis of the structure, role, and explanatory of force of the actual explanations recorded in *De Partibus Animalium* books II–IV; here, in Chapter 3, I shall first outline Aristotle's theory of explanation in biology as introduced in *De Partibus Animalium* book I. In section 3.1, I sketch the demonstrative character of the science of biology; this will provide some background to the larger scientific context within which Aristotle's use of teleological explanations takes place. In section 3.2, I discuss the notions of teleology that Aristotle employs in his discussion of the standards for explanation in the natural sciences in *De Partibus Animalium* book I. My aim here is to show that there are *two types* of teleology underlying these explanations: a primary kind that involves formal natures realizing a preexisting potential for form through conditional necessity, and a secondary kind that involves formal natures using materials that have come to be of material necessity for something good. Finally, in section 3.3, I define the different notions of necessity that appear in Aristotle's natural treatises and explain what role each plays in explanations of biological phenomena. In particular, I shall counter a possible objection to the positive role my notion of secondary teleology ascribes to material necessity in natural generation, i.e., the view that Aristotle's own discussions of the relation between teleology and

necessity – notably in *PA* I.1 – deny such a positive role.[1] I argue that this objection is grounded in a failure to distinguish between the causal and modal[2] ways in which Aristotle uses the concept of necessity.

The two arguments, which are developed independently of each other, together demonstrate that the material constraints and the influence of material necessity on the goal-directed actions of formal natures are relatively strong. Animals are the way they are not just because they have kind-specific potentials for form that are being realized, but also because of the material and the material potentials that are available to the formal nature during embryogenesis and the animal's subsequent development. This is not a negative claim: the goal-directed actions of the formal nature of an animal often (although not always) turn to a good use those materials that have come to be as a result of material necessity, and thereby equip living beings with features that are perhaps not strictly necessary for their survival or identity, but that contribute significantly to their well-being.

3.1 BIOLOGY AS A DEMONSTRATIVE SCIENCE

The relation between Aristotle's theory of scientific demonstration and inquiry as outlined in the *Analytica* and his practice in the physical and biological works has been the subject of much discussion in recent years among scholars of Aristotle,[3] and I do not wish to elaborate too much on this issue yet (I shall return to this question in Chapter 6). Instead, let me present as a working hypothesis for this chapter the thesis that Aristotle intended his biology to be a proper demonstrative science that approximates and builds upon the "guidelines" of his *Analytica Posteriora*.[4] This thesis is informed by the following two observations from the biological works: first, Aristotle shows genuine concern for identifying and following the appropriate scientific method in natural inquiry, and second, he repeatedly indicates that the materials presented in the biological treatises contain

[1] Consequently, scholars have explained away all material necessity in biology (Balme, 1987c); subsumed it under the operation of conditional necessity (Cooper, 1987; Johnson, 2005); or assigned a mostly constraining role to it in the realizations of function: see Gill (1997); Lennox (2001a, b) and especially (2001a, 187, 195–196) on "pre-conditional necessity"; and Pavlopoulos (2003, 164–166). The positive role I assign to material necessity is foreshadowed in Lennox's discussion of the omentum; see Lennox (2001b, 290–292).

[2] My account of necessity in Aristotle is much indebted to the analysis of modal and causal uses of necessity by Kupreeva (forthcoming).

[3] See Barnes (1981); Gotthelf (1987); Kullmann (1990); Lennox (2001a); and Lloyd (1990; 1996).

[4] For a defense of this thesis, see Gotthelf (1987), Lennox (*passim*), and Leunissen (2010).

the necessary ingredients for generating demonstrations of the natural kind.

Aristotle sets out the principles and standards for biological investigations in the first book of *De Partibus Animalium*.[5] His aim there is to provide standards from which one will be able to assess the "manner of the things demonstrated" (*PA* I.1, 639a12–15; 13–14: τὸν τρόπον τῶν δεικνυμένων) in the natural sciences, of which the study of animals is a part. Aristotle proceeds mainly through a discussion of methodological dilemmas, dealing with varied questions such as which causes the natural scientist should pick out and what their priority relations are (Aristotle argues for the priority of teleology over necessity, but without denying explanatory force to the latter); what the relation is between form and matter in animals (Aristotle explains that the two are complementary, and that therefore the natural scientist needs to study both); and whether the natural scientist should study the whole soul or only a part of the soul (Aristotle states that the capacity for thinking does not belong to the study of nature). Aristotle also offers a revision of the Platonic method of division and definition. This latter critique of dichotomous division leads, among other things, to the establishment of what exactly constitutes an animal kind: kinds share "a single common nature and forms in it that are not too distant" (*PA* I.4, 644b3–4: ἔχει τε μίαν φύσιν κοινὴν καὶ εἴδη ἐν αὐτῷ μὴ πολὺ διεστῶτα). Animals that belong to the same kind differ only in degree ("by the more and less" or "by bodily affections"), while animals that differ in kind are similar to each other only by analogy (*PA* I.4, 644a16–22; 644b12).[6]

The most striking feature of *De Partibus Animalium* book I is perhaps that in it Aristotle not only follows but also enriches the *Analytica*'s conception of science in order to make it applicable to the special and distinct study of living beings. For instance, the *Analytica* lacks a clear distinction between matter and form and seems devoid of the causal concept of conditional necessity.[7] Both are crucial to the study of (living) nature, and are therefore introduced and further refined in Aristotle's methodological discussion in *De Partibus Animalium* book I. This, I believe, gives evidence for the thesis that Aristotle self-consciously attempts to integrate his newly

[5] For an outline of *PA* I and its connections with the method presented in the *Analytica Posteriora*, see Lennox (2001a, 100–104).

[6] For what it means for animals within one genus to have a common nature, see Charles (2000, 316–326).

[7] See Lennox (2001a, xxii, 102, and *passim*).

developed science of biology into the scientific framework supplied by the *Analytica*.

Aristotle's conviction that his investigations contain what is needed to provide demonstrations of biological phenomena is visible in a few (but very well-known) methodological statements in the biological works. The clearest and least controversial text concerning the demonstrative nature of biology is the following (*HA* I.6, 491a7–13):

> These things, then, have been put forward in outline, to provide a foretaste of what things we have to investigate and what it is about them [that we have to investigate]. Later we shall discuss them in greater detail, in order that we may first gain understanding of the differences and the attributes belonging to all. After this, we must try to discover the causal explanations of these things. For it is the natural method to do this after having started with the investigation of the details concerning each thing; for from these it becomes apparent both about which things the *demonstration* must be, and from what things it must proceed (περὶ ὧν τε γὰρ καὶ ἐξ ὧν εἶναι δεῖ τὴν ἀπόδειξιν, ἐκ τούτων γίνεται φανερόν) (cf. *PA* I.1, 639a12–15; 640a1–9; *GA* II.6, 742b23–36).

The zoological research program sketched in this passage recommends the natural scientist to start with a collection of the basic facts to be explained (i.e., of the *hoti* in the language of the *Analytica*), and is mainly carried out in the *Historia Animalium* through (Aristotelian) divisions of the differences between animals. In this collection, Aristotle records the attributes and *differentiae* of animals (the *differentiae* are the differences with respect to the animals' modes of life, their activities, their characters, and their parts), with the purpose of establishing their correlations.[8] For example, Aristotle discusses similarities and differences between animals concerning the possession of hair as follows (*HA* II.1, 498b16–18):

> All animals, as many as are four-footed and live-bearing (πάντα δ' ὅσα τετράποδα καὶ ζῳοτόκα), are hair-covered, so to speak, and they are not like man who is sparsely haired and short-haired except on the head; with regard to the head he is the hairiest among animals.

Note that in this example Aristotle records both correlating features ("being a four-footed live-bearing animal" and "being hair-covered") and their precise extension ("all . . . as many as are . . . "), in addition to indicating how this correlation is different in another genus ("being a human" correlates

[8] I borrow these points, and the example below, from Lennox (2001a, 7–38); cf. also Lennox (1990, 175–182).

with "having the most hairy head of all animals"). Following the demonstrative model of the *Analytica* (see, e.g., *APr* I.30, *APo* I.13 and *APo* II.1), according to which the investigation of the facts is separate from and precedes the investigation of the reasons why, Aristotle thus collects in *Historia Animalium* the biological facts that always or for the most part go together, and therefore form possible candidates for being picked out as terms in syllogistic demonstrations in either the predicate or the subject position. These correlating pairs of facts constitute the "about which" of demonstrations. In this case, one of the explananda is why "having the most hairy head" (picked out by the predicate term) correlates always or for the most part with "being a human" (picked out by the subject term).

Ultimately, Aristotle also hopes that because of this collection we will be in a better position to single out those features and *differentiae* that are causally basic (i.e., factors that themselves cannot be explained any further through other factors) from the ones that are explained through these factors (see, e.g., *PA* II.14, 658b2–10). The *Historia Animalium* is thus also supposed to help us discover those causal features "from which" demonstrations (or the *dioti*) come about, and forms in that way a preliminary to the next, demonstrative stage in which Aristotle proceeds to *identify* these causes, which is recorded predominantly in *De Partibus Animalium* and *De Generatione Animalium*. The exceptional hairiness of human heads, for instance, is explained in *De Partibus Animalium* (see *PA* II.14, 658b2–10) by reference to both teleology and material necessity: due to the presence of the brain in the human head, this place is moistest, which makes it both very weak and most conducive to the growth of hair. At the same time, hair is what provides protection, and nature provides protection to the place that needs it most. The causally basic factors which are to be picked out as middle terms are "moistness" and "need of protection," both of which belong *most* to the human head (I shall explain the causal mechanism underlying this type of "double" explanation below).

Demonstrations in the natural sciences are, of course, as Aristotle explains in *De Partibus Animalium* book I (see especially *PA* I.1, 640a1–9; *PA* I.1, 640a33–b3; *PA* I.1, 642a32–b2), different from demonstrations in the mathematical sciences that form the main model of demonstrative science in *Analytica Posteriora*, even though both are a kind of theoretical science (*Meta* VI.1, 1026a6–8). Unlike the latter, the conclusions of biological demonstrations do not hold always and without exception, but merely "for the most part," and the necessity that governs the deduction is conditional, rather than unqualified (see below in sections 3.3 and 6.4).

However, already within the *Analytica Posteriora*, Aristotle indicates that there are also demonstrations of things that hold for the most part (see especially *APo* I.8, I.30, and II.12) and occasionally uses examples (e.g., thunder, lunar eclipses, and the shedding of leaves) that are drawn from the natural sciences. It thus seems safe to conclude that Aristotle attempts to build his science of biology on the model set out in his *Analytica Posteriora*, and that the differences we will find between the theory of the *Analytica Posteriora* and that of *De Partibus Animalium* book I do not affect the status of biology as a demonstrative science.

3.2 PRIMARY AND SECONDARY TELEOLOGY

The image of nature as a good housekeeper

In order to get a better grasp of Aristotle's theory of explanation in *De Partibus Animalium* book I, and perhaps of his explanatory project in the *De Partibus Animalium* as a whole, we need to make a distinction between what I call "primary" and "secondary" teleology. I shall illustrate this distinction by offering an elaborate interpretation of an image Aristotle draws of nature acting as a good housekeeper in *De Generatione Animalium*, and use my findings to shed light on Aristotle's standards for how to construe demonstrations of biological phenomena provided in the first book of *De Partibus Animalium*.

The image of nature that I believe is most helpful for understanding the double nature of Aristotle's teleology (even though one has to realize that Aristotle is not himself concerned with presenting a two-fold theory of teleology in this image) is part of an investigation into the natural order of generation of the various animal parts within the embryo in *De Generatione Animalium* book II (see *GA* II.1, 733a32; 734a16–34; and *GA* II.4, 740a2–16). Before quoting the image in full, I shall first sketch its context.

One of the issues Aristotle tries to settle in the second book of *De Generatione Animalium* is the order in which animal parts come to be. In *GA* II.4, he argues that, within the embryo, which "possesses all parts potentially in a way" (*GA* II.4, 740a2–4: καὶ ἐν τῷ κυήματι τρόπον τινὰ πάντων ἐνόντων τῶν μορίων δυνάμει), the heart is the first to take shape because it is the source of movement for the developing animal (*GA* II.4, 740b2–4; cf. *PA* III.4, 666a18–21). In *GA* II.6, he lays out a detailed method for how to determine the order in which the parts of an animal develop further, starting from the heart. As Aristotle points

out, this is something that cannot always simply be observed (bigger parts often appear earlier, even though they start developing later: *GA* II.6, 741b26–27) and is therefore "not easy" to make out (*GA* II.6, 742b6–7; cf. *GA* II.6, 742b9–10). According to the method Aristotle proposes, parts that generate other parts must come to be before all other parts, and parts that serve as an instrument must come to be after those parts that are "that for the sake of which" and that make use of the former (*GA* II.6, 742a16–b18). The underlying teleological principle in this threefold division in the chronology of the coming to be of parts is that nature does not produce parts before the animal is actually able to use them (otherwise, these parts would be in vain; see the analogy with the flute player in *GA* II.6, 742a26–28), conjoined with the fact that parts that are of the nature of an origin necessarily come to be first.

Aristotle accordingly explains that the generation of the heart is followed first by the blood vessels, out of which then all the other parts are formed – first the internal, then the external parts; first the upper, then the lower parts (*GA* II.6, 742a36–742b18). Within this sequence of generation, Aristotle notes that the time of the formation of the eyes presents a difficulty: although their formation starts – as one would expect based on their location in the animal body – early on in the formation of the embryo, they are the last organs to reach their completion (*GA* II.6, 743b32–744b11). Aristotle explains this peculiarity by reference to the principle that nature does not create parts too early or too late for an animal to be able to use them (see *GA* II.6, 744a35–b1; cf. *GA* V.8, 788b20–789a2 concerning teeth). With the image of nature as a good housekeeper Aristotle returns to his discussion of the *normal* sequence of the generation of animal parts (*GA* II.6, 744b11–27):

> Each of the other parts [i.e., all the parts of an animal with the exception of the eye and the heart discussed before] is formed out of the nutriment, (A) the parts that are the noblest and that partake in the most important principle [i.e., the essential parts: cf. *GA* II.6, 742a34–35 and V.1, 778b12–13] are formed from the nutriment which is concocted first and is purest; (B) the parts that are necessary, that is to say that are for the sake of the former parts, are formed from the inferior nutriment and the residues and leftovers. For just like a good housekeeper, so also nature is not in the habit of throwing away anything from which it is possible to make anything useful. Now in a household the best part of the food that comes in is set apart for (A) the free people, the inferior and the residue [of the best food] for (B1) the slaves, and the worst is given to (B2) the animals that live with them. Just as the intellect from the outside does those things with a view to growth, so nature in the things coming to be forms from the purest material (A) the flesh and the body of the other sense organs, and from the residues thereof (B1) bones

and sinews and (B2) hair, and also nails and hoofs and all similar parts; for this reason these are the last to assume their formation, for they have to wait till the time when nature has some residue to spare.[9]

This image is representative for the way Aristotle commonly picks out nature in his explanations of biological phenomena: nature is always personified as an agent, and portrayed as acting for the sake of something, while following a certain *logos* or formula (cf. *PA* I.1, 641b23–37). Aristotle calls this the "formal nature" of an animal, which incorporates the efficient, final, and formal cause of an animal, and is to be identified with its soul (see, e.g., *PA* I.1, 641a23–28; *DA* II.1, 412a19–21 and *GA* IV.4, 770b17).[10] Contrasted with this formal nature is the animal's "material nature": this is its body, its basic elemental make-up, and the kinds and amounts of food it can process. The material nature is a source of the constitutive matter for the formation of parts and is thus in constant interaction with the formal nature of the animal.

What is particularly important for our understanding of Aristotle's teleology in this image is the hierarchy of different types of animal parts that Aristotle develops in it, linking the ontological status of a part to the quality of its constitutive material and its place in the sequence of coming into being. According to the image drawn, nature uses the best materials to make the most important parts of the body, and makes those first, just as in a household, the housekeeper gives the best food to the most important members of the household, who are fed first.

Specifically, I take the image to suggest that not all biological parts are "created equally" (the first group of parts receive some kind of priority treatment, whereas others have to wait for their formation until nature has some residue to spare), which indicates that the underlying teleological processes that account for their coming to be and presence must be different. The most important parts in the image (A) are those that partake in the essence of an animal: they are made of the best nutriment, and come to be first.

[9] Τῶν δ' ἄλλων γίγνεται μορίων ἕκαστον ἐκ τῆς τροφῆς, τὰ μὲν τιμιώτατα καὶ μετειληφότα τῆς κυριωτάτης ἀρχῆς ἐκ τῆς πεπεμμένης καὶ καθαρωτάτης καὶ πρώτης τροφῆς, τὰ δ' ἀναγκαῖα μόρια καὶ τούτων ἕνεκεν ἐκ τῆς χείρονος καὶ τῶν ὑπολειμμάτων καὶ περιττωμάτων. ὥσπερ γὰρ οἰκονόμος ἀγαθὸς καὶ ἡ φύσις οὐθὲν ἀποβάλλειν εἴωθεν ἐξ ὧν ἔστι ποιῆσαί τι χρηστόν. ἐν δὲ ταῖς οἰκονομίαις τῆς γιγνομένης τροφῆς ἡ μὲν βελτίστη τέτακται τοῖς ἐλευθέροις, ἡ δὲ χείρων καὶ τὸ περίττωμα ταύτης <τοῖς> οἰκέταις, τὰ δὲ χείριστα καὶ τοῖς συντρεφομένοις διδόασι ζῴοις. καθάπερ οὖν εἰς τὴν αὔξησιν ὁ †θύραθεν ταῦτα ποιεῖ νοῦς οὕτως ἐν τοῖς γιγνομένοις αὐτοῖς ἡ φύσις ἐκ μὲν τῆς καθαρωτάτης ὕλης σάρκας καὶ τῶν ἄλλων αἰσθητηρίων τὰ σώματα συνίστησιν, ἐκ δὲ τῶν περιττωμάτων ὀστᾶ καὶ νεῦρα καὶ τρίχας, ἔτι δ' ὄνυχας καὶ ὁπλὰς καὶ πάντα τὰ τοιαῦτα· διὸ τελευταῖα ταῦτα λαμβάνει τὴν σύστασιν ὅταν ἤδη γίγνηται περίττωμα τῆς φύσεως.

[10] On formal natures, see also Lennox (2001a, 182–194).

Elsewhere Aristotle refers to these parts as being necessary (without further qualification) for the animal, as they are conditionally necessary for the performance of vital and essential functions. This presumably means that these parts are the result of the standard form of teleology, or of what I here call primary teleology. I shall explain this further below. The other parts in the image (B) are also necessary, but *in a more restricted and qualified way*.[11] These parts are said to exist for the sake of the first category (which is why I prefer to refer to them as "subsidiary" parts), and are made of inferior nutriment, and only come to be if nature has enough leftovers to spare. In *De Partibus Animalium*, Aristotle somewhat paradoxically refers to these parts as being "not necessary" (presumably, because they are not necessary without qualification, but rather necessary for the sake of other parts) and as being "for the better," because their presence improves the functioning and well-being of the animal in question. Even though the accounts in *De Generatione Animalium* and *De Partibus Animalium* are thus not overtly consistent in their ascriptions of "necessity" to these two types of parts, they do provide the same causal descriptions of the actions of the formal natures in the production of subsidiary parts: in both treatises, they are described as the product of nature *using* leftovers to make some useful feature for the animal in question. This, I believe, illustrates a different – secondary – kind of teleological causation.

In the next subsections, I shall work out this hierarchical picture of animal parts in more detail, mostly by drawing from material from the *De Partibus Animalium* (for a schematic outline, see Table 3.1).

Vital and essential parts

I submit that the first category of parts – represented by the "free people" in the image – consists of those parts that are the necessary prerequisites for the performance of the vital[12] and essential[13] functions specified by

[11] I translate the second *kai* in *GA* II.6, 744b14 epexegetically as "that is to say," which is arguably not the most natural reading of the text. However, I believe that I can justify this reading based on how Aristotle treats this group of parts in *other* contexts, most notably in *De Partibus Animalium*. See my discussion below.

[12] For examples of vital functions with their respective necessary parts, see *PA* II.3, 650a6–8; *PA* II.7, 652b15; *PA* II.10, 655b28–31; *PA* III.4, 665b10–15; *PA* III.4, 666a22–24; *PA* III.14, 674a13–19; *PA* IV.5, 681b13–16; *PA* IV.10, 686a5–7 and *GA* I.2, 716a18-I.8, 718b28.

[13] For examples of essential functions with their respective necessary parts, see *PA* II.2, 647a20–23; *PA* II.8, 653b19–23; *PA* III.6, 669b8–12; *PA* IV.5, 681b13–16; *PA* IV.12, 693b2–13; *PA* IV.13, 695b17–25 and *GA* V.1, 778a32–34. Note that flying is not an essential function of insects: some insects have wings by way of compensation for a lack of feet (*PA* IV.6, 682b5–6). For species being demarcated by the specific combination of necessary parts, see *Pol* IV.4, 1290b25–37.

Table 3.1 *The hierarchy of parts in the image of nature as a good housekeeper*

Biological part		Timing in growth	Material used	Example
A	Vital and essential parts ↔ Free people *Perform necessary functions*	Made first	Best nutriment	Fins *Necessary for swimming*
B1	Subsidiary parts ↔ Slaves *Contribute to necessary functions*	Made second	Inferior nutriment	Kidneys *Help collection of residue*
B2	"Luxury" parts ↔ Animals *Perform non-necessary functions*	Made third	Residues	Horns *Provide protection*

the definition of the substantial being of that animal (this is what it is to partake in the "most important principle" or essence of the animal).[14] Elsewhere Aristotle claims that their presence is *necessary* for the animal: through these parts the animal's form is realized, and without them the animal would not be able to survive, or it would not be able to be the specific kind of animal it is.

Outside the *De Generatione Animalium*,[15] Aristotle employs a very strict notion of necessity in his characterizations of such vital and essential parts. He calls a part necessary for an animal when he believes that nature could not have "designed" that animal without the part in question; without the part, the animal *immediately* fails to reach its natural ends (cf. *GA* IV.4, 771a11–14). This is clear from, for example, his description of the liver, which he considers to be a vital part of all blooded animals (*PA* IV.2, 677a36–b5):

> For it is reasonable that, since the nature of the liver is vital (ἐπίκαιρον) and necessary (ἀναγκαίαν) to all the blooded animals, its being of a certain character is a cause of living a shorter or longer time . . . and none of the other viscera is necessary to these animals, but only the liver (τῶν δ' ἄλλων οὐδὲν σπλάγχνων ἀναγκαῖόν ἐστι τοῖς ζῴοις, τὸ δ' ἧπαρ μόνον).

According to Aristotle, the presence of the liver is so basic to the life and survival of blooded animals that it is the only visceral organ they absolutely

[14] For examples of parts whose function is specified by the definition of the substantial being, see Code (1997, 139–140) and Gotthelf (1985, 27–54; 1987, 190–191).

[15] For evidence within the *De Generatione Animalium*, see especially *GA* I.4, 717a11–21, which I discuss in section 4.2.

cannot be without; that is, of course, in addition to the heart, which Aristotle had already established as being the *origin* of blood (cf. *PA* II.1, 647a35–b8 and III.4, 665b10–15). Because only the heart and the liver are necessary in this strict way for blooded animals, these are the only viscera present in *all* blooded animals (cf. *PA* III.4, 665a28–30; 665b10; 666a24–25; and III.7, 670a23–28). The other visceral parts, such as, for instance, the kidneys and the spleen, are not in the same way necessary for all blooded animals (Aristotle even calls them "non-necessary"; see my discussion of the kidneys below), which is why they are also not present in all blooded animals (cf. *PA* III.7, 670a30; III.9, 671a26–30; and III.12, 673b12–14). In other words, nature cannot produce blooded animals without a heart and liver, but it is among the natural possibilities to produce blooded animals lacking some of the other visceral parts.

The explanations Aristotle offers for the necessary vital and essential parts in *De Partibus Animalium* provide textbook examples of what I call primary teleology. For example, Aristotle explains the presence of fins in fish by reference to the definition of their substantial being (*PA* IV.13, 695b17–26):

> Fish do not have distinct limbs [such as arms or feet], owing to the fact that their nature according to the definition of their substantial being is to be able to swim (διὰ τὸ νευστικὴν εἶναι τὴν φύσιν αὐτῶν κατὰ τὸν τῆς οὐσίας λόγον), and since nature makes nothing either superfluous or pointless. And since they are blooded in virtue of their substantial being, it is on account of being swimmers (διὰ μὲν τὸ νευστικὰ εἶναι) that they have fins.

Fish are essentially swimmers: that is, being able to swim is part of the nature or substantial being of fish, and having fins is a necessary condition for fish being able to swim; hence fins are *kath'hauta* features of fish.[16] (It is important to note here that Aristotle treats the absence of fins in a small number of fish not as a refutation of his observation that fins are essential parts of the genus fish, but as an exception that deserves special explanation. I shall discuss such exceptional cases in section 4.2.) The coming to be and presence of these parts is thus explained by reference to

[16] Cf. *PA* III.6, 669b8–12; *PA* IV.5, 678a31–35; and *PA* IV.13, 697b1–13. Note that this type of explanation also holds for those parts whose presence can be deduced directly from the presence of necessary parts or can be "traced" to the definition of the substantial being of an animal (cf. *GA*. V.1, 778a34–35: ἐπ' ἐνίων πρὸς τὸν λόγον συντείνει τὸν τῆς οὐσίας): for example, while wings and being blooded are necessary parts of birds (i.e., they are *kath'hauta* features of birds; see *PA* IV.12, 693b10–14), being two-footed is a *kath'hauta sumbebêkos* feature of birds; see *PA* IV.12, 693b5.

their necessary function,[17] and that function in its turn is grounded in the substantial being of the animal. Teleological explanations of this primary kind exhibit parts to be the necessary prerequisites for the performance of vital or essential functions.

Aristotle introduces this type of teleological explanation as the primary kind of explanation in his methodological introduction to biology in *PA* I.1 (*PA* I.1, 639b13–19):

> Now it is apparent that the primary [kind of explanation] is the one we describe as being for the sake of something (φαίνεται δὲ πρώτη, ἣν λέγομεν ἕνεκά τινος). For that is an account, and an account is a starting point alike in things that are composed according to art and in those composed by nature. For after having defined by thought or perception – the physician [having defined] health, and the house-builder [having defined] the house – they [i.e., the physician and the house-builder] provide the accounts and the explanations (ἀποδιδόασι τοὺς λόγους καὶ τὰς αἰτίας) of that which each of them produces, and the reason why they have to be produced in that way.

These lines are usually taken as a defense of the priority of final causality over efficient causality,[18] but I believe that they rather pertain to the priority of teleological explanation over efficient explanation: the explanans is not a function, but a form that specifies the functions to be realized.[19] Just as in art the artifact that is produced and the way in which it is produced are explained by reference to the definition of the end product (i.e., "house") that specifies the function of that product (i.e., "shelter"), so too in nature the coming to be of an animal and its parts is explained by reference to the definition of the substantial being of that animal, which specifies – among other things – the functions to be realized (cf. *Meta* VII.7, 1032b5–22). This also explains why Aristotle believes his predecessors failed to provide explanations in terms of forms and functions for biological phenomena (*PA* I.1, 642a25–26: "because there was no 'what it is to be' and no 'defining of the substantial being'"). They lacked a proper starting point from which to determine functional parts and a means to connect them with the essential being of an animal – they were not able to recognize functional features

[17] Cf. *PA* I.5, 645b18–20. That fins are for the sake of swimming is not stated explicitly here, perhaps because this is obvious and/or has already been suggested previously: see *PA* IV.8, 684a14–15; *PA* IV.9, 685b16–23; and *PA* IV.12, 694b10–12.

[18] E.g., Lennox (2001b, 124–126).

[19] Cf. Bostock (2006, 62). Aristotle sometimes suggests that in natural science form and function are "almost one" (*GA* I.1, 715a4–6; 715a6: ὡς ἕν τι σχεδὸν ὑπολαβεῖν δεῖ), but I believe that a full identity between form and function only obtains in the case of fully realized forms (see section 1.1). What guides the process of generation is the potential for form that is being realized, whereas functions constitute the limits and end points of development.

as the realization of a preexisting potential for form that specifies the functions in need of realization. Aristotle's argument is that because definitions are primary, so too are explanations that proceed through such definitions.

He later explains that in nature, just as in house-building, generation is for the sake of being, and not being for the sake of generation, and that therefore the coming to be of parts should be explained by reference to the form that is being realized (*PA* I.1, 640a10–19).[20] From this he concludes that explanations in the natural sciences should be given in the following form (*PA* I.1, 640a33–35): "Therefore one should state in particular that since this is what it is to be a human being, on account of that it has these things (ἐπειδὴ τοῦτ' ἦν τὸ ἀνθρώπῳ εἶναι, διὰ τοῦτο ταῦτ' ἔχει): for it is not possible to be without those parts." Here, the definition of the substantial being of humans is implied to specify the functions a human being needs to perform for him to be the kind of being he is (i.e., what it is for a human being to be human is to be able to perform certain functions). And it is because these functions need to be realized, that he has certain parts – he has those parts that are necessary for the performance of the functions that are involved in making a human human.

Aristotle's statement that "it is not possible for a human being to be without those parts" indicates that the process responsible for the coming to be of such vital or essential parts is conditional necessity:[21] *given* that a living being has to be able to perform the functions specified in its form, it has to have such and such parts, and such and such differentiations of parts (which Aristotle defines as differences of "the more and the less" in *PA* I.4, 644b7–15), made of such and such constitutive materials, put in such and such a structure or configuration. In the context of *De Generatione Animalium*, Aristotle describes the actions of the formal nature of an animal in these cases as first using the spermatic residue that is present,[22] but then as "*making*" the required materials by processing (i.e., concocting)

[20] Empedocles evidently got this priority relation wrong, and is criticized by Aristotle for explaining "being" in terms of what happened to happen during generation (*PA* I.1, 640a19–24).

[21] See *PA* I.1, 642a7–12: "For we say nourishment is something necessary according to neither of those two modes of necessity, but because it is not possible to be without it. And this is as in the conditional type (τοῦτο δ' ἐστὶν ὥσπερ ἐξ ὑποθέσεως). For just as – since the ax must split – it is necessary for it to be hard, and if hard, then made of bronze or iron, so too since the body is an instrument (for each of the parts is for the sake of something, and likewise also the whole), it is therefore a necessity that it be of such a character and constituted from such things, if that is to be (ἀνάγκη ἄρα τοιονδὶ εἶναι καὶ ἐκ τοιωνδί, εἰ ἐκεῖνο ἔσται)." Cf. *GA* V.1, 778b15–19 and *PA* IV.10, 689a20–21.

[22] A crucial text in this context is *GA* II.6, 743a36-b8: here Aristotle explains that the formal nature makes use of heating and cooling (i.e., of material necessity) for the production of parts, which I take it describes the process of primary teleology involved in embryogenesis, in which the formal nature of an animal uses material potentials to conditionally necessitate the organs required for

the incoming food,[23] and shaping them into parts. The formal nature of an animal thus conditionally necessitates the materials it needs for the formation of parts that are necessary for the performance of necessary functions (cf. *GA* II.6, 743a36–b5).

In sum, the primary mode of explanation in biology exhibits parts to be the necessary prerequisites for the realization of functions specified by the definition of the substantial being of the animal that has those parts. The teleology operative in the coming to be and presence of such parts is primary; the necessity is conditional.

Subsidiary parts

The second category of parts – represented by the slaves in the image – consists of parts, I submit, that are not themselves necessary for the performance of vital or essential functions specified in the definition of the substantial being of a particular kind of animal. Instead, they are necessary in the sense that they *exist for the sake of* the "noblest" parts. The function of this second category of parts is thus to *contribute* to the performance of necessary vital or essential functions (without having a proper function of their own) and thereby to contribute to the well-being or living well of the animal, rather than to its living.[24] The distinction is similar to the one Aristotle makes with regard to the capacities of the soul, where the most basic capacities are said to be necessary for living, whereas the higher ones are depicted as being necessary for the sake of the good or living well (see, e.g., *DA* III.13, 435b20–21, discussed in section 2.2). Since the coming to be of these parts is said to be dependent upon and later in generation than that of the first category of vital and essential parts, I propose calling these parts "subsidiary."

In addition, I shall follow Aristotle's practice in the *De Partibus Animalium* of referring to these parts as being "non-necessary" for the widest

the realization of a potential for form. The operations of material necessity in these cases are thus entirely subsumed under the goal-directed actions of the formal nature of the animal (which makes it a form of conditional necessity) and only influence the coming to be of parts by materially constraining it.

[23] In *GA* II.6, 744b27–36, Aristotle distinguishes between the spermatic residue (*GA* II.6, 744b27: ἐκ τῆς σπερματικῆς περιττώσεως) already available for the development of the embryo and the "natural food" (*GA* II.6, 744b30: ἐκ τῆς φυσικῆς τροφῆς), coming in later through the process of nutrition of the mother and later of the animal itself. There are two kinds of natural foods: the first is "nutritious" and is used for the formation of complete parts; the second is "conducive to growth" and is used for the quantitative increase of existing parts (*GA* II.6, 744b34–36). Within the animal there may be residues of both types of food (*GA* II.6, 745a1–4).

[24] Cf. Aristotle's characterization of actual slaves in *Pol* I.4 as instruments of actions – not of their own, but of their masters. I thank Sean Coughlin for bringing this parallel to my attention.

kind of animals that needs to perform the function related to this part (because these parts are not immediately necessary for the performance of the particular vital or essential function in question) and as being "for the better" for the subclass of animals that do possess these extra features (because they serve the well-being or living well of the animals that have them).

Consider Aristotle's explanation of the presence of kidneys (*PA* III.7, 670b23–27):

> The kidneys are present in those that have them *not of necessity*, but *for the sake of the good and doing well*. That is, they are present, in accordance with their distinctive nature, for the residue which collects in the bladder in those animals in which a greater amount of such excrement comes about, in order that the bladder may better perform its own function.[25]

Kidneys are viscera, but unlike a heart or a liver, they are not present in all blooded animals. They are present only in those that have blooded lungs, because *they help the bladder perform its function better* by providing extra storage room for residue. Kidneys do not possess a function of their own. Apparently, Aristotle thinks that the kidneys are not themselves strictly necessary[26] for the collection of residue (only the bladder is), even though animals that have a bladder usually also have kidneys (see *PA* III.9, 671a26–671b3 and *GA* IV.4, 771a2–6, where Aristotle claims that while no animal can live without a heart or a liver or any other of the necessary parts, it can live "without a spleen or with two spleens or with one kidney"). The suggestion is thus that animals with blooded lungs could have been designed in a way that would not require the presence of kidneys; the presence of kidneys is not conditionally necessitated in the way that the presence of a bladder is. Instead, Aristotle believes that kidneys are present for the better: they assist the bladder in the collection of residues in those animals that produce larger amounts of residues and thereby contribute to their well-being.

According to the image, the matter nature uses to make subsidiary parts is second-best: presumably, it is the nutritious residue left over from the

[25] Οἱ δὲ νεφροὶ τοῖς ἔχουσιν οὐκ ἐξ ἀνάγκης, ἀλλὰ τοῦ εὖ καὶ καλῶς ἕνεκεν ὑπάρχουσιν· τῆς γὰρ περιττώσεως χάριν τῆς εἰς τὴν κύστιν ἀθροιζομένης εἰσὶ κατὰ τὴν ἰδίαν φύσιν, ἐν ὅσοις πλεῖον ὑπόστημα γίνεται τὸ τοιοῦτον, ὅπως βέλτιον ἀποδιδῷ ἡ κύστις τὸ αὑτῆς ἔργον.

[26] Similarly, Aristotle describes the presence of limbs as being "*not* among the necessities of life" (*PA* III.4, 665b21–27; 25–26: οὐκ ἔστι τῶν πρὸς τὸ ζῆν ἀναγκαίων), on account of the fact that animals continue to live after a limb is taken away or has been added; technically speaking, limbs are not part of "the necessary body" (*PA* III.4, 665b23: τοῦ ἀναγκαίου σώματος).

foodstuffs concocted for the formation of the vital and essential parts (cf. *GA* II.6, 744b26–745a1). However, since these parts are not themselves a necessary prerequisite for the performance of a necessary function, it seems that their coming to be cannot be conditionally necessitated by an internal potential for form, and is therefore not a case of primary teleology. Instead, Aristotle suggests (in *GA* II.6, 744b16–17) that it is the presence of residues that allows nature to *use* these extra materials to make parts that are serviceable to the animal's well-being.

This causal pattern of nature "using" as opposed to "making" features is especially clear in Aristotle's (otherwise puzzling) discussion of the female menses, which are said to come to be of material necessity and are then used by nature "for the better" (*GA* II.4, 738a33–b5):

> Thus the coming to be of this residue [i.e., the menses] among females is the result of necessity (ἐξ ἀνάγκης) because of the causes mentioned. Because her nature is not capable of concoction, it is necessary that residue must come to be, not only from the useless nourishment, but also in the blood vessels, and that they must overflow, when there is a full complement of [this residue, i.e., the menses] in those very fine blood vessels. And nature uses it for the sake of the better and the end for this place, for generation (ἕνεκα δὲ τοῦ βελτίονος καὶ τοῦ τέλους ἡ φύσις καταχρῆται πρὸς τὸν τόπον τοῦτον τῆς γενέσεως χάριν), in order that it may become another creature of the same kind as it would have become. For, even as it is, it is in potentiality the same in character as the body of which it is the secretion. In all females, then, residue necessarily comes to be.

Even though the presence of female menses is necessary for reproduction, Aristotle treats these menses as subsidiary parts, perhaps because they play no *active* role in reproduction and only play a role in reproduction *on occasion*.[27] The menses are not conditionally necessitated for this purpose, but come to be of material necessity. Only because they have the right material potentials (i.e., they are potentially the body from which they are secreted), nature uses them for reproduction at those times when there is also male sperma available in the womb. I shall return to this mode

[27] I borrow this argument from Lennox (2001b, 186–187), who uses it to explain why Aristotle insists on calling the menses residues. The following considerations may also have played a role in Aristotle's depiction of menses as subsidiary rather than as vital or essential parts: (i) menses, as does male sperma, come to be later in life during puberty, and are thus not formed in the first generation of parts; (ii) the coming to be of the menses correlates strongly with the availability of food and the amount of exercise one performs, which suggests that they are "leftovers," rather than structural features of the body; and (iii) even though the menses are necessary for reproduction, their presence is not required all the time (as, for instance, the presence of the heart is) and they are not always used for this purpose; in fact, for the most part, they are not used for reproduction but are secreted from the female body.

of explanation, and Aristotle's comments on it in *De Partibus Animalium* book I, after my discussion of the luxury parts and secondary teleology.

"Luxury parts"

The presence of animals in the image of nature as a good housekeeper, which receive the worst of food (presumably the residues from the growth-conducive food as described in *GA* II.6, 745a1–4), suggests that there exists a second kind of subsidiary part. I believe that these parts are neither immediately necessary nor contribute to the performance of necessary vital or essential functions. Their presence rather contributes to the well-being of animals in some other way. For lack of a better term, I shall refer to these parts as "luxury parts."[28]

This distinction between two kinds of subsidiary parts is not explicit in the final section of the image (*GA* II.6, 744b24–27). There Aristotle mentions bones, sinews, hair, nails, hoofs, "and all similar parts" as all being examples of parts that are made from residues. However, in the discussion that follows Aristotle separates this group into two: while bones and sinews are formed from the same material, namely the spermatic and nutritious residue, parts like nails, hairs, hoofs, horns, beaks, the spurs of birds, etc. are made from "the nutriment that is taken in later and that is concerned with growth, which is acquired from the mother and from the outer world" (*GA* II.6, 745a3: ἐκ τῆς ἐπικτήτου τροφῆς καὶ τῆς αὐξητικῆς, ἥν τε παρὰ τοῦ θήλεος ἐπικτᾶται καὶ [τῆς] θύραθεν). From this I conclude that the "luxury parts" are made from the residue of nutriment concocted for the sake of the sustenance of parts performing necessary functions, which have already fully developed before the animal's birth (i.e., they are fully developed in the sense of being complete; they may still grow in size).[29] Since there will be a continuous supply of this kind of nutriment and hence of residues thereof throughout the animal's life (their coming to be strongly correlates with the changes in supply due to aging), it is a distinctive feature of these parts that they can come into being *after the birth* of the animal, and often can keep on growing (*GA* II.6, 745a4–19).

[28] Note that Sorabji (1980, 157–158) uses the term "luxurious" with regard to all non-necessary parts, while I use it in a more restricted manner to refer only to those parts that are not immediately necessary for the performance of functions that are specified in the definition of the substantial being of the animal, and that do not contribute to their performance.

[29] Cf. *PA* II.2, 647b27–28; *PA* II.7, 653b10–18; *PA* II.9, 655a23–27; *PA* III.2, 663b28–35; *PA* III.8, 671a1–6; *PA* IV.10, 690a6–9; *GA* I.18, 724b22–725a5; *GA* II.6, 744b12–27; and *GA* II.7, 757a21–6.

From Aristotle's discussion of these parts in *De Partibus Animalium*[30] we learn that they share two more distinctive features. First, since all these parts are earthy and uniform, Aristotle calls them "tool-like": they have to be moved "from the outside" and are therefore only produced in animals that are able (and strong enough) to use them, which is why parts such as stings, spurs, horns, and tusks are often present in males, but absent in females.[31] Their earthy and uniform nature also explains why these parts can only perform simple functions (*PA* II.1, 646b10–25) and why there is no sensation in them (*DA* III.13, 435a11–435b4). Second, most of these parts serve the function of protection, defense, or coverage: a function that is not listed among the typical functions of the soul in Aristotle's *De Anima*. Perhaps, given that for Aristotle species are eternal, and that nature, as a good housekeeper, provides food for each kind of animal, protection and defense are not strictly necessary functions to be performed by the animal in order to survive or to reproduce. Presumably, then, there is no internal potential for form that is realized through the coming to be of these defensive parts. Luxury parts are parts *actual* animals can – at least temporarily – do without.

The causal pattern underlying the production of luxury parts, which is identical to that of the subsidiary parts, is outlined in the image: Aristotle explains that nature is not in the habit of throwing away residues if it is possible to make something useful from them (*GA* II.6, 744b16–17) – an image that is reflected in the actual explanations provided in *De Partibus Animalium*. Take the example of horns. After having explained that horns

[30] *PA* III.2, 663b31–35: teeth, tusks, and horns in the four-footed animals; *PA* IV.10, 687b22–24 and *PA* IV.10, 690a4–9: nails and hoofs; *PA* IV.12, 694a22–27: hard and large beaks, and spurs or claws in birds; *PA* II.14, 658b3–5: hair in human beings; *PA* IV.5, 679a28–30: ink in sepia. Cf. also *GA* V.1, 778a29–35. Aristotle's inclusion of beaks (ῥύγχη) in his second list of subsidiary parts is puzzling, since one would expect beaks to be essential parts of birds. In *PA* IV.12, 694a22–27, Aristotle suggests that it is the *differentiation* of beaks that is the result of nature using extra materials, rather than the presence of beaks themselves, which might be a more accurate characterization. In *HA* IX.32, 619a16–18, he mentions a kind of eagle whose beak keeps growing, ultimately causing the bird to die of starvation, which might imply that in their growing potential and earthy constitution, (some) beaks are similar to hair, nails, teeth, etc.

[31] *PA* III.1, 661b28–662a2:

> Of the tool-like parts that are for strength and protection, nature provides each of them only or more to those animals that are able to use them, and especially to the animals able to use them most – parts such as sting, spur, horns, tusks, and any other such part there may be. And since the male is stronger and more spirited, in some cases he alone has such parts, in other cases he has them more [than the female]. For as many parts for which it is necessary that the females have them as well (ὅσα μὲν γὰρ ἀναγκαῖον καὶ τοῖς θήλεσιν ἔχειν), e.g., parts related to nourishment, they have, but they have them less; while *those related to none of the necessities* (ὅσα δὲ πρὸς μηδὲν τῶν ἀναγκαίων), they do not have. It is also on account of this that among deer, males have horns, while the females do not.

are *present* for the sake of self-defense and attack, Aristotle explains their *coming to be* as a case of the formal nature using what is present of necessity (*PA* III.2, 663b21–22): "We must say what the character of the necessary nature is, and how nature according to the account has made use of things present of necessity for the sake of something."[32] Horns are made in larger animals from the surplus of earthen material that has come to be of necessity, which is then used by the formal nature (i.e., "the nature according to the account") of those animals to make defensive parts, *because* of the kind of material potentials the available material has (*PA* III.2, 663b25–35). Aristotle does not refer to a potential for form that would have been realized by the coming to be of horns, but instead points to the kind of potentials the residues happen to have that are used for the production of horns: because those materials are hard they have a potential for defense, and this makes them suitable for the production of defensive parts.[33]

In many cases, the materials that have come to be "of necessity" will be the result of material processes (see, e.g., *PA* III.10, 673a32–b1; *PA* IV.3, 677b22–29; and *PA* IV.4, 678a3–10), which themselves take place in an animal body of conditional necessity for the sake of sustaining the parts performing necessary functions. However, these material processes lead *incidentally* to the generation of residues (which are thus technically speaking not conditionally necessitated for the sake of realizing some preexisting internal form), some of which[34] are then used by nature for (*pros* or *charin*) something – a purpose which is usually picked out in the second half of the explanation of the presence of parts such as these.

In a few cases, the materials – and sometimes even complete functional parts – are the result of material elements acting entirely of their own

[32] πῶς δὲ τῆς ἀναγκαίας φύσεως ἐχούσης τοῖς ὑπάρχουσιν ἐξ ἀνάγκης ἡ κατὰ τὸν λόγον φύσις ἕνεκά του κατακέχρηται, λέγωμεν.

[33] I take this to be the meaning of *PA* II.9, 655b2–12:

> Close to bone according to the sense of touch are also such parts as claws, solid hoofs, split hoofs, horns, and the beaks of birds. All these [parts] animals have for protection; for the whole [parts] constituted from these [uniform parts] and the ones synonymous with those parts, for instance the whole hoof and whole horn, have been constructed with a view to the safety of each of these animals . . . Of necessity all of these parts have an earthen and hard nature; *for this potential is of the defensive kind* (ὅπλου γὰρ αὕτη δύναμις).

[34] Cf. *PA* IV.2, 677a15–18:

> Sometimes nature makes use even of residues for some benefit (κατάχρηται μὲν οὖν ἐνίοτε ἡ φύσις εἰς τὸ ὠφέλιμον καὶ τοῖς περιττώμασιν), yet one should not on this account search for what something is for in every case; on the contrary, when certain things are such as they are, many other such things happen from necessity because of these (ἀλλά τινων ὄντων τοιούτων ἕτερα ἐξ ἀνάγκης συμβαίνει διὰ ταῦτα πολλά).

accord. This is, for instance, how eyebrows and eyelashes come to be (*PA* II.15, 658b14–25):

> The eyebrows and eyelashes are both for protection . . . The eyelids are at the ends of small blood vessels; for where the skin terminates, the small blood vessels also reach their limit. So because the moist secretions oozing are bodily, it is necessary that – unless some function of nature stops it with a view to another use – even owing to a cause such as this, hair from necessity comes to be in these locations.[35]

Eyebrows and eyelashes come to be of material necessity and because the formal nature did not *stop*[36] the flow of materials in order to use it for something else. Their presence is for (*charin*) protection – a function they seem to be able to perform due to the material potentials and the structure they have of necessity (cf. also Aristotle's account of the omentum, a fatty membrane covering the stomach and the intestines, in *PA* IV.3, 677b22–32 and my discussion of this example in section 4.3).

In short, both subsidiary and luxury parts *come to be* of material necessity, but are *present* for a function. The formal natures of animals make use of the extra materials, and it is this use that determines the function of these parts and that explains why the materials are still present. The process is teleological, because the goal-directed actions of the formal nature determine the ultimate use that is being made of the residues, but these uses are not realizations of a preexisting potential for form; rather, they "emerge" from the kind of potentials the available materials happen to have. In addition, these subsidiary and luxury parts are not strictly speaking necessary for the execution of necessary functions, but they may contribute to their performance, or allow the animal to perform a non-necessary function. In either case, the parts contribute to the well-being or the living well of the animal, rather than to its mere existence or living.

[35] Αἱ δ' ὀφρύες καὶ αἱ βλεφαρίδες ἀμφότεραι βοηθείας χάριν εἰσίν . . . αἱ δὲ βλεφαρίδες ἐπὶ πέρατι φλεβίων· ᾗ γὰρ τὸ δέρμα περαίνει, καὶ τὰ φλέβια πέρας ἔχει τοῦ μήκους. Ὥστ' ἀναγκαῖον διὰ τὴν ἀπιοῦσαν ἰκμάδα σωματικὴν οὖσαν, ἂν μή τι τῆς φύσεως ἔργον ἐμποδίσῃ πρὸς ἄλλην χρῆσιν, καὶ διὰ τὴν τοιαύτην αἰτίαν ἐξ ἀνάγκης ἐν τοῖς τόποις τούτοις γίνεσθαι τρίχας.

[36] Lennox (2001a, 192; 2001b, 42) translates this section as "unless some function of nature *redirects* it to another use" (emphasis is mine) and concludes (in 2001a, 192) that the necessity involved must be conditional. However, nature is not doing anything yet, but may *stop* the flow with a view to another use; this suggests that the operation of necessity cannot simply be a case of conditional necessity and primary teleology. For similar examples of the formal nature of an animal refraining from taking action in the formation of parts that seems to take place of material necessity, see *GA* I.8, 718b16–28 and *GA* I.11, 719a14–15.

Secondary teleology

Summing up, the causal processes responsible for the coming to be and presence of both kinds of subsidiary parts are teleological in Aristotle's view – since all parts are *present* for the function they perform, but they are not so without qualification. The formal nature of the animal assigns a function to (1) a flow of materials or (2) a part, but only *after* this material or even the whole part has already come into being as a result of material necessity. In the first case, nature actively *uses* materials that have come to be of material necessity for the formation of parts by redirecting, distributing, or organizing these materials, instead of throwing them away (see, e.g., *PA* II.9, 655a26–28; *PA* III.2, 664a1–3; *PA* IV.12, 694a28–694b1; *GA* III.1, 749b27–750a4). In the second case, nature passively "co-opts" entire parts that have come to be solely of material necessity. It does so simply by not intervening in the materially necessitated process, because their coming to be will be useful for the animal (see, e.g., *PA* II.15, 658b14–25 and *PA* IV.3, 677b22–32).[37] In neither case does the function the part ends up performing conditionally necessitate its coming into being, even though that function does explain why it is present (for it explains why the formal nature of the animal retained the materials) and is thus a necessary part of our knowledge of it (see *PA* II.9, 655b15–20).

Additionally, Aristotle oftentimes seems reluctant to say that these parts are *for the sake of something* (*heneka tinos*) in the more technical sense, and rather speaks in terms of something being "for" (*pros*, *charin*, *eis* or *epi*) some function.[38] Both Aristotle's cautious use of teleological language and his references to material necessity as a cause of coming to be suggest that the teleology involved is "secondary," rather than primary. While primary

[37] Devin Henry argues (in personal correspondence) that the second case, in which formal natures passively co-opt materially necessitated parts, constitutes in fact a tertiary kind of teleology, where both the matter and the actual formation of the part occur through material necessity alone and where there is therefore no sense in which that part can be said to have come to be for the sake of an end. However, Aristotle's explanations do not reflect this extra distinction. The primary distinction Aristotle draws is between (1) parts that both come to be and are present for the sake of something and (2) parts that come to be of material necessity but are present for something. The latter category also includes parts such as eyebrows and the omentum (see *PA* IV.3, 677b22–32), in which there appears to be no active role at all for formal natures in the coming to be. Even though their coming to be is thus not for the sake of something, Aristotle believes that their presence still is, for it is the goal-directed formal nature that has "allowed" the materially necessary processes to take place in the first place. Additionally, even where a formal nature actively uses materials that have come to be of material necessity, Aristotle will not say that those parts have *come to be* for the sake of something, but only that they are *present* for something. The distinction between the two types of explanation thus indicates whether a part is conditionally necessitated for the performance of a vital or essential function, or whether it is the result of nature using extra materials for a good purpose.

[38] Cf. Lennox (2001b, 291).

teleology only pertains to individual formal natures and the realization of their own form, I suggested in Chapter 1 that secondary teleology applies both to the interaction within an animal between its formal and material natures (in which the former "uses" what has been produced by the latter for something good), and to the so-called "inter-species" teleology, where living beings use what is available to them for their own benefit.

If my interpretation is right, then the material nature of an animal has a much larger and more positive influence on the generation of animals and their parts than is usually attributed to it: the material nature does not merely constrain the realizations of parts necessary for the animal's life or being;[39] it also creates possibilities for the formal nature of the animal to make additional, "non-necessary," subsidiary and luxury parts that will contribute to the animal's well-being or even produces parts independently of the actions of the formal nature, which allows these parts to grow. While primary teleological processes thus guarantee life and identity to a living being, I believe that secondary teleology is responsible for the living being's quality of life and its well-being.

In *PA* I.1, Aristotle refers to the modes of teleological explanation that pick out secondary teleology right after his example of the primary mode of explanation that picks out primary teleology discussed above (*PA* I.1, 640a33–35). If it is not possible to explain the parts an animal has as the necessary conditions of some animal being the kind of animal it is, then Aristotle believes we should rely on an alternative mode of explanation (*PA* I.1, 640a35–b4):

> If one cannot [say this], [one should say] the nearest thing, namely that it is thus either in general (because it cannot be otherwise), or that it is in a good way thus. And these things follow. And since it is such, its generation necessarily happens in this way and is such as it is. This is why this one of the parts comes to be first, then that one. And similarly in this way with regard to all things that are constituted by nature.[40]

I take this elliptical passage to mean that in cases where it is not possible to say that a particular animal cannot be without certain parts because either (i) the function that part performs is not part of the definition of the substantial being of the animal; or (ii) the part is not necessary for

[39] On this "constraining" role of material necessity in the generation of animals, see Lennox (2001a, 182–204).

[40] Εἰ δὲ μή, ὅτι ἐγγύτατα τούτου, καὶ ἢ ὅλως (ὅτι ἀδύνατον ἄλλως) ἢ καλῶς γε οὕτως. Ταῦτα δ' ἕπεται. Ἐπεὶ δ' ἐστὶ τοιοῦτον, τὴν γένεσιν ὠδὶ καὶ τοιαύτην συμβαίνειν ἀναγκαῖον. Διὸ γίνεται πρῶτον τῶν μορίων τόδε, εἶτα τόδε. Καὶ τοῦτον δὴ τὸν τρόπον ὁμοίως ἐπὶ πάντων τῶν φύσει συνισταμένων.

the performance of a necessary function, the explanations (as presented in *PA* I.1, 640a35–b1) will have to refer to material necessity and/or the good. The "good" indicates that the feature contributes to the well-being of the animal and hence refers to a subsidiary or luxury function.[41] As Aristotle points out next, the alternative type of explanation applies to parts that are formed at later stages in the development of the animal. The parts that are necessary for the performance of necessary functions are first in the order of generation (the phrase starting with "since it is such . . . " in *PA* I.1, 640b1–2 refers back to parts that are necessary for an animal on account of its essence; the parts that come to be first are these necessary parts). The parts that contribute to the performance of necessary functions, or whose functions are not necessary but do contribute to the well-being of the animal (and are therefore good) come to be next.

The expression "and these things follow" could refer to a third mode of explanation in which references to teleology are completely absent.[42] This type of explanation pertains to parts such as the spleen, residues, and some of the animal's affections (such as possibly eye color or pitch of voice in some kinds of animals; see *GA* V.1, 778a18–21) which do not perform any function of their own, or contribute to the function of any other part, and come to be entirely as a result of materially necessitated processes that take place during generation (see, e.g., *PA* III.7, 669b27–670a32 and *PA* IV.2, 677a15–18). The coming to be of this third type of part "follows" from the animal's material nature.

In sum, Aristotle introduces three general modes of explanation in *De Partibus Animalium* book I: explanations that pick out primary teleology; explanations that pick out secondary teleology; and, finally, explanations that pick out purely material necessity. I shall return to these three modes of

[41] I take the necessity and the good mentioned here to refer to the causes of why an animal has certain parts (i.e., as referring back to "on account of that it has these parts" in *PA* I.1, 640a34), and not to the relation between the part and the animal as such, as Code (1997, 139–142) believes. Code distinguishes three types of parts: (i) those that follow from the definition of the animal; (ii) those that are necessary, but do not follow from the definition; (iii) those that are not necessary, but are present in the animal because it is good. Under this scheme, the second category only comprises parts such as the spleen (in fact, it is the only part Code mentions as an example), which seems unlikely. The spleen is an exceptional case in Aristotle's biology (see *PA* III.6, 669b25–31 and *PA* III.7, 670a31–32): it does not have a proper function; it is present for the sake of symmetry; it comes to be of material necessity; and the relation between the spleen and the animals that have it is accidental. I also disagree with Gotthelf (1987, 189), who takes the second category to refer to those parts that are "necessary given an essential function because it makes some necessary contribution to the performance of that function." For Aristotle contributory parts are never necessary (cf. *PA* III.7, 670b23–27); if they were, such parts could never be absent, and observation shows that they sometimes are (*GA* I.4, 717a11–21).

[42] See Lennox (2001b, 135) for an overview of possible interpretations.

explanation and their application in *De Partibus Animalium* books II–IV in section 4.2.

3.3 "NECESSITY IS SPOKEN OF IN MANY WAYS"

The problem of necessity

The positive role I have attributed to material necessity in natural generation needs further argumentation, since many scholars believe that Aristotle's own discussions of the relation between teleology and necessity (in *APo* II.11, 94b27–95a3; *Ph* II.8, 198b10–199a7; *Ph* II.9, 199b34–200b11; *GC* II.11, 337a35–338b19; *PA* I.1, 639a1–642b4, and *Meta* I.3, 983a24–984b22) deny such an independent role of material necessity in the sublunary natural realm. These scholars argue that, because Aristotle denies that there is any *unqualified* necessity in the sublunary natural realm, ultimately references to *material* necessity in biological explanations need to be subsumed under, if not reduced to, the operation of *conditional* necessity.[43] Building instead on Kupreeva's analysis of necessity in Aristotle,[44] I shall here argue that this view rests upon confusions about the ways in which Aristotle uses the different concepts of necessity.

In particular, I believe that scholars have mistakenly taken Aristotle to be talking uniformly about the nature of *causality* that governs natural processes in his discussions of teleology and necessity, while in fact (or at least so I shall argue) he is often rather concerned with the nature of *causal inferences* and with the necessity that obtains between cause and effect in causal sequences (i.e., with whether cause and effect follow each other always and necessarily, or rather for the most part and contingently). In addition, it appears that in some cases they have wrongly identified Aristotle's notion of material necessity with his notion of unqualified necessity.[45]

The crux for a better understanding of Aristotle's use of the different notions of necessity lies in what Kupreeva calls a difference between a "causal use" and a "modal use" of necessity.[46] Usually, and especially when

[43] Cooper (1987, 255–259); Lennox (2001a, 36n.38); Lennox (2001b, 233): "A single explanandum is explained both as necessary and for the sake of protection. The necessity is presumably conditional, but Aristotle does not make this obvious." My account is most congenial to that of Gill (1997, 146–147).

[44] Kupreeva (forthcoming).

[45] For the identification of material necessity with unqualified necessity, see for instance Cooper (1987, 259–60 (also 260n.20), 266); Gill (1997, 147 (also 147n.6)); and Johnson (2005, 154–155, 191).

[46] A third use of necessity – which will not be discussed further in this chapter – refers to the notion of logical implication or consequence, characterizing the conclusion of an account; see, e.g., *PA* III.4, 666a16–19; 31–33.

discussing the types of cause that are operative in nature, Aristotle refers to necessity to indicate a particular type of causality. This is the causal use of necessity: it refers to the necessity of materials acting according to their own material nature in a way that is either dependent on or independent of some preexisting internal potential for form that needs to be realized (i.e., conditional versus material necessity). For instance, in *Ph* II.9, 199b34–200a15, Aristotle explicates how necessity operates in natural things[47] that are for the sake of something and concludes, without rejecting the necessity of material natures altogether, that in natural generation the necessity that is operative is not unqualified material necessity as his predecessors had thought, but rather conditional necessity (*Ph* II.9, 200a13: ἐξ ὑποθέσεως δὴ τὸ ἀναγκαῖον).

In other contexts, however, and in particular when discussing the type of demonstration required in the natural sciences as opposed to that required in the other theoretical sciences dealing with eternal objects (such as in *PA* I.1, 639b29–640a9, *Ph* II.9, 200a15–22, and *GC* II.11, 337b14–25), Aristotle uses necessity to refer to a particular type of modal relationship that holds between two either consecutive or simultaneous states of affairs in a continuous causal sequence. This is what Kupreeva calls the modal use of necessity:[48] it pertains to the question of whether a cause necessitates its effect always, or only for the most part (i.e., unqualified necessity versus material or conditional necessity). For instance, suppose that ice is the solidification of water due to a complete cessation of heat (for the example, see *APo* II.12, 95a16–21). In order to provide the appropriate form of demonstration, Aristotle wonders whether, whenever there is a complete cessation of heat, we can be sure that there will always be, without exception, the solidification of water (for Aristotle, the complete cessation of heat and the solidification of water are simultaneous processes). In other words: is the relation between "complete cessation of heat" and "solidification of water" necessary in an unqualified or in a qualified way? If the relation is one of unqualified necessity, we can infer the presence of the effect from the current presence of the cause (for the cause will always, without exception, necessitate its effect). If the relation is one of necessity *in a qualified way* (i.e., either material or conditional), then we cannot

[47] Cf. *Ph* II.8, 198b11–12: ἔπειτα περὶ τοῦ ἀναγκαίου, πῶς ἔχει ἐν τοῖς φυσικοῖς. See Cooper (1987, 262).

[48] Note that Kupreeva's observation that Aristotle sometimes *uses* (his familiar notions of) necessity in a *modal way* (i.e., in order to identify the type of necessity that obtains between cause and effect in causal sequences) does not require us to attribute a (contemporary) notion of "modal necessity" to Aristotle, which is a move I would resist.

draw any causal inferences from cause to effect (for it is not absolutely necessary that when the cause occurs, the effect occurs as well), but only from effect to cause (given that the effect has occurred, it is absolutely necessary that the cause has occurred as well). Aristotle is interested in the nature of the relation between cause and effect, because it determines what kind of causal inferences we can draw about different causal sequences, and these inferences play a role in his theory of scientific demonstration (see especially *APo* II.11–12, discussed in Chapter 6).

What Aristotle denies, then, when he claims in *PA* I.1 or *GC* II.11 that there is no unqualified necessity in the sublunary natural realm, is that causes in this realm are ever sufficient for their effects. This means that we can never draw any causal inferences from cause to effect about non-cyclical sublunary natural phenomena, and that our demonstrations will have to start from effects, rather than from causes.

Let me further clarify these distinctions between causal and modal uses of necessity below.

Three types of necessity: material, conditional, and unqualified

Since it is not possible to present a discussion of all the relevant texts here, I shall instead offer an overview of the three main types of necessity that Aristotle distinguishes in his natural treatises and apply this analysis to key passages in *PA* I.1, the text that is most relevant for the understanding of Aristotle's theory of explanation in biology.

First, Aristotle uses "necessity" *simpliciter* (or more specifically, the expression "of necessity," *ex anagkês*) for the most part to refer to the causal process of coming to be in which some outcomes are necessary, given the *material natures* of the things involved in that process. This is the type of necessity that is known in the scholarly literature as "material necessity." Aristotle uses this expression to refer either to a certain type of causality (in opposition, for instance, to final causality) or to a certain type of causal chain. That is, within a materially necessitated causal sequence in which the cause (e.g., a complete cessation of heat in water) is responsible for the (here, simultaneous) coming to be of the effect (e.g., the formation of ice), the expression "of necessity" signifies that it is the material nature of the subject (e.g., water), that – in the sublunary realm, for the most part – necessitates the coming to be of the effect (e.g., given the material nature of water, a body of water will solidify due to complete cessation of heat). Because material necessity does not always necessitate its effects in the sublunary realm, the inference we can draw on the basis of the presence

of the cause in such rectilinear materially necessitated processes is that the effect will only come to be as well *for the most part*, but not that it always does.

Second, "conditional necessity" usually refers to the kind of causal necessitation involved in primary teleology, in which the things that come to be do so because they are necessary for the realization of an end, which is itself specified by the definition of the substantial being of something. When used in reference to a causal chain, it indicates that the coming to be of the prior event in that causal chain is conditional upon the necessity of the posterior, i.e., the effect and final cause, to come to be. The direction of necessity here works from the (prior) necessitating causes to the effect (i.e., from the possession of a form in potentiality to the realization of that form), although what chronologically comes to be last (i.e., the end that constitutes the final cause) is prior in explanation. In those cases where conditional necessity obtains, the coming to be or presence of the prior (e.g., a foundation) is necessary *only on the condition* that the posterior (e.g., a house) is to be realized. Inferences in these cases are one-directional: the coming to be or presence of the prior does not always necessitate the coming to be or presence of the posterior, and hence one can only draw the inference that if the posterior has come to be or is present, then necessarily the prior has also come to be or is present. In other words, the chronological end point of the causal chain provides the starting point for the inference to be used in a demonstration or explanation.

Finally, Aristotle mostly uses the expression "unqualified necessity" to refer to the "absolutely" necessary relation between the prior and the posterior in a consecutive causal sequence, in which the prior always, without exception, necessitates the posterior, because the occurrence of the posterior is necessary without qualification – the process of necessitation cannot be stopped by the interference of other factors. This allows for inferences from the prior to the posterior in those cases where unqualified necessity obtains (for instance, in mathematics, or in cyclical natural processes): if the prior (e.g., clouds) comes to be, then necessarily and without exception the posterior (e.g., rain) will come to be too. As we would say, the prior in these cases is both necessary and sufficient for the coming to be and presence of the posterior. In cyclical processes, the inference works in both directions, because the causal nexus is reciprocal.[49]

In some cases, Aristotle also uses the expression "unqualified" to indicate that the necessity responsible for some outcome does not presuppose and is

[49] Cf. Charles (1988, 14–17).

Table 3.2 *Causal and modal uses of necessity*

Necessity	Causal use	Modal use
Material	Outcomes are necessary, *given the material natures* of the things involved in that process; materials act according to their own natures.	Necessity between two items in a materially necessitated causal chain is qualified, because the cause necessitates its effect *for the most part*.
Conditional	The coming to be of antecedents is necessary, *given that the end is to come to be*; formal natures use materials acting according to their own natures for the realization of a preexisting internal potential for form.	Necessity between two items in a teleologically caused chain is qualified, because the antecedents necessitate the end that constitutes the final cause for the most part.
Unqualified	Equals material ("unconditional") necessity; materials act according to their own natures independently of ends that are to be realized.	Necessity between two items in an eternal/cyclical causal chain is unqualified, because the cause necessitates its effect always and without exception.

not dependent on the presence of a potential for form that is to be realized, and that in that sense the necessity involved is "simple" or "unconditional," as opposed to "conditional" (see for instance *Ph* II.9, 199b34–200a15). This use, however, is less prevalent than the modal one. Unqualified necessity, understood as a means of qualifying the necessity between two events in a causal chain, cannot as easily be identified with material necessity, which indicates primarily a type of causality. This is even more so, because most materially necessitated processes in the sublunary realm are rectilinear and allow for exceptions (the effect need not always come about), while unqualified necessity indicates that effect follows cause necessarily and always.

A fourth type of necessity, which I shall just mention here for the sake of completeness, is what Aristotle calls "enforced necessity," which causes things to behave against nature and inclination. Aristotle mentions it in *APo* II.11, 95a1–2 (ἡ δὲ βίᾳ ἡ παρὰ τὴν ὁρμήν), but the notion does not seem to play a major role in Aristotle's natural treatises. For a schematic outline of the three main uses of necessity,[50] see Table 3.2.

[50] It is unclear how exactly Aristotle's list of five types of necessity in *Meta* V.5 is supposed to map on to his treatment of necessity in the natural treatises; for suggestions, see Cooper (1987, 260n.20) and Gill (1997, 147n.6).

These distinctions between "causal" and "modal" uses of necessity, and between material and unqualified necessity, are important, for it is only unqualified necessity in a modal sense that Aristotle explicitly denies applies to rectilinear natural processes in the sublunary realm. Aristotle explains the difference between a conditionally necessary causal chain and an absolutely necessary causal chain in the following text (*GC* II.11, 337b14–25):

> If it is the case that the coming to be of something earlier is necessary if a later thing is to be, e.g., if a house, then foundations, and if that [i.e., foundations], then clay, does it follow that if there have come to be foundations, a house too must necessarily come to be? Or can we not yet say this, unless it is necessary without qualification that the latter itself come to be? If that is the case, then it is necessary that the house also comes to be when the foundation has come to be: for such was the relation of the earlier to the later, namely that if that one is to be, necessarily the other one will be first. If, accordingly, it is necessary for the later one to come to be, it is necessary also for the earlier one; and if the earlier one comes to be, it is accordingly necessary for the later one [to come to be too] – but not because of the earlier one, but because it was assumed that it was necessary that it would exist. So in those cases where it is necessary for the later one to exist, there is conversion, and it is always necessary, if the earlier has come to be, that the later should also come to be.[51]

The distinction is this: in the case of conditionally necessitated processes, of which house-building is a standard example (see *Meta* VII.17, 1041a23–30, *APo* II.12, 95b32–38, and *DA* I.1, 403b3–7), the coming to be of the prior (i.e., the foundations) is necessary *if* the posterior (i.e., the house) is to be, but it is not the case that once the prior has come to be, the posterior necessarily will come to be as well (i.e., the presence of foundations does not guarantee the presence of the house). Only if a process of coming to be is absolutely necessary – for instance, when we posit that the relationship between foundations and a house is necessary "without qualification" – would the causal inference "if there are foundations, the house will be as well" be valid. Aristotle explains that this kind of unqualified necessity only holds for things that are eternal and/or are subjected to eternal cyclical processes (such as the movement of the heavens, the evaporation cycle, and

[51] Εἰ δὴ τὸ πρότερον ἀνάγκη γενέσθαι, εἰ τὸ ὕστερον ἔσται, οἷον εἰ οἰκία, θεμέλιον, εἰ δὲ τοῦτο, πηλόν, ἆρ' οὖν καὶ εἰ θεμέλιος γέγονεν, ἀνάγκη οἰκίαν γενέσθαι; ἢ οὐκέτι, εἰ μὴ κἀκεῖνο ἀνάγκη γενέσθαι ἁπλῶς· εἰ δὲ τοῦτο, ἀνάγκη καὶ θεμελίου γενομένου γενέσθαι οἰκίαν· οὕτω γὰρ ἦν τὸ πρότερον ἔχον πρὸς τὸ ὕστερον, ὥστ' εἰ ἐκεῖνο ἔσται, ἀνάγκη ἐκεῖνο πρότερον. Εἰ τοίνυν ἀνάγκη γενέσθαι τὸ ὕστερον, καὶ τὸ πρότερον ἀνάγκη· καὶ εἰ τὸ πρότερον, καὶ τὸ ὕστερον τοίνυν ἀνάγκη, ἀλλ' οὐ δι' ἐκεῖνο, ἀλλ' ὅτι ὑπέκειτο ἐξ ἀνάγκης ἐσόμενον. Ἐν οἷς ἄρα τὸ ὕστερον ἀνάγκη εἶναι, ἐν τούτοις ἀντιστρέφει, καὶ ἀεὶ τοῦ προτέρου γενομένου ἀνάγκη γενέσθαι τὸ ὕστερον.

the cycle of air; see *GC* II.11, 337b30–338a18). In contrast, conditional necessity holds for the generation of animals, which is a sublunary natural process that is rectilinear and that concerns beings whose substances are perishable (*GC* II.11, 338b6–11; 338b9–11: "For it is not necessary if your father came to be, that you come to be, but if you came to be, then he came to be").

In short, in the sublunary realm, Aristotle says that we cannot simply draw inferences from the existence of the prior to the existence of the posterior – especially not if those inferences are to play a role in scientific demonstration. The difference between the two domains is that in the realm of the heavenly bodies, where all causal chains are eternal and cyclical, the prior always necessitates the posterior (i.e., sequences are necessary without qualification); while in the changing, sublunary realm the prior necessitates the posterior only for the most part (either by material or by conditional necessity). Aristotle needs to clarify these distinctions, because the validity of demonstrations – especially in the natural sciences – depends on the correct representation of the necessary relation between items in a causal sequence in those demonstrations.[52] The problem of the structure of demonstration in the natural sciences is central to Aristotle's discussion of teleology and necessity in *PA* I.1, to which I shall now turn.

Teleology, necessity, and demonstration in PA *I.1*

The discussion of demonstration in the natural sciences in *PA* I.1, and how it is different from demonstration in the other theoretical sciences (that deal with non-perishable substances), is itself part of a critique of the modes of explanation employed by Aristotle's predecessors, who attempted to trace back all their explanations to necessity (*PA* I.1, 639b21). The problem Aristotle finds with the materialist explanations of his predecessors, however, is not so much that this type of explanation is wrong, or that the type of causality picked out in these explanations has no independent role to play in the sublunary natural world, but rather that they had not made the right distinctions between the ways in which necessity in nature is spoken of (*PA* I.1, 639b22: οὐ διελόμενοι ποσαχῶς λέγεται τὸ ἀναγκαῖον).[53] Aristotle puts

[52] See Charles (1988, 7–8) and Leunissen (2010). For the idea that demonstrations of natural processes are to reflect the actual order of causation in the world, see *APo* II.11, 94b23–26; *APo* II.12 and *APo* II.16.

[53] Cf. Aristotle's criticism of Democritus and the natural philosophers in *PA* I.1, 641a5–8: "He spoke way too simply . . . So is also the way in which the natural philosophers speak of the generations and causes of configuration". According to Aristotle, Democritus thought that things are what they

forward two types of necessity that both pertain to natural beings: "unqualified necessity" and "conditional necessity" (*PA* I.1, 639b22–29):

> The [necessity] that is unqualified belongs to the eternal things, and the one that is conditional also belongs to all things that come to be (ὑπάρχει δὲ τὸ μὲν ἁπλῶς τοῖς ἀϊδίοις, τὸ δ' ἐξ ὑποθέσεως καὶ τοῖς ἐν γενέσει πᾶσιν), as well as to things produced, such as to a house and to any other such thing. For it is necessary that such material is present if there is to be a house or any other end: and it is necessary that first this comes to be and is changed, and next [that] that [comes to be and is changed], and so step by step up to the end and that for the sake of which each thing comes to be and is. It is the same way too for things that come to be by nature.

In this passage, Aristotle differentiates the domains of the natural world[54] according to the type of necessity that pertains to them, and thereby introduces a special type of necessity into the domain of generated natural beings. While unqualified necessity holds of the eternal, natural realm of the heavenly bodies, among the *generated* natural beings there is *also* a kind of necessity present, namely conditional necessity (this is what I take to be the most natural reading of the particle *kai* in *PA* I.1, 639b23). Aristotle then gives a characterization of conditional necessity in terms of the material that has to be present first, and the changes that have to take place, if some (natural or artificial) end is to be realized.

The aim of this passage is not to deny the existence of material necessity in the sublunary realm, but to introduce a special kind of necessity in that realm, which is conditional, and which involves a special form of causal inference. The same holds for Aristotle's claim in *PA* I.1, 642a1–7 that there is a *third* type of necessity present in things that partake of generation, thereby adding conditional necessity to the two types of

are in virtue of their configuration and color. Against this theory, Aristotle claims that although, for instance, a corpse has the same shape as a human being, we would not call a corpse a human being, except homonymously, because it cannot perform the functions that belongs to a human. The same holds for bronze or wooden hands, a drawing of a physician, or a flute made of stone: we do not call them a hand, a physician, or a flute, because they cannot perform their proper functions (*PA* I.1, 640b29–641a5). Aristotle thus stresses that what something is, is ultimately determined by the function(s) it performs. In Aristotle's view, Democritus' theory is not specific enough or is stated "too simply," because he failed to connect the notion of form to characteristic functions. The deficiency in the account of the natural philosophers is that they answer the question "By what powers is something crafted?" only in terms of the nature of the elements, but neglect to explain for the sake of what the elements move the way they do (*PA* I.1, 641a8–13). This is why Aristotle concludes that these natural philosophers "did not speak correctly" (*PA* I.1, 641a14).

[54] Pace Gotthelf (1987, 170–171), I believe that the contrast between the eternal and the generated is a contrast *within* the realm of the natural, and not between mathematics and the science of nature; this is clear from the introduction of the issue (*PA* I.1, 639b20: Τὸ δ' ἐξ ἀνάγκης οὐ πᾶσιν ὑπάρχει τοῖς κατὰ φύσιν ὁμοίως).

necessity introduced in *APo* II.11. 94b37–95a2,[55] which are "natural" or material necessity (*APo* II.11, 94b37–95a1: ἡ μὲν γὰρ κατὰ φύσιν καὶ τὴν ὁρμήν) and "enforced" necessity (*APo* II.11, 95a1–2: ἡ δὲ βίᾳ ἡ παρὰ τὴν ὁρμήν).[56] He does not exclude the presence of these other two types of necessity in nature,[57] nor does he reduce all necessity in nature to conditional necessity.[58] All Aristotle says here is that it must be this third type of necessity that is meant by "those who speak of 'from necessity.'"

Aristotle's explication of conditional necessity in *PA* I.1, 639b26–29, is important in this context, because it shifts the focus from causality to causal inferences: it specifies the causal sequence and the type of inference that belongs to (non-cyclical) generations of sublunary natural things. The "mistake" Aristotle's predecessors made is to have neglected the conditionality of necessity pertaining to all generated things, both natural and artificial. Thus, when giving explanations in terms of necessity with regard to (non-cyclical) *generated* natural things, one should not make the mistake of thinking that the necessity of the causal sequence is absolute (as is the case in eternal natural processes). That is, one should not think that the prior *necessitates without exception* the coming to be of the posterior, but rather acknowledge the fact that the prior is merely a necessary precondition of the posterior.

The distinction between the necessity involved in different kinds of causal sequences is relevant for the discussion of demonstration proper, to which Aristotle turns next (*PA* I.1, 639b29–640a9):

However, the mode of demonstration and of necessity is different in the natural and the theoretical sciences. These have been discussed elsewhere. For the starting

[55] Rather than the five different meanings of necessity discussed in *Meta* V.5, pace Charles (1988, 8–10) and Cooper (1987, 259n.19).

[56] Interestingly, Aristotle connects these two types of necessity with teleology in *APo* II.11, but without introducing his notion of conditional necessity yet. Aristotle provides two examples, illustrating how "it is possible for the same thing to be both for the sake of something and from necessity" (*APo* II.11, 94b27–28). Both examples concern phenomena (i.e., light shining through lanterns in *APo* II.11, 94b28–31, and thunder in *APo* II.11, 94b31–32) in which the necessity involved is material necessity (which is not conditional upon the end for the sake of which the phenomenon is said to occur), and in which the proclaimed purposes of the phenomena do not seem to be the *proper* ends or final causes of these phenomena. (I believe that these examples illustrate secondary teleology, in which a function or use is imposed by an external goal-directed agent on things that happen of material necessity.) At least in this context, Aristotle allows material necessity to operate independently and at the same time to serve some (secondary) purpose.

[57] Lennox's translations of this passage (2001b, 7: "but it is especially in things that . . ." and 2001a, 186: "but the third sort *is* present in those things which come to be") are misleading, as they suggest that the two types of necessity mentioned first do not exist in things that partake of generation. The Greek, on the other hand, does not exclude this possibility, but rather emphasizes that in things that partake of generation there is a *third* type of necessity.

[58] As Balme (1972, 76–84, 100; 1987c, 283–5) holds.

point is in some [i.e., the theoretical sciences] what is, but in others [i.e., the natural sciences] what will be. For: "since health or man is such, it is necessary that this is or comes to be," but not "since this is or has come to be, that of necessity is or will be." Nor is it possible to connect the necessity in such a demonstration to eternity, so as to say, "since this is, therefore that is." These matters too have been determined elsewhere, namely in what sorts of things [this kind of necessity] is present, what kind of processes convert, and for what cause.[59]

Demonstrations have to pick out the right kind of necessity: for most generated natural beings, causal sequences from the prior to the posterior can be interrupted (for the necessity is not connected to eternity), which is why one can only draw inferences from what has already come to be to its antecedent causes. The starting point for demonstrations in the natural sciences[60] is thus the posterior, or the realized end, from which its necessary antecedents can be deduced. The inference in natural demonstrations is one-directional from the end to the preconditions of the end, and the necessity to be picked out is thus conditional. For the objects of the theoretical sciences, where the necessity can be connected to eternity and where the sequences of causes convert, the inferences work also in the other direction: if this is, then that too will be.[61] For a demonstration to be valid, it has to capture the "direction" of the inference in the right way.

At the end of *PA* I.1, Aristotle offers an example of what such a demonstration in the natural sciences should look like (*PA* I.1, 642a32–642b2):

[59] Ἀλλ' ὁ τρόπος τῆς ἀποδείξεως καὶ τῆς ἀνάγκης ἕτερος ἐπί τε τῆς φυσικῆς καὶ τῶν θεωρητικῶν ἐπιστημῶν. Εἴρηται δ' ἐν ἑτέροις περὶ τούτων. Ἡ γὰρ ἀρχὴ τοῖς μὲν τὸ ὄν, τοῖς δὲ τὸ ἐσόμενον· ἐπεὶ γὰρ τοιόνδε ἐστὶν ἡ ὑγίεια ἢ ὁ ἄνθρωπος, ἀνάγκη τόδ' εἶναι ἢ γενέσθαι, ἀλλ' οὐκ ἐπεὶ τόδ' ἐστὶν ἢ γέγονεν, ἐκεῖνο ἐξ ἀνάγκης ἐστὶν ἢ ἔσται. Οὐδ' ἔστιν εἰς ἄἴδιον συναρτῆσαι τῆς τοιαύτης ἀποδείξεως τὴν ἀνάγκην, ὥστε εἰπεῖν, ἐπεὶ τόδε ἐστίν, ὅτι τόδε ἐστίν. Διώρισται δὲ καὶ περὶ τούτων ἐν ἑτέροις, καὶ ποίοις ὑπάρχει καὶ ποῖα ἀντιστρέφει καὶ διὰ τίν' αἰτίαν.

[60] Normally, Aristotle depicts natural science as being itself one of the theoretical sciences (see Lennox 2001b, 129; *Meta* VI.1, 1025b18–1026a23 and *PA* I.1, 641b11), and distinguishes the theoretical sciences from the practical and productive ones. In this passage, however, Aristotle singles out that part of the science of being that is concerned with *generated* things from that which is concerned with *eternal* things. I believe that this reading is most consistent with the preceding distinctions between the natural generated beings on the one hand and the eternal (natural) beings on the other. Natural science thus has to be understood in the narrow sense of the science that deals with natural beings whose substances are perishable. For alternative interpretations, see Lloyd (1996, 29), and Johnson (2005, 162–163).

[61] Cf. *Ph* II.9, 200a15–22, where Aristotle discusses the validity of inferences from the prior to the posterior (and the other way around) in causal sequences dealing with mathematical objects on the one hand, and natural, generated objects on the other hand. In some sense, inferences pertaining to mathematical objects are *similar* to inferences pertaining to natural, generated things: for in both cases, the causal sequence and the necessitation are linear and one-directional, and hence the inference works in one direction only. What is *different* in the two cases is that the starting point and the end point of the inference are reversed (this is also what the different uses in tense in this passage point to): in mathematics, the inference is from the prior to the posterior, while in natural generation the inference is from the posterior to the prior. See also Gotthelf (1987, 197–198).

One should give demonstrations in the following way: for example, breathing *exists* for the sake of this [i.e., cooling], while it [i.e., cooling] *comes to be* from necessity because of these. But "necessity" sometimes means that if this is to be "that for the sake of which" then these must be so [i.e., by conditional necessity]; but at other times it means that things are so in respect of their character and nature [i.e., by material necessity]. For it is necessary for the hot to go out and come in again upon meeting resistance, and for the air to flow in – that is already necessary. But because the heat meets internally with resistance, the reason for the entrance of the air from outside is in [for this use of ἐν compare *Ph* IV.3, 210a21] the cooling.[62]

In this example, Aristotle illustrates the structure of demonstrations in the natural sciences, but also, and perhaps more importantly, acknowledges explicitly the explanatory power of references to both conditional necessity and the type of necessity rooted in the material nature of elements. Breathing is for the sake of something, namely cooling, and an animal will have to be able to cool itself if it is to live (cf. *PA* III.6, 669a11–13); hence the organs for cooling come to be by conditional necessity. However, the circulation of air itself does not occur for the sake of something, nor is it conditional upon some end: it happens in accordance with and due to the element's natures and powers. As Aristotle puts it: the circulation of air is *already* (i.e., not conditionally, but materially) necessary (*PA* I.1, 642a36: ἤδη ἀναγκαῖόν), and can subsequently be used by the formal nature of an animal for a secondary purpose (such as voice: see *DA* II.8, 420b13–20). In sum, if Aristotle's own example[63] of an explanation of a natural phenomenon refers to both conditional and material necessity, we should expect his actual explanations to include references to material necessity as well.[64]

[62] Δεικτέον δ' οὕτως, οἷον ὅτι ἔστι μὲν ἡ ἀναπνοὴ τουδὶ χάριν, τοῦτο δὲ γίγνεται διὰ τάδε ἐξ ἀνάγκης. Ἡ δ' ἀνάγκη ὁτὲ μὲν σημαίνει ὅτι εἰ ἐκεῖνο ἔσται τὸ οὗ ἕνεκα, ταῦτα ἀνάγκη ἐστὶν ἔχειν, ὁτὲ δ' ὅτι ἔστιν οὕτως ἔχοντα καὶ πεφυκότα. Τὸ θερμὸν γὰρ ἀναγκαῖον ἐξιέναι καὶ πάλιν εἰσιέναι ἀντικροῦον, τὸν δ' ἀέρα εἰσρεῖν. Τοῦτο δ' ἤδη ἀναγκαῖόν ἐστιν. Τοῦ ἐντὸς δὲ θερμοῦ ἀντικόπτοντος, ἐν τῇ ψύξει τοῦ θύραθεν ἀέρος ἡ εἴσοδος. Cf. *PA* I.1, 642a13–15.

[63] However, as Lennox (2001b, 151) points out, this example does not exactly represent Aristotle's own account of the mechanics of breathing as he describes it in *Juv* 27, 480a25-b4. Of course, it is not uncommon for Aristotle to use examples that draw from common beliefs, rather than from his own theories (cf. Balme 1972, 101), but this does not mean that Aristotle is not committed to the general pattern of explanation – especially since he is giving an example of good practice. Bos and Ferwerda (2008; 189–196) suggest that the main subtext for Aristotle's example is Plato's account of respiration in *Ti* 78d and 79d: under this interpretation, Aristotle acknowledges the causal influence of material necessity in the process of respiration as described by Plato, but corrects him for having neglected teleology: ultimately, it is the function of cooling that explains why breathing takes place in animals.

[64] Cf. Cooper (1987, 257–258).

3.4 CONCLUSION

Building upon key passages in Aristotle's natural treatises, this chapter has outlined an interpretation of Aristotle's theory of teleological explanation in *De Partibus Animalium* book I that integrates both conditional and material necessity, and that lays out three basic modes of explanation for biological phenomena.

I have argued that in his explanations Aristotle picks out (roughly speaking) two types of teleology that go together with two types of necessity: primary teleology with conditional necessity, and secondary teleology with material necessity. Parts are always *present* in the animals that have them because of the function they perform, but their *coming to be* is due to either one of two different kinds of necessity in interaction with different kinds of actions performed by the formal nature of an animal. Sometimes nature conditionally necessitates the coming to be of the part's constitutive materials and generates that part; at other times it uses materials that are already available due to material necessity for something good, or simply lets materially necessitated processes take their own course in the formation of structures, because they are beneficial for that animal. All these processes are teleological, but not in the same way, and accordingly, explanations of biological phenomena will have to pick out either primary or secondary teleology. In a small number of cases, material necessity will cause the generation of non-functional features that are not discarded by the formal nature of an animal; explanations of these cases will therefore only pick out material necessity, constituting the third and final mode of explanation.

The integration of material necessity in secondary teleological explanations lends support to the view that Aristotle's theory of teleology was not developed for the sake of replacing the materialist explanations of his predecessors.[65] For Aristotle, material natures usually operate under the constraints of teleology, but not always, and not every feature of an animal is a realization of a preexisting internal potential for form. When Aristotle restricts unqualified necessity to the eternal realm of the heavenly bodies he does not thereby deny the existence of material necessity in the sublunary realm. He rather points out that in causal sequences that take place in the heavenly realm the prior always necessitates the coming to be of the posterior, because the coming to be of the posterior is necessary "without qualification." In the sublunary realm the posterior in a causal sequence is (unless the sequence is circular) never necessary "without qualification,"

[65] First put forward by Sauvé Meyer (1992, 794–795; 820–825).

whether it is necessitated by conditional necessity or by material necessity – a fact that has repercussions for the structure of demonstrations to be offered in the natural sciences.

The role of material necessity in the sublunary realm is therefore not confined to the negative part of constraining the realizations of ends in natural beings. It also has a more positive role to play, in that it provides extra possibilities – "extra" in the sense that the possibilities are not already given with the soul a certain kind of animal possesses – for the realization of features that may contribute to the animal's well-being. Nature does more than just provide the means for living – if possible, it also provides the means for living well.

CHAPTER 4

Explaining parts of animals: the practice of teleological explanation in the De Partibus Animalium *II–IV*

4.0 INTRODUCTION

This chapter investigates Aristotle's application of his theory of natural teleology in the actual explanations he provides in the biological treatises. My discussion draws mainly on the heuristics and explanations Aristotle displays in *De Partibus Animalium* II–IV, but I complement this account where appropriate or necessary with examples from the other biological treatises.

I shall first, in section 4.1, provide some introductory remarks about the organization of *De Partibus Animalium* books II–IV and Aristotle's basic heuristic strategies for the formulation of predominantly teleological explanations. In section 4.2, I turn to those cases in books II–IV where Aristotle's usual heuristic strategies prove insufficient and where he engages in a series of inferences building upon the postulation of a teleological principle, such as "nature does nothing in vain," before or while formulating the actual explanation. I argue that these principles are part of Aristotle's method of discovery and that they function predominantly as heuristic tools for the identification of causally relevant features when these are not immediately discernible. Note that I am *not* making the claim here that Aristotle's entire theory of natural teleology serves a heuristic function;[1] instead I suggest that his *use of teleological principles* is best characterized as serving such a function. I take it that the (final) causes these principles help discover are all non-eliminable features of the biological world, which are realized through the goal-directed actions of the formal natures of animals. Finally, in section 4.3, I present an overview of the basic patterns of explanation Aristotle uses in books II–IV to account for the presence, absence, and differentiations of animal parts and specify the causal and explanatory role of final causes therein.

[1] For this view, see Wieland (1975), Nussbaum (1978), and Sorabji (1980); for my realist interpretation of Aristotle's theory of natural teleology, see also Chapter 1.

Together these sections provide a comprehensive account of the structure, use, and explanatory force of teleological explanations in Aristotle's biology, both those that involve the application of teleological principles and those that refer immediately to final causes.

4.1 THE ORGANIZATION AND HEURISTIC METHODS OF *DE PARTIBUS ANIMALIUM* BOOKS II–IV

The project and organization of De Partibus Animalium *books II–IV*

The focus in *De Partibus Animalium* is, as the title of the treatise indicates, not on individual animal kinds, but rather on the distribution and configuration of their parts.[2] There are no entries on specific animal kinds, and instead of naming all the individual animal kinds with which a certain presence, absence, or differentiation of a part correlates, Aristotle refers to the cluster of *differentiae* that characterize the entire group of animals or to the name[3] of the widest class of animals that have the part. The precise extension of the correlation between features and the animals that have them is usually left open.[4] Species are only singled out when they exhibit unique differentiations or otherwise anomalous features (note that there are relatively few animal species that are mentioned by name in *De Partibus Animalium*).[5]

This focus on parts guides both the overall organization of *De Partibus Animalium* and the organization of the explanations themselves. Aristotle seems to follow two principles of exposition. First, following the teleological hierarchy between parts, he discusses – part by part – first the uniform parts, then the non-uniform parts. Second, the discussion of the non-uniform, external parts takes human physiology as a starting point (*PA* II.10, 656a9–14; cf. *HA* I.6, 491a19–26; for the internal parts Aristotle is forced to rely on analogies with animals close to human beings; see *HA* I.16, 494b19–24), and works from top to bottom: separating the blooded animals from the

[2] This does not mean that the animals to which the parts belong are unimportant: parts are only truly (and not merely homonymously) parts when they belong to a living being and are able to function for the sake of its life and well-being. Parts and their differentiations are explained first and foremost in terms of the functional contribution they make to the animal as a whole.

[3] Sometimes this class has no preexisting name, as is the case with "lung-possessors": *PA* III.6, 669b10–13 (669b10: ἀλλ' ἀνώνυμον τὸ κοινὸν ἐπ' αὐτῶν).

[4] Cf. Lennox (2001a, 70n.31).

[5] For instance, the Indian ass and the oryx are singled out for having only one horn, while the majority of animals with horns have two (*PA* III.2, 663a21–23). Cf. Balme (1987b, 88) on the famous case of the mole.

bloodless, Aristotle first covers all the parts located on or around the head, then the parts located around the heart, and finally the limbs.

The organization of *De Partibus Animalium* books II–IV runs as follows. Aristotle opens book II with an elaborate and general discussion of the *uniform* parts (*PA* II.1–9), focusing on their teleological relationships to other parts, their distinctions (based on whether they have soft, moist, dry or solid material potentials), their role in the animal's body, and their influence on the animal's character. He then moves on to a discussion of the *external, non-uniform* parts. First (in *PA* II.10-III.2), Aristotle discusses the non-uniform parts that are located on the *head* of blooded animals, such as the organs of sense perception, kinds of eye protection (eyelids, eyelashes, and eyebrows), and the mouth. Next (in *PA* III.3–VI.4), moving down from the neck, Aristotle turns to a discussion of all the *internal, non-uniform* parts located around the *heart*, such as the heart and blood vessels, lungs, liver, and other viscera. At this point, Aristotle moves to a discussion of the *external and internal non-uniform* parts of *bloodless* animals (mainly the crustaceans and insects; *PA* VI.5–9), limiting his discussion to the features that are different in the bloodless animals from the blooded ones. Having discussed the bloodless animals, Aristotle returns to his exposition of the *remaining external, non-uniform parts* of blooded animals (*PA* VI.9–13). Here Aristotle's organization of his discussion of parts is more intrinsically connected to the kinds of animals that have those parts: he first discusses the parts left unexplained in the live-bearing animals, then in the egg-laying animals, and finally in birds and fish. Aristotle ends his explanation of parts by a brief discussion of animals that dualize between two natures, such as dolphins, whales, seals, bats, and the Libyan ostrich (*PA* IV.13–14). At the end of his treatise, Aristotle sums up the general aims of his investigation in *De Partibus Animalium* and refers forward to the project recorded in *De Generatione Animalium* (*PA* IV.14, 697b26–29): "About the parts, then, the cause owing to which each is present in the animals has been stated, of each of the animals in turn; these things having been determined, the next step is to go through the facts about their generation."

Within this larger organizational structure, the actual explanations provided observe the following format:[6]

1. Identification of part P;
2. Identification of the widest kind of animals (A_{1-n}) to which P belongs;

[6] For explicit statements about Aristotle's explanatory project, see the references in Lennox (2001a, 5) and *PA* II.7, 653b9–18; *PA* III.4, 667b12–14; and *PA* IV.14, 697b27–30.

3. Explanation of why P belongs to each A that has P, by identifying the cause(s) of the coming to be and presence of P in A;
4. Explanation of why P is absent in those animals in which the presence of P could have been expected;
5. Identification of the differentiations of P (ΔP);
6. Identification of the widest kind of animals (B_{1-n}) to which ΔP belongs;
7. Explanation of why P is differentiated the way it is in each kind of animal that has P, by identifying the cause(s) of the differentiation of P (ΔP).

The investigation of why a certain part is absent (mentioned in the list above as item 4) is usually prompted by some form of comparative observation or analogical reasoning.[7] The question why snakes have no feet, for instance, is prompted by comparative observation: all blooded land-dwellers possess feet, except for snakes (which belong to this wider kind of blooded land-dwellers), and hence this absence needs to be explained. The investigation into the absence of outer ears in birds is prompted by analogical reasoning: all human beings and four-footed live-bearing and egg-laying animals have outer ears, and are blooded, just like birds. And given that birds do have auditory channels, it is reasonable to expect birds to have outer ears as well. In short, when an animal lacks a part that has been observed to be present among all the other kinds of animals that belong to the same wider class, or when an animal only possesses one of the two parts that are usually observed to be present together, this immediately leads to the question of why this particular animal lacks the part in question.

I shall discuss Aristotle's heuristics for the discovery of the causes of such "significant" absences in section 4.3; for the present purposes it will suffice to outline Aristotle's basic strategies for the formulation of explanations of the presence and differentiation of parts.

Aristotle's basic heuristic strategies

Aristotle is not usually very explicit about his methods for the discovery of the causally relevant features that are to be picked out in his explanations, but his remarks indicate that for the most part he relies on the following two strategies.

First, causally relevant features, and in particular functions, can usually be detected by visual inspection of the part in question.[8] This is because

[7] Cf. Lennox (2001a, 214).
[8] See also Bolton (1997, 118) on final causes being "better known to us."

a function is often simply the (regular and good or beneficial) "work" performed by a part when used. Aristotle frequently refers to observations in the presentation of his findings in the biological works: external parts are available for immediate perceptual scrutiny (see, e.g., *PA* II.8, 653b30–31; *PA* III.14, 674a12–13; *PA* IV.10, 689a20–21; cf. *HA* I.6, 491a23 and *GA* II.4, 740a5–6), whereas the causal features of internal parts can be revealed through dissections (see, e.g., *PA* IV.5, 679b35–680a3; *PA* II.7, 652b3–6; *PA* III.4, 667b10–13; *PA* III.5, 668b27–30; and *HA* I.17, 497a30–35).

Second, there are cases where the explanation of the presence of a part involves nothing more than to link it to one of the functions already specified in the definition of the animal's substantial being, and then exhibit it as a necessary prerequisite for the realization of that function. Once the full and real (as opposed to the nominal) definition of an animal has been established through division, the per se functions and the parts that are necessary for their realization follow from that definition. For instance, "animal" is defined by its perceptive capacity, and from this, Aristotle claims, it follows that it necessarily has a heart, the primary perceiver (*PA* III.4, 666a34–5), and flesh, the organ of touch, which is the primary mode of perception (*PA* II.8, 653b22–23). The causally relevant features in these cases (i.e., the form of the animal and the functions it specifies) are already known, and Aristotle only needs to identify which part performs the function in question.

The use of observations and definitions is complemented by either one of the following two "search strategies": Aristotle either specifies the widest class of animals to which a particular part belongs (thereby subsuming "lower" species under a "higher," more extensive kind; cf. *APo* II.13, 96a20–38), or attempts to identify the particular combination of *differentiae* that correlates with the presence of a part within a particular species.

(Note that these two patterns largely coincide with what Lennox labels A-type and B-type explanations.[9] Although I grant that my distinction is somewhat artificial, I prefer to treat these strategies primarily as heuristics and only secondarily as explanations, because in most cases they present an *intermediate* stage between the identification of explananda and the exposition of the ultimate and complete explanation. I do not wish to deny that this intermediate stage also carries some explanatory power and even constitutes an explanation – of the preliminary sort – in itself, but I believe that there is a deeper level of explanation possible that Aristotle is ultimately

[9] See Lennox (2001a, 7–38).

searching for and which cannot always be immediately identified with the application of these strategies as such.[10])

The first strategy, the identification of the widest class of animals that has a particular part, allows Aristotle to *unify* animals with a particular feature under the same form (or definition of their substantial being) or under the same material nature. The identification of the widest class thus helps to demarcate what formal or material features are shared by all the animals within this wider kind, and which are thus most likely to be the causally primary facts to be picked out in the full explanation. The class to be identified can consist of one of the "major genera" (i.e., live-bearing four-footers, egg-bearing four-footers, birds, fish, cetaceans, cephalopods, crustaceans, testaceans and insects; sometimes human beings also count as a separate genus), but also of one of the other classes (e.g., blooded or bloodless; terrestrial, aquatic, flying or stationary; or even "lunged" or "horn-bearing" animals).

Take, for instance, Aristotle's discussion of the viscera (in *PA* III.4, 665a27–31). From the outset Aristotle indicates that having viscera is distinctive of blooded animals (ἴδια τῶν ἐναίμων), while none of the bloodless animals have them (τῶν δ' ἀναίμων οὐδὲν ἔχει σπλάγχνον); the widest class to which viscera belong primitively is thus identified as the class of blooded animals. The presence of viscera in all the animals that have them correlates with the availability of the constitutive material of viscera, i.e., blood, in these animals (cf. *PA* II.1, 647a34–b9). Animals with viscera thus share the same material nature, which in turn is determined by the definition of the substantial being these animals have (*PA* IV.5, 678a31–35). It is this commonality in their form that ultimately explains why all and only those animals have viscera.

In the case of animals that "dualize,"[11] the identification of the two wider kinds to which these animals tend not only helps to find the causally primary fact that accounts for the presence of a part (e.g., in *PA* III.6, 668b32–669a14 the identification of dolphins and whales as breathers of air helps to explain the presence of lungs in these animals, which seems paradoxical for animals that do not dwell on land), but also reveals absences of parts that require explanation. In the latter case, Aristotle takes the two

[10] Cf. also Lennox (2001a, 67–8n.16) and Gotthelf (1997a, 94n.23).

[11] The expression in Greek is ἐπαμφοτερίζει τὴν φύσιν. Balme (1987b, 85–86) defines "dualizers" as animals that "tend to both sides of a division" and therefore escape precise grouping; they partake at the same time in both forms and in none of them (*PA* IV.13, 697b1–3): "because of tending towards both sides . . . on this account they partake of both and neither" (διὰ τὸ ἐπαμφοτερίζειν . . . διὰ τοῦτο ἀμφοτέρων τε μετέχουσι, καὶ οὐδετέρων).

widest classes to which an animal tends as a starting point, deduces what parts should be present if the animal were in fact a full member of both classes, and finally matches his "thought experiment" with the parts actually found in the animal under discussion. Without this search strategy, some explananda (such as the absences of both tails and buttocks in apes; see *PA* IV.10, 689b31–34)[12] would have escaped Aristotle's notice.

The second strategy is employed when a feature seems to belong to a particular animal kind in virtue of being the specific kind of animal it is. Aristotle then searches among the animal's *differentiae* in order to detect the one *differentia* or combination of *differentiae* that correlates with and therefore possibly accounts for this feature's presence. Note again that here the boundaries between "heuristic strategy" and "explanation" become somewhat fuzzy, because in many cases the identification of the correlating *differentia(e)* is the full explanation of the feature in question; in some cases, however, and especially when there are several *differentiae* involved, the explanation may not be complete until the causal hierarchy of the relevant *differentiae* has been established as well.

It is hard to find examples of the application of this strategy where the identification of the causally relevant *differentia* also immediately yields the explanation of the *presence* of a part;[13] the strategy seems mainly successful in discovering the causes of the *differentiations* of parts. Since differentiations for the most part serve the functional optimization of a part in the particular kind of animal that has it, these differentiations will be intimately connected to the animal's specific material or formal nature (see *PA* II.2, 648a13–19 and my discussion of this text in section 4.3 below), rather than to its generic nature.[14] For instance, whereas an elephant has a nose in virtue of being a breather of air (i.e., in virtue of being part of a wider kind that universally possesses noses as a necessary prerequisite for the performance of a necessary function), it has the *specific* nose it has in virtue of possessing a unique combination of *differentiae*, several of which turn out to be causally primary (namely being a land-dweller, a swamp-dweller, blooded, and having a large size; see *PA* II.16, 658b32–659a35).[15]

[12] For this example, see Lennox (1987a, 108). Cf. the case of seals and bats in *PA* IV.13, 697b1–13 and of the river crocodile in *PA* IV.11, 690b19–24.

[13] For an example of a "*mediated*" explanation of a presence of a part, see *PA* IV.10, 689b1–31: the discovery that having a tail correlates universally with being four-footed *points to* the causally basic fact that four-footers are dwarf-like and are hence in need of protection of their residual outlet, which is provided by the presence of tails.

[14] Lennox (2001b, 331) aptly speaks of "adaptation explanations" in this context.

[15] Elephants have *long* trunks because they need an organ that allows them to breathe air while being in the water looking for nourishment (being both swamp-dwellers and land-dwellers, elephants get their nourishment from the water, but because of their large size they can only move very slowly, and need an instrument to breathe while in the water). The special use that elephants make of

Being the specific kind of animal it is, the elephant needs to realize its vital function of breathing air in a specific way, and by making the nose long, nature enables the elephant to do this (i.e., the formal differentiation of this particular breather requires a functional differentiation of the nose, which is realized by adding length).

For the most part, these two strategies suffice for the generation of explanations. When they do not, Aristotle applies a third and alternative heuristic strategy: the use of teleological principles.

4.2 Aristotle's use of teleological principles as heuristic tools

The status of teleological principles as hypotheses in the natural sciences

Teleological principles, such as "nature does nothing in vain," consist of generalizations over the goal-directed actions of the formal nature (or soul) of an animal while engaged in animal generation. The principles stand out from other sentences describing the actions of the formal natures of animals by their appeal to the universality of the actions described: it is posited that in generating the animal and its parts, the formal nature (for instance) *always* does what is better or best, or *never* does what is in vain, and that these actions take place in contrast or in addition to what happens "of necessity."[16] The principles are thus causal characterizations of the actions of formal natures at the most general level possible. I take it that the different kinds of actions ascribed to these formal natures reflect the operations of different kinds of causality that typically obtain in the production of animals and their parts. Teleological principles are thus no mere metaphors; they all carry ontological force.

Although Aristotle does not tell us much about how he conceptualizes their role in the natural sciences, we are reasonably well informed about their scientific status.[17] There are two important passages in which Aristotle refers to these principles as "hypotheses" (or "suppositions"), while offering some additional insight into their scope and nature. The first passage

this trunk (i.e., they use it for grasping) is a case of secondary teleology, in which nature makes use of the trunk's softness and flexibility (which are conditionally necessary for the trunk to be long) for a second purpose (*PA* II.16, 659a20–23): "Since the trunk is such [i.e., has the right material potentials], nature, as usual, uses the same parts for several things, [here using] it in place of the use of front feet (ὑπάρξαντος οὖν τοιούτου τοῦ μυκτῆρος, ἡ φύσις παρακαταχρῆται, καθάπερ εἴωθεν, ἐπὶ πλείονα τοῖς αὐτοῖς μορίοις, ἀντὶ τῆς τῶν προσθίων ποδῶν χρείας)." On the elephant's trunk, see also Gotthelf (1997a).

[16] For Aristotle's use of value terms in these principles, see Gotthelf (1988).

[17] On the nature and scientific status of teleological principles, see Lennox (2001a, 182–204). My account here draws heavily on his analysis.

indicates that the scope of such principles is *the whole science of nature* (*IA* 2, 704b12–705a2):

> The starting point of our investigation is achieved by positing [principles] that we are accustomed constantly to use for our science of nature, assuming that this is the way in which things are in all the works of nature (ἀρχὴ δὲ τῆς σκέψεως ὑποθεμένοις οἷς εἰώθαμεν χρῆσθαι πολλάκις πρὸς τὴν μέθοδον τὴν φυσικήν, λαβόντες τὰ τοῦτον ἔχοντα τὸν τρόπον ἐν πᾶσι τοῖς τῆς φύσεως ἔργοις). One of these is that nature does nothing in vain, but always, given the possibilities, does what is best for the substantial being of each kind of animal; therefore, if it is better in a certain way, that is also how it is by nature. Next, we must posit [as principles] the dimensions of magnitude as many and of whatever kind belong to whichever kind of animal . . . Further, [we must posit] that the sources of movements in place are thrusts and pulls.

Each of the principles mentioned in this passage posits "that something is the case or is not the case," which according to the distinctions made in the *Posterior Analytics* indicates that these posits are hypotheses rather than definitions (*APo* I.2, 72a19–21): "A posit that assumes either of the parts of a contradictory pair, I mean that something is the case or is not the case, is a hypothesis" (cf. also *APo* I.10, 76a31–37 and 76b3–23).

Whereas definitions demarcate the subject domain of a particular investigation at hand, hypotheses are propositional assertions about this domain. The hypotheses are used in the context of the *De Incessu Animalium*, because they are assumed to apply to "*all* the works of nature":[18] they pertain to everything that has a formal nature, which includes both the sublunary animals and the heavenly bodies.

In the second passage that is relevant for our discussion, Aristotle uses a teleological principle to explain why teeth come to be at the precise moment they do, and indicates that the source of these principles lies in *empirical evidence* (*GA* V.8, 788b20–24):

> But since we suppose – making suppositions based on the things we observe (ἐπεὶ δὲ τὴν φύσιν ὑποτιθέμεθα, ἐξ ὧν ὁρῶμεν ὑποτιθέμενοι) – that nature neither falls short, nor produces anything pointless among the possibilities in each case, it is necessary for animals that are to take in nourishment after suckling to have instruments for the chewing of food.

For Aristotle, the ability to lay down hypotheses correlates with the amount of experience one has with the domain of investigation, and in the natural

[18] The *De Incessu Animalium* passage suggests that the three principles mentioned are only a subset of all the principles we should already be familiar with (perhaps from having worked through other biological treatises); Aristotle singles out these three in order to provide the appropriate framework for the explanation of animal progression.

sciences this experience is the result of the accumulation of observations, preserved by memory (see *GC* I.2, 316a5–10 and *APr* I.30, 46a17–27).[19] In other contexts, Aristotle points out that domain-specific principles concerning perceptible phenomena (such as the teleological principles under discussion) are empirical in a double sense (see especially *Cael* III.7, 306a5–17). Not only do they need to be derived from perceptible phenomena, they also always need to be checked and judged against what is actually perceived.[20] The implication is that if the principles cannot successfully account for the observations as they stand, they must have been assumed wrongly, and should be rejected (cf. *GA* III.5, 756a2–5; *GA* III.10, 760b28–33; and *NE* I.8, 1098b11–12). The teleological principles are empirical in nature, just as the theory of teleology itself is empirical.[21]

The role of teleological principles in explanation

As for their role in the natural sciences, Lennox has made it clear that these principles are no mere slogans, written down by Aristotle to remind his readers of his commitment to the teleology of nature; nor are they expressions of Aristotle's supposed demiurgic or cosmic conception of nature.[22] Rather, as is evidenced by the two passages discussed above, we should consider these teleological principles to play an important *explanatory* role in Aristotle's science of nature. In fact, so Lennox argues, these principles are explicitly used as premises in the explanations recorded in *De Partibus Animalium*.[23]

This may well be the case for the way Aristotle uses teleological principles in some pre-scientific contexts, but I believe that their role in *De Partibus Animalium* (and perhaps also in the other biological works) is better described as that of a heuristic tool that *points towards* the ultimate explanation of some phenomenon, where this ultimate explanation is to be reconstructed without the teleological principle figuring as one of its premises. As I shall argue in the sections below, Aristotle invokes teleological principles in those cases where simple, immediate observation and the use of definitions do not yield the required (final) causes. These principles are then used to generate a set of inferences that will lead to the identification of the causally relevant features, and these features are then to be picked out in the ultimate, syllogistic explanation.

[19] Cf. Kullmann (1990, 338–340). [20] Matthen and Hankinson (1993, 421).
[21] Gotthelf (1987, 214, 229). Cf. *Resp* 10, 476a13: "[S]ince we *see* (ὁρῶμεν) that nature does nothing in vain."
[22] Lennox (2001a, 182–204). [23] Lennox (2001a, 211–218).

Of course, this set of inferences, which includes the postulation of a teleological principle, is part of the larger explanatory account of some feature, and the teleological principles themselves are certainly not devoid of explanatory content (they are, after all, as I indicated above, causal characterizations of the actions of the formal nature at the most general level). My claim is merely that these principles are not part of the demonstrative explanation *properly speaking*, but function rather as intermediate steps towards it. My considerations for proposing this refined explanatory role for teleological principles in the production of Aristotelian explanations are threefold.

First, I believe that, consistent with Aristotle's theory of science as set out in the *Posterior Analytics* and with his recommendations for how to provide explanations in the science of nature in *PA* I.1, the implicit structure of many of the explanations Aristotle provides in *De Partibus Animalium* is that of a demonstrative syllogism, which is of the form AaB, BaC, ∴ AaC.[24] This pattern, of course, does not exhaust all the possible forms of explanation that can be used in biology, but given Aristotle's discussion of it in *PA* I.1 (see especially *PA* I.1, 640a3–6 and my discussion of this text in Chapter 6), it might well be the most "scientific" one. However, since the teleological principles are propositional in form (the principles are hypotheses that posit that something is or is not the case, and hypotheses are "among the propositions": see *APo* I.2, 72a20 and *APo* I.10, 76b35–37),[25] they do not fit well into the formal structure of a demonstrative syllogism, which requires premises to have a universal predicative structure.[26] Even if the principles are part of the partial or informal explanation of some phenomenon,[27] the formal requirement of the demonstrative syllogism

[24] See Lennox (2001a, 5–6; 2001b, 206); see also Chapter 6.

[25] Pace Charles (2000, 72n.20) and Lennox (2001a, 209) who take *APo* I.10, 76b36 (ἀλλ' ἐν ταῖς προτάσεσιν αἱ ὑποθέσεις; "the hypotheses are among the propositions") to mean that the hypotheses are among the *premises* of demonstrations, and Gotthelf (1987b, 185–194), who uses the terms "principle" and "premise" interchangeably for all three types of principle he distinguishes in Aristotle. Goldin (1996, 54, 54n.26), on the other hand, argues that in *APo* I.10, 76b36 "hypotheses" means "premises," and that accordingly the claim is that "premises belong to the propositions." I believe that Aristotle's use of technical terms in *APo* I.10 is consistent with his introduction of these terms in *APo* I.2, and in the latter context "*protasis*" means proposition; cf. Barnes (1993, 97–8). In short, Aristotle says here that the hypotheses are among the propositions, which does not imply that they are also among the premises.

[26] This is especially clear in the case of disjunctive principles: "doing everything because it is necessary *or* for the better" is not the kind of predication that Aristotle typically uses in the *Analytica Posteriora*. On this issue, see also Detel (2006, 255–256).

[27] As Lennox (2001a, 6, 36n.37) points out, such informal explanations often contain important content that will be lost in the ultimate, syllogistic demonstration, and I acknowledge that they play a crucial role in our process of learning about biological phenomena; however, at the level of strict demonstration, they no longer play a role.

(to which I believe Aristotle adheres at least to some extent in *De Partibus Animalium*) thus makes it unlikely that they can be part of the explanation properly speaking.[28]

Second, since these principles are *generalizations* of the actions of formal natures, they cannot (because of their universal nature) exhibit *the most basic* or *primary* causal fact of each particular biological phenomenon – and the latter is what is picked out in the ultimate explanation of that phenomenon. Reconstructions of the demonstrative syllogism in which "what is best" or "what is in vain" function as middle terms would in the theory of the *Posterior Analytics* resemble explanations that "are stated extravagantly" in that the middle terms are too far away to carry much explanatory force (see *APo* I.13, 78b28–31; cf. *Ph* II.3, 195b21–25 and *GA* II.8, 747b27–748a15). They would provide explanations only of a very unspecific and weak kind. It would also make Aristotle's explanations vulnerable to objections of being ad hoc and circular, since by using a predicate such as "what is best" as a middle term one can demonstrate an animal to have *any* feature it has because it is best, whereas the real issue for Aristotle is to get to know *whether* a certain feature is actually "what is best" for a particular kind of animal and if it is, *why* it is so.

Third, the twofold nature of teleology itself (as discussed in Chapter 3) implies that teleological explanations in *De Partibus Animalium* need to do more than merely identify some feature's final cause: a complete explanation will also reveal whether it is a formal or a material factor that is primarily driving the realizations of functions (i.e., whether the underlying causality is that of primary or of secondary teleology), and whether that feature is immediately necessary or rather subsidiary to the animal that has it. The complex causal relations between animals, parts, and functions demand heuristic strategies that go beyond immediate observation and division.

In other words, while I believe that teleological principles in *De Partibus Animalium* provide the framework within which the causally relevant facts can be detected, and as such are certainly part of the larger explanatory context, they do not specify these facts themselves. Their function in *De Partibus Animalium* books II–IV is therefore mainly *heuristic*. I shall argue for this interpretation in the section below through an analysis of Aristotle's actual use of teleological principles in the biological works.

[28] Cf. Gotthelf (1997a, 89), who – in drawing a diagram of Aristotle's explanation of the elephant's nose in *PA* II.16 – places the teleological principles "in a horizontal box at the bottom, to indicate their role in underwriting the explanations, without indication as to how exactly they do."

Examples of the heuristic use of principles of "optimal production"

There are at least three different kinds of teleological principles operative in Aristotle's *De Partibus Animalium*, which are all used in specific explanatory contexts and ascribe different kinds of goal-directed actions to formal natures.

One type of principle concerns the *distribution* of parts over the animal's body, and posits that nature – if nothing prevents it – always places parts at the most valuable[29] location possible, while at the same time safeguarding the balance or symmetry between the two halves of the body (along the three dimensions: up and down, left and right, front and back), such that each part has a counterpart. Aristotle uses this type of principle to generate teleological explanations of why parts are *located* where they are: the principles help to identify what aspect of the animal's material or formal nature explains why the part's location is the best possible for this kind of animal.[30]

A second type of principle concerns the number of parts an animal has, and posits that nature always *assigns* or *gives* as many parts to an animal as are both necessary and sufficient for it to function. Nature's actions in giving parts to animals are always economical: if possible, animals have one part for the performance of each function (and never more than one), but if necessary, nature will use the same part for multiple functions. Aristotle uses this principle to generate teleological explanations of why animals have the *number* of parts they have by relating this number to some aspect of the animal's material or formal nature.[31]

Ultimately, these two types of principle are variations of the principle that "nature does nothing in vain, but always, given the possibilities, does what is best for the substantial being of each kind of animal."[32] This

[29] For the notion of the most honorable as linked to biological functions, see *PA* II.10, 656b22–25; *PA* III.3, 665a13–15; and *PA* IV.7, 683b19–24; see also *IA* 4, 705a29–b5, *IA* 4, 706a21–25, *IA* 5, 706b12–16. Cf. Lennox (2001a, 266–272).

[30] I call these principles "principles of balanced distribution." They are used in, e.g., *PA* II.7, 652a30–33; *PA* II.10, 656b27–657a12; *PA* II.14, 658a18–24; *PA* III.3, 665a23–26; *PA* III.4, 665b18–21; *PA* III.6, 669b18–26; *PA* III.10, 672b19–24; *PA* IV.11, 691a28-b4; and *PA* IV.12, 695a9–13; cf. also *GA* I.8, 718b25-b29; *GA* I.11, 719a13–15; *GA* II.1, 732a3–8; *IA* 2, 704b18–22; *Cael* II.2, 284b10; *Cael* II.2, 285a11; *Cael* III.4, 303b2.

[31] I call these principles "principles of economical assignment." They are used in, e.g., *PA* II.16, 659a20–22; *PA* III.1, 661b28–31; *PA* III.1, 662a18–24; *PA* III.2, 663a17–18; *PA* IV.6, 683a19–25; *PA* IV.7, 683b5–7; *PA* IV.10, 689a4–15; *PA* IV.8, 684a27–30; and *PA* IV.10, 687a10–15; cf. also *GA* I.1, 716a24–27. Note that parts that come in pairs, such as eyes, ears, lungs, and kidneys, are no exception to the "economical" workings of nature: these parts are one in form, but double in structure because of the doubleness of the body: see *PA* II.10, 656b32–657a10 and *PA* III.7, 670a4–7; Lennox (2001b, 227).

[32] Cf. Lennox (2001b, 188).

principle operates at the most basic level in the context of determining the causal processes governing the *production* of parts and of establishing why an animal has or lacks a part to start with. Since this is the primary level at which teleology operates, I shall focus in my discussion below on Aristotle's use of those two principles that posit that nature always "makes" or "produces" features because it is necessary, better, or best to do so.

The first principle of what I call "optimal production" posits that nature always does everything either because it is necessary or because it is better. Aristotle rarely quotes the principle in full, but his *De Partibus Animalium* is full of references to features being either necessary or for the better, and I take it that those references provide equal evidence for Aristotle's use of this principle (see, e.g., *PA* III.7, 670a23–29; *PA* III.7, 670b23–27; and *PA* IV.11, 691b32–692a8). For the most informative text on how Aristotle uses the principle, however, we need to turn to Aristotle's *De Generatione Animalium* (*GA* I.4, 717a11–21; 26–31):

> With regard to the differences of spermatic organs in males, if one is to search for the explanations of why they are there, one must first grasp for the sake of what the structure of testes exists. Now if nature does everything either because it is necessary or because it is better, then this part too must be because of one or the other (εἰ δὴ πᾶν ἡ φύσις ἢ διὰ τὸ ἀναγκαῖον ποιεῖ ἢ διὰ τὸ βέλτιον, κἂν τοῦτο τὸ μόριον εἴη διὰ τούτων θάτερον). That it is not necessary for generation is evident (ὅτι μὲν τοίνυν οὐκ ἀναγκαῖον πρὸς τὴν γένεσιν φανερόν): for it would be present in all that generate, but as it is neither the snake nor the fish have testes (for they have been seen coupling and with the channels full of semen). It remains then that they are for the better in some way (λείπεται τοίνυν βελτίονός τινος χάριν) . . . Those who need to be more temperate have in the one case [of nutriment] intestines that are not straight, and in the other case [of sexual reproduction] their ducts twisted to prevent their desire being too violent and hasty. The testes are contrived for this (οἱ δ' ὄρχεις εἰσὶ πρὸς τοῦτο μεμηχανημένοι); for they make the movement of the spermatic secretion steadier.

The phenomenon Aristotle seeks to explain here is why there is a differentiation of spermatic organs *in all males that reproduce sexually*, that is, why some of these male animals have ducts for semen, testes, and a penis, whereas others only have ducts. As he points out, the first step towards formulating an explanation is identifying the function of testes. From the outset it is clear that testes must have something to do with sexual reproduction (and not just with any form of reproduction). What needs to be determined is what their *specific* function is, and then relate this to their presence in some animals, and their absence in others. This is where the use of teleological principles comes in: if parts such as testes are either necessary

(where "necessary" indicates "conditionally necessary" for the performance of some function) or for the better (where "for the better" indicates that the feature is subsidiary to the animal that has it), and cross-species observation reveals that not all animals that reproduce sexually have testes, then the only option that remains is that testes are "for the better."

It is important to note here that for Aristotle the two options are mutually exclusive (if a part is not necessary, then it *must* be for the better), and that he uses these qualifications for parts in an absolute manner, without regard for the level of specificity of animal kinds in which these parts are realized. For instance, Aristotle keeps referring to testes as being "for the better" for the animals that have them (i.e., their status as subsidiary parts is a fixed one), even though they seem necessary for reproduction in those animals. This points out that the permanent qualification of a part as being necessary or for the better is not meant to be *descriptive* of a part's status in actual, realized living beings (take away some actual animal's testes, and it will not be able to reproduce anymore – in the current realization of many animals, testes are certainly necessary). I take it that these qualifications rather pertain to the *hypothetical "design"* of animals, where nature is, metaphorically speaking, still figuring out how to best realize the potential(s) for form for each individual kind of animal. Definitions of the substantial being of animals, which are themselves fixed and eternal, only determine what functions ought to be realized in animals of what size, not what parts ought to be made, how many of them there should be, or where they should be placed. Thus, if a male animal is to reproduce sexually, nature cannot make it without having ducts for semen, because without these ducts, sexual reproduction would be entirely impossible. Ducts for semen are thus conditionally necessary for sexual reproduction (they are the primary "realizers" of this function). However, nature could make – and in fact has made, as observation of the current biodiversity shows – male animals without testes, because testes are, strictly speaking, not necessary for sexual reproduction, but rather *enhance* this function in those which are already able to sexually reproduce in virtue of their possession of ducts for semen. A complete explanation of the presence of testes will thus also have to specify their exact contribution to the function of sexual reproduction. This also implies that having the potential(s) for form of a sexually producing male animal does not conditionally necessitate the coming to be of testes (otherwise they would have been present in all that sexually reproduce). The manner of causation that underlies the coming to be and presence of testes will therefore be different from that of ducts for semen. I submit that necessary parts such as ducts for semen are the

result of the operation of primary teleology, whereas subsidiary parts such as testes are the result of the operation of secondary teleology.

Aristotle continues his investigation into why animals that all perform the same function of sexual reproduction do not all have the same set of parts associated with that function by relating the presence of testes to the structure of the ducts and to the character of the animals that have their ducts twisted rather than straight. In this way, Aristotle discovers that the contribution testes make to sexual reproduction is that they make the emission of seed steadier, thus slowing down copulation in animals that are hot-tempered in character and that need to be more temperate in reproduction. This, then, ultimately provides the answer to why only some animals have testes in addition to ducts for semen: testes are present only in those animals which are too passionate and for which it is better to generate in a more temperate manner. Testes are thus present not for sexual reproduction, but for *slower* reproduction in those animals that without them would copulate too quickly. The causally primary factor of the presence of testes is the passionate character of some animals: it is this formal feature that requires a functional differentiation, which nature – if possible – realizes by adding an extra part in these animals.[33]

Aristotle relies on the same principle to find the causally primary facts explaining material differentiations of parts (*PA* II.2, 648a13–19):

> And similarly with the other parts, both parts such as these and the non-uniform parts should be assumed to possess a differentiation, in some cases with a view to what is better or worse, in other cases with a view to each animal's functions and substantial being. For instance, two kinds of animals may both have eyes, but in one these eyes are hard, while in the other they are of fluid consistency; and while the one does not have eyelids, the other has them – both are with a view to a greater accuracy of vision.[34]

According to this passage, material differentiations of parts are present either "with a view to what is better or worse," or "with a view to each

[33] Reconstructing the explanation using the principle as one of the premises (e.g., premise 1: nature does everything either because it is necessary, or because it is better; premise 2: testes are not necessary but for the better; conclusion: nature makes testes) would obscure both the relevant causal features: the function of testes being to make the emission of seed steadier, and the formal feature of "being too passionate" that explains why the presence of testes is helpful only to some of the male animals that reproduce sexually.

[34] Ὁμοίως δὲ καὶ περὶ τῶν ἄλλων καὶ τῶν τοιούτων μορίων καὶ τῶν ἀνομοιομερῶν ὑπολεπτέον ἔχειν τὴν διαφοράν, τὰ μὲν πρὸς τὸ βέλτιον ἢ χεῖρον, τὰ δὲ πρὸς τὰ ἔργα καὶ τὴν οὐσίαν ἑκάστῳ τῶν ζῴων, οἷον ἐχόντων ὀφθαλμοὺς ἀμφοτέρων τὰ μέν ἐστι σκληρόφθαλμα τὰ δ' ὑγρόφθαλμα, καὶ τὰ μὲν οὐκ ἔχει βλέφαρα τὰ δ' ἔχει πρὸς τὸ τὴν ὄψιν ἀκριβεστέραν εἶναι.

animal's functions and substantial being." Although Aristotle does not refer to a complete teleological principle here, I believe that the two options that are mentioned match the distinctions referred to in the principle that "nature does everything either because it is necessary or because it is better." Differentiations of parts are usually for the functional optimization of that part in the specific animal that has it, but whereas some of these functional optimizations are immediately necessary for the animal to survive as the kind of animal it is (nature could not have made these animals without these differentiations), others rather contribute to their well-being (nature makes these differentiations, not because they are necessary, but because they are for the better).

Differentiations of parts that are "with a view to what is better or worse" are primarily the result of material necessity, the outcomes of which may or may not be used for the better by the formal nature of the animal for the functional optimization of a part (only in the latter cases does Aristotle qualify these differentiations as teleological). Differentiations that are for the better are not strictly necessary for the animal – i.e., the differentiation is not of immediate vital or essential importance to it – but they do serve its well-being. For instance, whether an animal has relatively hard or fluid eyes depends largely on its material constitution (cf. *GA* V.1): if the eyes are hard, this is for the worse in terms of vision, but for the better in terms of protection; if the eyes are fluid, this is for the better in terms of vision, but for the worse in terms of protection. Similarly, Aristotle explains the presence of webbed feet in water birds by identifying why such feet are *for the better* in these animals (*PA* IV.12, 694a22–b11):

> It is of necessity that this comes about during generation (ἐξ ἀνάγκης δὲ τοῦτο περὶ τὴν γένεσιν συμβέβηκεν). For the earthen and warm material in the body becomes parts useful for protection . . . In some [nature] constructs length for the legs, in others – instead of this – it fills the gaps in their feet . . . Of necessity, then, these things happen owing to these causes (ἐξ ἀνάγκης μὲν οὖν ταῦτα συμβαίνει διὰ ταύτας τὰς αἰτίας); but it is for the better that they have such feet, for their way of life (ὡς δὲ διὰ τὸ βέλτιον ἔχουσι τοιούτους τοὺς πόδας τοῦ βίου χάριν), in order that, since they live in water where wings are useless, they have feet useful for swimming. For they become oars for sailing just like the fins of fish. Therefore, when of the first group the fins fail, or of the second group the material between their feet, they no longer swim.

Nature uses the residues that have come to be of material necessity in birds that live in water to fill in the gaps between their toes, so that they can paddle while being in the water: having webbed feet is subsidiary to their aquatic way of life.

Differentiations of parts that are "with a view to each animal's functions and substantial being" are the result of primary teleology: these differentiations are strictly necessary for the animals that have them. Without this functional optimization of the part, the animal would not at all have been able to live or be able to be the kind of animal it is. For instance, animals with moist eyes that need to see sharply have eyelids by way of protection for their eyes, whereas animals with hard eyes do not need any eye protection (see *PA* II.13). Similarly, Aristotle explains the presence of strong wings in some birds by identifying that feature of their substantial being that makes it *necessary* for them to have such wings (*PA* IV.12, 693b28–694a9):

> Further, some of the birds are able to fly and have large, strong wings, e.g., those with talons, and the flesh-eaters; it is a necessity for them to be able to fly on account of their way of life (ἀνάγκη γὰρ πτητικοῖς εἶναι διὰ τὸν βίον), so for the sake of this they have both many feathers and large wings . . . But some birds are not able to fly, but are heavy – those whose way of life is earthbound and that are fruit-eaters or are swimmers and spend their life around water.

Only birds whose way of life requires them to be good flyers have strong wings: this differentiation is conditionally necessary for their survival (cf. *PA* II.13, 657b22–29 on why terrestrial birds do not have sharp vision: "for nothing related to their way of life requires them to have it").

In all the examples discussed above, the principle that "nature does everything either because it is necessary or because it is better" helps to determine the ontological status of some feature (i.e., whether it is necessary and the product of primary teleology or subsidiary and the product of secondary teleology) and thereby to discover the causally primary fact responsible for its coming to be and presence. Necessary features are to be explained by reference to some formal aspect of the substantial being of the animal that *requires* (and therefore conditionally necessitates) the presence of a part or its differentiation. Subsidiary (including luxury) features are to be explained by reference to some material aspect of the animal that makes the coming to be of a part or its differentiation possible, in addition to some formal aspect of the substantial being of the animal that reveals why the animal *benefits* from this feature's presence. The presence of both features is thus ultimately due to the goal-directed actions of the formal nature of the animals involved, either by realizing a preexisting potential for form that requires certain differentiations of parts to be present, or by using available materials to make differentiations that are for the better.

The second principle that is concerned with the production of parts posits that "nature does nothing in vain, but always, given the possibilities,

does what is best for the substantial being of each kind of animal." The principle is never stated in full in *De Partibus Animalium*, but there are many partial references (for formulations of the complete principle, see *IA* 2, 704b12–18; *IA* 8, 708a9–12; and *IA* 12, 711a18–29).

In accordance with the line of interpretation proposed by Lennox,[35] I believe that Aristotle employs the "nature does nothing in vain" part of the principle *for the most part* in cases where he needs to provide an explanation of "paradoxical" *absences* of parts, and I focus on these cases in my analysis below. Note, however, that in a minority of cases Aristotle also uses this part of the principle in order to discover the cause of the *presence* of biological phenomena, such as capacities without which a living being would not be able to achieve its natural ends (see, e.g., *DA* III.12, 434a30–b8 and my discussion of this example in section 2.2), or the presence of the male in the process of reproduction in animals whose sexes are separate (see *GA* II.5). The underlying heuristic mechanism, I believe, is the same in both cases: imagine the opposite scenario where the phenomenon that is *now* present (or absent) is absent (or present), and the "observable" consequences of the reversed condition for the living being in question will point towards the causally primary facts related to its substantial being.

When dealing with "paradoxical" absences of parts, observations as such are of no help in finding the relevant causal factors for why these parts are absent. Aristotle suggests that instead of using immediate observation, we should theorize about why nature (hypothetically speaking) would have designed the animal the way it is. We do this by assuming that nature does nothing in vain, and from there reason counterfactually that *if* the formal nature of a particular animal had equipped that animal with the part that is now absent, the presence of that part would have been in vain, *because of* some other feature of that animal that is more necessary (or "basic") to the animal's substantial being.[36] What this feature is can only be discovered through this kind of thought experiment: if the absence of a part is to be explained teleologically, then it is necessary to exhibit some other, more

[35] See Lennox (2001a, 205–223).

[36] There are several reasons why Aristotle concludes that the presence of a part would have been in vain: (i) the animal is not able to use the part, either at all or to use it properly (see, e.g., *PA* IV.12, 694a13–20: heavy birds have talons and not spurs because they cannot use the latter); (ii) the animal already possesses a part that performs a similar function (see, e.g., *Resp* 10, 476a11–15: no animal needs both gills and lungs); (iii) the animal does not need the function for the sake of which the part would come to be (see, e.g., *PA* II.13, 658a6–10: fish do not need eyelids since their eyes do not need any protection in the water); and, finally, (iv) the presence of the part would have been harmful to the animal (see, e.g., *PA* IV.12, 694a16–18: the presence of crooked claws would harm heavy birds; *GA V.2*, 781b22–28: the presence of outer ears in seals would lessen their hearing ability instead of improving it).

basic feature of the animal as interfering with the functionality of the part that is now missing.

The use of the teleological principle thus reveals a design problem, which nature has solved by "removing"[37] the part which is the least crucial or necessary to the animal's substantial being. If the thought experiment does not reveal any design problems it means that there is no teleological explanation to be provided for the absence of the part. Instead, the explanation is likely to be material: the part is missing because the suitable constitutive material is missing in this animal kind (for examples, see below in section 4.3). Once one identifies the feature that would have made the presence of the other part in vain, the principle allows the inference that that is in fact why the part is absent: nature never produces parts that are in vain.[38]

Aristotle's explanation of why snakes have no feet illustrates this use of the principle that nature does nothing in vain (*IA* 8, 708a9–20):

> In snakes the cause of why they are footless is both that nature does nothing in vain, but always from among the possibilities, [does] what is best for each thing, preserving the proper substantial being of each and its essence; and, in addition, that which we stated before, namely that no blooded animal can move itself at more than four points. For from these [two principles] it is evident that of the blooded animals *whose length is out of proportion to the rest of the nature of their body*, such as snakes, none of them can possibly have limbs. For they cannot have more than four feet (since in that case they would be bloodless), and if they had two feet or four they would be almost completely immobile: so slow and useless would their movement necessarily be.[39]

Observation shows that all blooded animals that live on land have feet; blooded land-dwellers share to a certain extent the same formal nature, which explains the occurrence of certain co-extensive features such as the possession of a maximum of four feet. The snake, however, also possesses all the properties that belong to blooded land-dwellers, except for feet. This

[37] For nature "taking away" parts if their presence would have been in vain, see *PA* IV.11, 691b1–5 and *Cael* II.8, 290a29–35 (and my discussion of this passage in section 5.4); cf. *PA* III.2, 663a32–33; 664a1–3; *PA* IV.9, 685a25–27; and *GA* III.10, 760a30–33; b25–27.

[38] This type of reasoning reflects what Aristotle elsewhere calls a "syllogism from a hypothesis." See Bobzien (2002, 365).

[39] τοῖς δ' ὄφεσιν αἴτιον τῆς ἀποδίας τό τε τὴν φύσιν μηθὲν ποιεῖν μάτην, ἀλλὰ πάντα πρὸς τὸ ἄριστον ἀποβλέπουσαν ἑκάστῳ <ἐκ> τῶν ἐνδεχομένων, διασώζουσαν ἑκάστου τὴν ἰδίαν οὐσίαν καὶ τὸ τί ἦν αὐτῷ εἶναι· ἔτι δὲ καὶ τὸ πρότερον ἡμῖν εἰρημένον, τὸ τῶν ἐναίμων μηθὲν οἷόν τ' εἶναι πλείοσι κινεῖσθαι σημείοις ἢ τέτταρσιν. ἐκ τούτων γὰρ φανερὸν ὅτι τῶν ἐναίμων ὅσα κατὰ τὸ μῆκος ἀσύμμετρά ἐστι πρὸς τὴν ἄλλην τοῦ σώματος φύσιν, καθάπερ οἱ ὄφεις, οὐθὲν αὐτῶν οἷόν θ' ὑπόπουν εἶναι. πλείους μὲν γὰρ τεττάρων οὐχ οἷόν τε αὐτὰ πόδας ἔχειν (ἄναιμα γὰρ ἂν ἦν), ἔχοντα δὲ δύο πόδας ἢ τέτταρας σχεδὸν ἦν ἂν ἀκίνητα πάμπαν· οὕτω βραδεῖαν ἀναγκαῖον εἶναι καὶ ἀνωφελῆ τὴν κίνησιν. Cf. *IA* 2, 704b12–18; *IA* 4, 705b25–29 and *PA* IV.11, 690b14–18.

absence is explained by showing counterfactually how the presence of four feet would have been in vain: given that a snake – being blooded as it is – can only possess a maximum of four feet (this is a non-teleological principle of nature; giving the snake more than four feet would damage its substantial being and is therefore not a natural possibility), those four feet if present would not enable it to move swiftly at all. The reason why becomes apparent when one imagines the four feet to be present: the length of the snake is out of proportion to the rest of its body, and with only four feet it would rub its belly against the ground. It is thus the snake's disproportionate dimensions that render the presence of a maximum of four feet non-functional: no blooded animal whose length is out of proportion to the rest of its body can move with a maximum of four feet, and snakes are such animals. It is for this reason that nature did not equip snakes with feet (cf. *PA* IV.13, 696a10–15). Notice again that the level of reasoning pertains to the hypothetical design of snakes: even though the "original design" of snakes – as being blooded land-dwellers – may have required the possession of four feet, such animals were never actually realized. The thought experiment is supposed to reveal what other feature of the animal made nature adjust the design of snakes and "take away" their feet in realizing them. Once we have identified that feature, we can formulate an explanation that works without having to attribute any actual conscious intentionality to nature.[40]

Aristotle invokes the second part of the principle to generate explanations of the presence of parts[41] and their differentiations almost always in those cases where observation of the wider kind shows that there are *several* possible ways in which nature could have fulfilled a certain functional need. Aristotle uses this principle as a means to find the causally primary feature connected to the animal's substantial being that reveals why the one part, rather than the other one, is the best fit for this kind of animal to perform a particular function. The "possibilities" from among which nature – in the hypothetical setting – determines which kind of part to produce in each kind of animal are *natural* possibilities:[42] the range of what is *possible* for a

[40] Using the format of the *Posterior Analytics*, the explanation of the footlessness of snakes can be reconstructed as follows: premise 1: having (a maximum of) four feet holds of no blooded animal whose length is out of proportion to the rest of its body; premise 2: having the length out of proportion to the rest of their body holds of all snakes (which are blooded animals); conclusion: having (a maximum of) four feet holds of no snakes.

[41] Lennox (2001a, 215–218; 220–221n.4) proposes a similar interpretation, but the examples he provides (*PA* IV.13, 695b17–27 and *IA* 8, 708a9–20) in fact illustrate the use of this principle in explaining the *absence* of parts. Note that the same principle can also be applied to explain the timing of a part's coming to be: see *GA* II.6, 744a35-b1 and *GA* V.8, 788b20–789a2.

[42] Lennox (2001a, 207): "the range of possibilities is represented by the generic features of the more extensive kind to which an animal belongs."

certain kind of animal to have is in fact what can be observed to be *realized* in actual, similar animals (at whatever level of generality is appropriate). The possibilities are thus established inductively through observation.

Aristotle uses this principle, for example, to explain why human beings have hands instead of forelimbs (*PA* IV.10, 687a15–18):

> And being upright in nature, mankind has no use (οὐδεμία χρεία) for forelimbs, and instead of these, nature provides arms and hands . . . So if it is better thus, and nature does, among the possibilities, what is best (εἰ οὖν οὕτως βέλτιον, ἡ δὲ φύσις ἐκ τῶν ἐνδεχομένων ποιεῖ τὸ βέλτιστον), it is not because they have hands that human beings are most intelligent, but because they are the most intelligent of animals that they have hands.

All blooded live-bearing and land-dwelling animals have forelimbs, except for human beings, who have hands – and it is this distribution that needs to be explained. The causally relevant facts that explain this distribution are found by applying the principle that nature does what is best among the possibilities: between the two options, hands and forelimbs, hands are the best option available for human beings given their particular substantial being. This is so for two reasons: first, since human beings walk upright (this is an essential feature of humans: see *PA* IV.10, 686a25–31), they do not need forelimbs for walking, and – as we saw above – nature does not produce non-functional features. This, however, explains only why humans do not have forelimbs. Second, and more importantly, nature has given hands to human beings because they of all animals are the most able to use them *on account of* their being the most intelligent. Being most intelligent is what distinguishes human beings from the other blooded live-bearing and land-dwelling animals, and it is this feature of their substantial being that is picked out as the explanatory middle term in the explanation for why human beings have hands (cf. *PA* IV.10, 687a9–10: "it is reasonable that *because of their being most intelligent*, they received hands"; *PA* II.14, 658a21–24 and *PA* IV.10, 690b3–4).

Whereas "for the better" in the first principle discussed above refers to the ontological status of the part (it indicates that the part is a product of secondary teleology and that it serves the animal's well-being), "what is best" referred to in this second principle rather refers to what realization of a certain function constitutes the optimal fit for an animal *given the kind of animal it is*.[43] If observation shows that there are multiple natural

[43] It is because of this that the principles of balanced distribution and economical assignment can be subsumed under the principle that nature does what is best, given the possibilities, for the substantial being of each kind of animal. See in particular Aristotle's explanation of the differences

possibilities (i.e., that there are multiple parts an animal potentially could have had as the realization of a certain potential for form), Aristotle needs to explain why this, rather than another possibility is realized in this particular animal. As is clear from the example discussed above, this involves not just giving a specification of the function for the sake of which the part is present, but also, and even more so, identifying that element in the definition of the substantial being of the animal that reveals *why this part is in fact the best fit for the animal that has it*. These causally primary features are what the teleological principle helps to identify. If there is no such feature to be found, then there is no teleological explanation for the particular differentiation between parts and animals that have them. Compare in this context also *PA* IV.9, 685b12–16, where Aristotle states that the presence of one row of suckers in one kind of octopus is not because it is best, but because it is necessary: observation shows that octopuses can have either one or two rows of suckers, but there is no teleological explanation for this variation in the distribution of parts. Rather, the differentiation is conditionally necessary given the differences in dimensions between different kinds of octopuses.

In sum, the examples discussed above all involve phenomena that cannot simply be explained by the identification of (observable) functions.

In the first examples discussed, the function of a part or its differentiation is known, but it needs to be established whether the coming to be and presence of this function is primarily driven by matter or by form. That is, it still needs to be determined whether the part is a necessary prerequisite for the performance of the function in question and is the result of formal natures realizing a preexisting potential for form, or whether the part contributes to the performance of the function in question and is the result of formal natures using materials that have come to be of material necessity for the betterment of the animal.

The second series of examples concerned parts that can be observed to be present in one group of animals, but that are found to be absent in another group that is otherwise very similar or related to the first group. In both cases, it is some aspect of the definition of the substantial being of each particular kind of animal that explains why the part is present or absent in that group.

of the location of hair in different kinds of animals in *PA* II.14, 658a16–24; 658a22–24: "Therefore nature adds this protection to the more valuable parts, because it is always a cause of the better among the possibilities (τοῖς τιμιωτέροις ὑπέγραψεν ἡ φύσις τὴν βοήθειαν· ἀεὶ γὰρ ἐκ τῶν ἐνδεχομένων αἰτία τοῦ βελτίονός ἐστιν)."

The causally relevant features are in both cases discovered through the use of teleological principles: they provide the heuristic framework within which the exact causal relation between part, function, and specific kind of animal can and needs to be found. It is this use to which Aristotle alludes in the following passage (*Resp* 3, 471b24–29):

> The main cause of why [investigators] do not speak well about these things is on the one hand that they lack experience of the internal parts, and on the other hand do not make the assumption that nature in every case acts for the sake of something (καὶ τὸ μὴ λαμβάνειν ἕνεκά τινος τὴν φύσιν πάντα ποιεῖν); had they inquired for the sake of what respiration belongs to animals, and had they investigated this question in the presence of the parts involved, that is, the gills and lungs, they would quickly have found the explanation (εὖρον ἂν θᾶττον τὴν αἰτίαν).

In this passage, Aristotle seems to imply that the importance of the assumption that nature acts in every case for the sake of something lies in its power to guide our investigations towards the discovery of explanations. If this passage is representative of Aristotle's general views about teleological principles in all of his natural treatises,[44] it would seem that their use is indeed (also) heuristic.

4.3 EXPLANATIONS IN BIOLOGY: REFERENCES TO FORM, MATTER, AND FUNCTION

Classifying patterns of explanation in De Partibus Animalium

In this final section, I shall provide an appendix-style overview of the most important patterns of explanation that can be found in Aristotle's *De Partibus Animalium* (note, however, that this overview is not meant to be exhaustive and that my discussion of representative examples necessarily has to remain brief). The patterns discussed can be consulted independently.

My purpose in presenting this listing of patterns of explanation is both to demonstrate the richness and flexibility of Aristotle's explanatory project in this biological treatise, and to illustrate the different roles played by the four Aristotelian causes and especially by the final cause in his explanations. It is my contention that whereas the importance of final causes lies in their explanatory priority (they are easily identified through observation and often form the starting points of explanations), material or formal features constitute the causally primary factor in the explanations. That is,

[44] Pace Lennox (2001a, 219–220), I believe that this passage illustrates the main use of teleological principles.

the coming to be and presence of ends that constitute the final causes are themselves – depending on whether the teleology is primary or secondary – primarily driven by either material factors (i.e., by the availability of extra materials that formal natures may or may not use for the betterment of the animal) or formal factors (i.e., by the presence of a potential for form that needs to be realized), which have causal priority. In Chapter 6 I shall provide a tentative explanation for why teleological explanations have this particular structure; for now it will suffice to lay out the basic patterns of explanation.

Since my focus lies on the identification of the roles and interrelations of the four causes in Aristotle's explanations, I have organized my overview accordingly. I shall first discuss patterns of explanation in which Aristotle refers first to formal(-efficient) causes, next the ones in which he refers first to material(-efficient) causes, and finally those patterns in which he refers first to final causes. In those cases where Aristotle refers to more than one cause in the same explanation, my analysis will make clear which factor has explanatory priority and which has causal priority. Also, following the order in which Aristotle presents his explanations, my exposition will start with the explanations of the presence of parts, proceed with those of the absence of parts, and end with the explanations of their differentiations.

Explanation by reference to formal causes

Pattern I: Explanation of the presence of vital and essential parts by reference to (functional) features included in the definition of the substantial being of an animal

As we saw in section 3.2, Aristotle usually explains the presence of vital and essential features by reference to the definition of the substantial being of the animal. These features are exhibited as the necessary prerequisites for the performance of vital or essential functions. In these cases, the animal's essence or form is picked out as the causally primary factor in the explanation of the feature's presence.

For instance, Aristotle explains the presence of fins in fish by reference to fish being essentially swimmers: fins can be exhibited to be (the usual) necessary prerequisites for an animal to be able to swim (*PA* IV.13, 695b17–26; see section 3.2). Another important example is his explanation of why some animals have blood (*PA* IV.5, 678a31–35): "For that some animals are blooded while some are bloodless will belong in the account defining their substantial being (ἐν τῷ λόγῳ ἐνυπάρξει τῷ ὁρίζοντι τὴν οὐσίαν αὐτῶν)" (Cf. *PA* IV.12, 693b2–13; *PA* IV.13, 695b17–25 and *PA* II.2,

648a20). Being blooded is a feature that is specified by the definition of the substantial being of these animals: it is a *kath'hauta* feature. Besides blood (or its analogue), there are a few other parts that are explained to be present in *all* animals in virtue of what it is to be an animal. The definition of the substantial being of "animal" specifies the necessary functions of perception and nutrition, and all animals will therefore have a heart or its analogue (as the primary seat of perception) and at least flesh, and a mouth and stomach, because these parts are the necessary prerequisites for the realization of these necessary functions (see *PA* II.8, 653b19–29, *PA* III.4, 666a34–5, and *PA* IV.5, 678b1–6). Note, however, that definitions of substantial beings do not only specify the necessary functions an animal needs to perform, but also its dimensions and other non-functional features, and presumably (as evidenced by the example of being blooded) also the basic material make-up of an animal.[45]

The same pattern of explanation applies also to those features that are not themselves specified by the definition of the substantial being, but that immediately follow from it (i.e., features that belong to the animal *kath'hauta sumbebêkos*). For instance, having a heart (here: as an origin and container of blood) and liver is explained as being a necessary consequence of being a blooded animal (*PA* III.7, 670a23–27): "Now the heart and liver are necessary to all animals . . . All blooded animals must have both of these (πάντα δὲ δεῖται τὰ ἔναιμα δυοῖν τούτοιν), which is why these two viscera alone are possessed by all blooded animals, while those that breathe have a third, the lung." The causally primary feature that explains the presence of the heart and the liver is the fact that the animal is blooded, which is part of its essence or form.

Sometimes, especially in the case of dualizers, Aristotle explains the presence of a part in a particular kind of animal by reference to the definition of the substantial being of the wider class of animals to which that animal kind belongs. For example, Aristotle explains the two-footedness of the ostrich by identifying it as being *in this respect* a bird (*PA* IV.14, 697b13–27): "The same mode [i.e., that of being a dualizer] also pertains to the Libyan ostrich; for it has some parts of a bird, others of a four-footed animal . . . and while it is two-footed like a bird, it is hoofed, as though four-footed."

[45] E.g., the length and thinness of a certain kind of octopus (*PA* IV.9, 685b12–15; cf. *IA* 8, 708a9–20); "being segmented into parts" in insects (*PA* IV.6, 682b27–29); "having claws" in lobsters (*PA* IV.8, 684a32-b1); and "being divine" in humans (*PA* IV.10, 686a25–31); dimensions of some insects (*PA* IV.6, 683a18–19); and dimensions of animals in general (*DA* II.4, 416a15–18; *GA* II.6, 745a5–6; and perhaps also *Pol* V.9, 1309b18–35). See also Code (1997, 139–140); Gotthelf (1985, 41, 44–45, 53n.22); and Gotthelf (1987, 189–192).

Since two-footedness is a *kath'hauta sumbebêkos* feature of birds (see *PA* IV.12, 693b5),[46] and since ostriches share to some extent the features of birds, ostriches are also two-footed.

In these examples, the causally primary fact is constituted by the definition of the substantial being of the widest class of animals to which the part to be explained belongs. Functions play a role in these explanations only by being subsumed in this definition (i.e., even though fins are for the sake of swimming, their presence is explained by reference to fish being swimmers).

Note that Aristotle never refers to formal causes as the ultimate causes of absences of parts: "bloodlessness" (see *PA* IV.5, 678a31–35 quoted above) is not really an exception to this rule, since it indicates, not that an animal lacks blood altogether, but that it lacks *red* blood. Bloodless animals possess a part analogous to red blood, with similar material potentials (see *PA* I.5, 645b9–10).

In the case of dualizers, Aristotle sometimes explains the absence of a part that is a necessary realization of one of the two forms at stake by stating that in this case the animal tends towards the *other* form. Aristotle then continues by identifying features that are more basic to the dualizer's substantial being, and indicates how the presence of the missing part would have been in vain given the presence of these other features. Ultimately, it seems, Aristotle is reluctant to say that an animal lacks a part because it lacks the form of which the part is a necessary realization, but rather explains the absence in terms of formal features the animal does have, and with which the presence of the now missing part would have functionally interfered (for an example, see Aristotle's discussion of the lack of tails and a rump in bats in *PA* IV.13, 697b1–13).

Pattern II: Explanation of the necessary differentiations of parts by reference to differentiae *and dimensions included in the definition of the substantial being of an animal*

Aristotle explains differentiations of parts that are necessary for an animal by reference to the *differentia* – specified in the definition of the animal's substantial being – for which this differentiation is a necessary requirement. In other words, Aristotle identifies the formal differentiation of this particular animal relative to the form of other animals that are part of the same wider kind, and then points to this formal differentiation as what conditionally necessitates the differentiation of the part relative to its realization in other related animals.

[46] Cf. Bayer (1998, 501–502).

We have already discussed some examples in which a *differentia* explains the presence of a differentiation of a part: birds that hunt for food need *strong* wings (*PA* IV.12, 693b28–694a9) and elephants, who search for food in swamps, need *long* noses for the sake of breathing air (*PA* II.16, 658b32–659a35). Whereas the definition of the substantial being of the wider kind of animals to which a particular kind of animal belongs explains the presence of its necessary parts (e.g., wings in birds and noses in breathers of air), it is a *differentia* of that animal that accounts for (many, but not all) the differentiations of those parts (e.g., strong wings in hunting birds and long, flexible noses in elephants) and that defines it as a subspecies.

In addition to *differentiae* in character, lifestyle, and activities, Aristotle also refers to differences in dimensions between animals as the formal cause of a part's differentiation (*PA* IV.9, 685b12–16):

> Now while the other octopuses have two rows of suckers, one kind of octopus has a single row. This is because of the length and thinness of their nature; for it is necessary that the narrow tentacle should have a single row of suckers. It is not, then, because it is best that they have this feature, but because it is necessary owing to the distinctive account of their substantial being (οὐκ οὖν ὡς βέλτιστον ἔχουσιν, ἀλλ' ὡς ἀναγκαῖον διὰ τὸν ἴδιον λόγον τῆς οὐσίας).

The differentiation between one or two rows of suckers is not due to one row being a better fit for one kind of octopus, given its particular substantial being, and two rows being a better fit for the other kind. Rather the differentiation is a necessary consequence of the essential differences in the dimensions of these two kinds of octopuses. The kind of octopus that is longer and thinner than the other kind has, necessarily, in virtue of lack of space, only one row of suckers.

In these examples, the causally primary fact of a part's differentiation is a particular *differentia* specified in the definition of the substantial being of the animal in question. And again, even though most necessary differentiations are for the sake of a functional optimization of a part (e.g., stronger wings are for the sake of better flying), it is the animal's essence that is causally primary (e.g., some birds are hunters in their way of life).

Explanation by reference to material causes

Pattern III: Explanation of the coming to be of subsidiary and luxury parts by reference to material necessity

As I argued in section 3.2, Aristotle explains the coming to be of subsidiary and luxury parts in the first place by reference to material necessity. Parts are subsidiary or luxury items if they are not the necessary prerequisites

for the performance of vital or essential functions and are therefore not realizations of preexisting internal potentials for form as specified in the definition of the animal's substantial being. In these cases, the availability of residual material or even of entire structures that have come to be of material necessity is what "allows" the formal nature of an animal to make use of them. Formal natures can only produce parts that contribute to the animal's well-being when there are extra materials available to do so. The functions such parts serve or contribute to are usually picked out in the second half of these "double-barreled" explanations. However, the material potentials of the available materials constitute the causally primary facts: the potentials both constrain and guide the uses to which nature can put them, which are either to make a part that contributes to the performance of a necessary function, or to make a part that performs a "luxury function," such as defense or coverage.

Let me analyze one more example to clarify the interrelations of the causally relevant factors involved (*PA* IV.3, 677b22–32):

> The generation of this part [i.e., the omentum] occurs of necessity in the following way; when a mixture of dry and moist is heated, the surface always becomes skin-like and membranous, and this location is full of such nutrient . . . The generation of the omentum, then, occurs according to this account, and nature makes use of it for a good concoction of the nutrient, in order that the animals may concoct their nutrient easier and faster; for what is hot is able to concoct, and what is fat is hot, and the omentum is fat.[47]

The *coming to be* of the omentum is explained entirely in terms of material necessity: the presence of dry and moist materials that make up the stomach and intestines, combined with the presence of heat, results in the solidification of the materials on the outside of the stomach. It is this "sheet" or membrane that constitutes the omentum. The formal nature of the animal plays no role in this part's coming into being. However, once the membrane is in place, the formal nature co-opts it as a subsidiary part. Since the membrane is fat, and fat is hot, and since what is hot is able to concoct, the membrane contributes to the concoction of food, by making the process easier and faster. The membrane's contribution to the function of food concoction thus explains why it is *present*: because the part is useful,

[47] Ἡ μὲν οὖν γένεσις ἐξ ἀνάγκης συμβαίνει τοιαύτη τοῦ μορίου τούτου· ξηροῦ γὰρ καὶ ὑγροῦ μίγματος θερμαινομένου τὸ ἔσχατον ἀεὶ δερματῶδες γίνεται καὶ ὑμενῶδες, ὁ δὲ τόπος οὗτος τοιαύτης πλήρης ἐστὶ τροφῆς . . . Ἡ μὲν οὖν γένεσις τοῦ ἐπιπλόου συμβαίνει κατὰ τὸν λόγον τοῦτον, καταχρῆται δ' ἡ φύσις αὐτῷ πρὸς τὴν εὐπεψίαν τῆς τροφῆς, ὅπως ῥᾷον πέττῃ καὶ θᾶττον τὰ ζῷα τὴν τροφήν· τὸ μὲν γὰρ θερμὸν πεπτικόν, τὸ δὲ πῖον θερμόν, τὸ δ' ἐπίπλοον πῖον.

the formal nature of the animal retains the part and does not prevent its growth. The material potentials of the omentum give rise to the function it performs in the animals that have it, and are as such causally primary.

In a small number of cases, Aristotle refers solely to material necessity to explain both the coming to be and the presence of a part. Examples of such parts are the spleen[48] and many of the differentiations in the affections (such as hair color, eye color, and pitch of voice) that Aristotle discusses in *GA* V.1–7. These parts and differentiations are not strictly necessary for the animal to have, nor do they make any significant contribution to the well-being of the animal; but they are also not too harmful for the animal. In these cases, the formal nature of the animal has neither co-opted the part for a good purpose, nor excreted it from the animal's body. Such parts are solely the result of the interactions of materials during the generation of the animal (cf. *GA* V.1, 778a29–b1), and the potentials of the materials involved are causally primary in the explanations of both their coming to be and their presence.

In both cases, material necessity has causal primacy in the development of the part.

Pattern IV: Explanation of the absence of parts by reference to the lack of constitutive material

Aristotle often explains the absence of a part by reference to the lack of constitutive materials for that part in a particular animal. What is causally prior in these cases is the material nature of an animal, which puts up insurmountable constraints on the actions of the formal nature: since the animal lacks the appropriate kind of materials necessary for the production of a certain part, that animal therefore also lacks that part.[49]

For instance, this is how Aristotle explains the absence of outer ears in birds and egg-laying four-footers (*PA* II.12, 657a17–22):

[48] Reconstructing the precise causal explanation of the spleen is difficult. The spleen comes to be as a necessary consequence (*PA* III.7, 670a29–30: Ὁ δὲ σπλὴν κατὰ συμβεβηκὸς ἐξ ἀνάγκης ὑπάρχει τοῖς ἔχουσιν) of the availability of residues around the gut and bladder. Its presence is accounted for by reference to the principle of optimal balance (*PA* III.7, 669b27–670a2): "And it is on account of the liver being positioned more on the right that the nature of the spleen has developed; so that while in a way it is necessary, it is not exceedingly necessary [on this reading, see Lennox (2001b, 346)] in all the animals." The spleen is thus necessary for the bilateral symmetry of the body, and even though it does not perform any proper function, it is also not entirely useless (*PA* III.7, 670b4–6): "For the spleen draws off the residual fluids from the stomach and because it is blood-like it can assist in the concoction (δύναται συμπέττειν) of them." Another part that does not perform a proper function and that might just be a necessary consequence is the esophagus; see *PA* III.3, 664a24–31.

[49] On this pattern of material explanation, see Lennox (2001b, 228).

Birds only have [auditory] channels because of the hardness of their skin, and because they do not have hairs but are feathered: they do not have the sort of matter from which ears may be formed (οὐκ οὖν ἔχει τοιαύτην ὕλην ἐξ ἧς ἂν ἔπλασε τὰ ὦτα). And the same holds of those among the four-footed animals who lay eggs and have scales: for the same account also applies to these.

The material nature of birds and of some of the four-footers simply does not contain materials suited for the formation of outer ears, which is why they are absent (cf. *PA* II.5, 651a26–27; *PA* II.13, 657b13–15; b36; *PA* III.3, 664b20–665a9 and *PA* IV.5, 678a27–34).

A variation on this kind of explanation is the one in which the absence of a part is explained by reference to there *not being enough* constitutive material for the production of this part and another part, where the presence of this second part is either better for this particular animal or takes away the usefulness of the presence of the first part.[50]

Examples of the first pattern can be found in Aristotle's explanation of the lack of a complete set of upper teeth in horned animals (*PA* III.2, 664a1–3: nature takes from the nourishment assigned to the upper teeth for the growth of horns) and of the absence of tails in long-legged birds (*PA* IV.12, 694b18–20: the matter that is used in other birds to make tails is used up in these birds for the growth of legs). In each case, nature diverts the flow of materials designated or available to produce one part for the production of a different part, which explains why the first part remains incomplete or is entirely absent. The hierarchy according to which nature assigns priority to the production of the second rather than to that of the first is presumably a functional one:[51] necessary parts are realized first and completely, whereas subsidiary or luxury parts are realized later and are either missing or realized in incomplete form.

An example of the second pattern can be found in Aristotle's explanation of the absence of tails in human beings (*PA* IV.10, 689b21–25):

Mankind, then, has both haunches and fleshy legs because of the explanation just stated, and because of this it is tailless – for the nourishment which is being driven there is used up on these, and because it has haunches the necessity of the use

[50] Another variation of this type of explanation is used in *GA* I.5, 717b14–19 (cf. *GA* I.7, 718a18):

> Further, whereas the four-footed animals have the organ for coition, since it is possible for them to have it, birds and footless animals cannot have it because the former have their legs up by the middle of the belly and the latter have no legs at all, while the nature of the penis is connected with the legs and its position is there (καὶ τῇ θέσει κεῖσθαι ἐνταῦθα).
>
> Here the absence of a part is explained by reference to the absence of the "proper location" of that part.

[51] On this "principle of functional priority", see Lennox (2001a, 192–193).

of tails is taken away (ἥ τε γὰρ ἐκεῖ τροφὴ πορευομένη εἰς ταῦτα ἀναλίσκεται, καὶ διὰ τὸ ἔχειν ἰσχία ἀφῄρηται ἡ τῆς οὐρᾶς ἀναγκαία χρῆσις) – but for four-footers and the other animals it is the opposite.

Human beings, in order to be able to walk upright, need to have upper bodies that are lighter than their lower ones (which is why nature takes the bodily parts from the upper body and adds them to the lower one: *PA* IV.10, 689b11–13). However, by making the lower body heavier, nature has used up all the fleshy parts, which means that it cannot produce tails in human beings. In addition, the fleshiness of the haunches provides in itself sufficient protection for the residual outlet (cf. *PA* IV.10, 689b28–30), so that there is no more use for the presence of a tail (i.e., the presence of a tail would have been in vain). The absence of tails thus receives a complex explanation: tails are absent because their constitutive material has been used up for the production of a second part, whose presence makes the presence of tails superfluous.

In all the examples discussed above, what has causal priority is the material nature of the animal (cf. *PA* IV.12, 694b18: "all [birds] are from the same matter" and, perhaps, *PA* III.2, 664a5–6: "the cause of this is that both are of the same [material] nature, namely that of horn-bearers"). It is this factor that determines whether or not the materials necessary for the production of particular parts are available, either at all or in a sufficient supply.

Pattern V: Explanation of the coming to be of differentiations of parts that are "for the better" by reference to material necessity

In line with his explanations of the coming to be of subsidiary and luxury parts, Aristotle explains the coming to be of differentiations that are "for the better" primarily by reference to material necessity. It is the availability of residual materials that "allows" the formal nature of an animal to make use of them for the functional optimization of a part, which, although not strictly necessary for the animal, serves the animal's well-being. The potentials of the available materials are again the causally primary facts that give rise to the function to which the material is ultimately put by the animal's formal nature.

Earlier I discussed why human beings have the hairiest heads of all animals with hair (*PA* II.14, 658b2–10; see section 3.1) and why the feet of ducks are webbed (*PA* IV.12, 694a22–694b10; see section 4.2). Let me here present a slightly different example in which Aristotle explains why kidneys are the fattest of all viscera (*PA* III.9, 672a1–21):

The kidneys have the most fat of all the viscera: on the one hand, this is out of necessity, because the residue is filtered through the kidneys . . . So of necessity [they] come to be fatty because of this cause, as a result of what happens of necessity in animals with kidneys; on the other hand, they are also [fatty] for the sake of the preservation of the hot nature of the kidneys.[52]

The explanandum at stake is a differentiation between the realizations of parts within the same class of parts, namely viscera. For the kidneys are the fattest of all viscera, and according to Aristotle, this is due primarily to processes that take place of material necessity in the kidneys themselves.[53] By filtering fatty residue, the kidneys become more and more fatty themselves. But because what is fat is also very hot (see *PA* IV.3, 677b31–32), the formal nature of animals that have kidneys can make use of this material potential to preserve the heat of the kidneys, which contributes to the well-being of these animals.

The material causes picked out in explanations such as these are all materials that come to be of material necessity; due to the material potentials they have, nature can use or co-opt them for the functional optimization of parts.

Explanation by reference to final causes

Pattern VI: Explanation of the presence of parts by reference to the function these parts perform

In the patterns of explanation discussed above, final causes are picked out either indirectly (through the definitions of the substantial beings of animals), or directly, but in combination with material causes which are primarily responsible for the coming to be of functional features (the functions to which the materials are put account for their presence). Here I shall turn to the pattern of explanation in which Aristotle explains the presence of parts by first identifying their function.

In many cases, especially when explaining the presence of necessary parts, the reference to the function the part performs in the animal that has it completes the full explanation of the part's presence. This, for instance,

[52] Ἔχουσι δ' οἱ νεφροὶ μάλιστα τῶν σπλάγχνων πιμελήν, ἐξ ἀνάγκης μὲν διὰ τὸ διηθεῖσθαι τὸ περίττωμα διὰ τῶν νεφρῶν· . . . Ἐξ ἀνάγκης μὲν οὖν πιμελώδεις γίνονται διὰ ταύτην τὴν αἰτίαν ἐκ τῶν συμβαινόντων ἐξ ἀνάγκης τοῖς ἔχουσι νεφρούς, ἕνεκα δὲ σωτηρίας καὶ τοῦ θερμὴν εἶναι τὴν φύσιν τὴν τῶν νεφρῶν.

[53] Here I disagree with Lennox (2001a, 106–108), who argues (2001a, 107) that "we are told that kidney fat arises for the sake of the contribution it makes to preserving the (hot) nature of the kidneys."

is how Aristotle explains the presence of the larynx (*PA* III.3, 664a17–20): "The larynx is naturally present for the sake of breath (Ὁ μὲν οὖν φάρυγξ τοῦ πνεύματος ἕνεκεν πέφυκεν); for through this part animals draw in and expel breath when they inhale and exhale." The larynx is a necessary prerequisite for the function of breathing, and it is with a view to allowing the larynx to perform this function (together with the part's second function in humans of speech) that nature has made it from cartilaginous material (*PA* III.3, 664a35–b2; the reference to necessity in this passage is clearly conditional necessity). Aristotle does not always explicitly relate necessary functions such as breathing to the definition of the substantial being of those animals as breathers, but on occasion he does, as in the explanation of the presence of lungs (*PA* III.6, 669b8–13):

> In general then the lung is for breathing, and it is bloodless and of such a kind for the sake of living beings. But what is common to these animals is nameless, and no name has been given such as "bird" [has been given] to a certain kind. For this reason, just as being for a bird is from something, so too having a lung belongs to the substantial being of these animals (καὶ ἐκείνων ἐν τῇ οὐσίᾳ ὑπάρχει τὸ πλεύμονα ἔχειν).

Summarizing his discussion of lungs, Aristotle first gives the function for the sake of which lungs are present (i.e., breathing), and then connects this function to what is common in the substantial being of the animals that have lungs. This suggests that it is ultimately a shared formal feature (i.e., being a breather of air) that is the causally primary factor in the explanation of why all "lunged animals" have lungs.

In the explanations of the presence of subsidiary and luxury parts, Aristotle also often starts his explanation by identifying the specific function a part serves. In section 3.2 we discussed Aristotle's explanation of the presence of kidneys: kidneys are present for the contribution they make to the collection of residue – a function that is primarily performed by the bladder in all animals with blooded lungs (*PA* III.7, 670b23–27). Kidneys are not necessary for this function (nature could have made these animals without kidneys, and they would still have been able to collect their residue in virtue of the fact that they possess a bladder), but their presence optimizes the functional performance of the bladder and they are therefore good for the animal to have (had nature made these animals without kidneys, they would not have been able to collect their residues as well as they can now that they do have kidneys). However, since kidneys are not the necessary prerequisites for the animal to perform this function of collecting residue (for otherwise, they would have been present in all blooded animals), it

seems that the coming to be of kidneys cannot be explained by reference to conditional necessity and primary teleology. The function subsidiary parts such as kidneys end up performing is instead primarily caused by material necessity: it is because material necessity produced extra materials with certain potentials that formal natures can use those materials for the production of parts that serve the animal's well-being. Even though the goal-directed actions of the formal natures are responsible for the structure, retainment, and presence of such parts, these parts would never have come to be if it were not for the prior operation of material necessity.

This pattern of what I have called secondary teleology is much clearer in the case of luxury parts: again, Aristotle starts by identifying the function for which the luxury part is present, but then often continues to discuss the causal role played by materially necessitated processes in the coming to be of that part. For example, this is how Aristotle starts his discussion of horns (*PA* III.2, 662b23–30):

> We must speak about horns. For those, too, grow naturally in those that have them on the head. No animal that is not live-bearing has them. In virtue of similarity and extension "having horns" is also attributed to some other animals, but the function of horns belongs to none of them (ἀλλ' οὐδενὶ αὐτῶν τὸ ἔργον τοῦ κέρατος ὑπάρχει). For live-bearing animals have them for protection and strength (βοηθείας γὰρ καὶ ἀλκῆς χάριν), which turns out to be the case for none of the other animals said to have horns. For none of them use their horns either while defending themselves or for overpowering, which are the functions of strength.

However, as we saw in section 3.2, in the second half of his discussion of horns, Aristotle turns to the question of how "nature according to the account has made use of things present of necessity for the sake of something" (*PA* III.2, 663b21–22) and states that it is the defensive potentials of the residual material available in these animals that allowed nature to use it for the production of horns (*PA* III.2, 663b22–35). What is causally primary in the full explanation of the presence of horns is thus the potentials the materials have of necessity; the function of defense is imposed on the available materials only secondarily.

In all these examples the presence of parts is explained first and foremost by reference to the function they serve, but this function is not necessarily also the causally primary fact in the full explanation. The primary cause of the coming to be and presence of vital and essential parts is form;[54] the

[54] Cf. Charles (1997, 30): "The favoured mode of explanation applicable to biological natural kinds is teleological, and the Form of the kind is the explanatorily basic feature."

primary cause of the coming to be and presence of subsidiary and luxury parts is matter.[55]

Pattern VII: Explanation of the differentiation of parts by reference to a second function a part needs to perform

Sometimes Aristotle refers to two or even more functions in the explanation of the presence of parts. An example of this is Aristotle's account of teeth (*PA* III.1, 661a36–b6):

> In other animals [i.e., other than human beings], the nature of the teeth is present in common [cf. *PA* III.1, 661b7: *koinê chrêsis*] for the preparation of nutrition, yet distinctively according to kinds in some for strength, which in turn has been divided into the performance of strength and the avoidance of it – for some have it for the sake of both, namely both the avoidance of it and the performance of strength, such as for example as many among the wild animals as are of the nature of flesh-eaters; others have them for protection, such as many of the wild and tame animals do.

According to this passage, the *common* function of teeth is the preparation of nutrition, which presumably means that in all animals that have teeth, their presence is to be explained by reference to this function (teeth are presumably subsidiary parts for the function of nutrition; cf. Aristotle's discussion of teeth in *GA* V.8). In addition to producing and differentiating the part for the performance of this primary function, nature may also adapt or co-opt it for a secondary function, which is distinctive for different kinds of animals (*PA* I.5, 645b20–28; *PA* III.1, 662a22–24): "But nature has collected all these uses together in one, producing a differentiation of this part for the differences of its operation."[56] This second function is in many cases a luxury function, or a function that is already realized by some other part that is the necessary prerequisite for the realization of that function. So, although this second function is not part of the causal account of the part's coming to be as such, it may play a role in causing its material or structural differentiation(s).

What guides the actions of the formal nature in producing one part for the sake of one function or in uniting several functions in one and the same part are the principles of "economical distribution" (see above, section 4.2), illustrated by Aristotle in the following analogy (*PA* IV.6, 683a19–25):

[55] Note that Aristotle never refers directly to functions to explain absences of parts; instead he invokes the principle that nature does nothing in vain; see my discussion of this principle above, in section 4.2.

[56] Ἡ δὲ φύσις ἅπαντα συνήγαγεν εἰς ἕν, ποιοῦσα διαφορὰν αὐτοῦ τοῦ μορίου πρὸς τὰς τῆς ἐργασίας διαφοράς.

And it is better, where possible, not to have the same instrument for dissimilar uses, but the one that is defensive [i.e., the sting] 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.[57]

Nature prefers to produce one part for the performance of one function (here, stings for protection and tongues for nourishment), but where this is not possible, for instance because the animal is too small to carry more parts, nature uses – (παρα)καταχρῆται[58] – one part for several functions (here, in small two-winged insects, the tongues serve for both nourishment and protection).

In all these examples, the part's primary function explains its presence as such; the animal's *differentiae* explain the part's primary differentiations; and the secondary function explains the part's secondary differentiations.[59]

Pattern VIII: Explanation of differentiations of parts by reference to the functional optimization they serve

Aristotle explains differentiations of parts by reference to the functional optimization they serve in the animals that have those differentiations, both when they are necessary for the animal to survive or to be the kind of animal it is, and when they are "for the better" and serve the animal's well-being. We have already seen several examples of both necessary and subsidiary functional optimizations of parts; here I present one more example of each kind of explanation.

As Aristotle points out, not only are the differentiations of wings in birds necessary for their distinctive ways of life (*PA* IV.12, 693b28–694a9), but so are those in insects (*PA* IV.6, 682b7–11):

[57] Βέλτιον δ' ἐνδεχομένου μὴ ταὐτὸ ὄργανον ἐπὶ ἀνομοίας ἔχειν χρήσεις, ἀλλὰ τὸ μὲν ἀμυντικὸν ὀξύτατον, τὸ δὲ γλωττικὸν σομφὸν καὶ σπαστικὸν τῆς τροφῆς. Ὅπου γὰρ ἐνδέχεται χρῆσθαι δυσὶν ἐπὶ δύ' ἔργα καὶ μὴ ἐμποδίζειν πρὸς ἕτερον, οὐδὲν ἡ φύσις εἴωθε ποιεῖν ὥσπερ ἡ χαλκευτικὴ πρὸς εὐτέλειαν ὀβελισκολύχνιον. Ἀλλ' ὅπου μὴ ἐνδέχεται, καταχρῆται τῷ αὐτῷ ἐπὶ πλείω ἔργα.

[58] See, e.g., *PA* II.16, 659a20–23: "Since it [i.e., the trunk] is such, nature, as usual, uses the same parts for several things (ἡ φύσις παρακαταχρῆται, καθάπερ εἴωθεν, ἐπὶ πλείονα τοῖς αὐτοῖς μορίοις), here using the trunk in place of the front feet." Cf. *PA* II.16, 659a34–36 (again about the elephant's trunk); *PA* II.16, 659b34–660a2 (tongue; lips); *PA* III.9, 671a35-b2 (kidneys); *PA* IV.10, 689a5–7 (outlets for residues and semen); *PA* IV.10, 688a19–25 (mammae); and *PA* IV.10, 689b34–690a4 (tails).

[59] Cf. Lennox (2001b, 245).

Among those [i.e., insects] that are flyers – the ones whose life is nomadic and for whom it is necessary to range widely for nutrition (διὰ τὴν τροφὴν ἀναγκαῖον ἐκτοπίζειν), are both four-winged and have a light body mass, such as for instance the bees and the animals related to them: for they have two wings on each side of the body.

Those insects that are flyers do not all have the same number of wings (and the same body mass): bees, for instance, have four wings (rather than two or none) because their nomadic way of life and expansive search for food *require* a specific functional optimization of their ability to fly. Note that Aristotle only identifies the *differentiae* in virtue of which bees have the number of wings they have, without specifying the exact function that is being served by this differentiation. Even though the differentiation of wings is present for a functional optimization of those parts, the *differentiae* are causally primary in this explanation.

Another example of a differentiation that is not necessary, but better for the animal to have (again, because nature could have designed the animal without this differentiation), is the distinctive ability of snakes to turn their head to the rear while the rest of their body remains at rest (*PA* IV.11, 692a2–8):

A cause of this is that, like insects, they are capable of coiling, such that they have their vertebrae flexible and cartilaginous. This thus happens to them from necessity (ἐξ ἀνάγκης), because of this cause, but it is also for the better (πρὸς δὲ τὸ βέλτιον), for the sake of protection against being hurt from behind.

The function the differentiation of backbones serves in snakes is that of protection: it allows them to turn their head and watch out for dangers, and this is beneficial to them. This benefit, however, is not what conditionally necessitated the differentiation; the special ability is rather a necessary consequence of material potentials that are present for the sake of allowing the snake the capacity for locomotion. Again, the material potentials are causally primary in this explanation; they give rise to the function of coiling of necessity, which is then co-opted by the formal nature of snakes for their protection.

In sum, whereas material or structural differentiations of parts typically serve a functional optimization of that part in the animal that has it, these functional differentiations themselves are either given with the substantial being of the particular kind of animal, or follow from the available material potentials.

4.4 CONCLUSION

In the sections above, we have seen that Aristotle uses a wide variety of heuristic and explanatory strategies in order to explain the presence, absence, and differentiations of biological features in *De Partibus Animalium* books II–IV.

When the explananda are so complex that both mere observation of the animals in question and the use of their definitions fail to reveal the causes sought for, Aristotle relies on a third strategy. It involves the use of teleological principles, which generate thought experiments that help to discover the relevant causal factors to be picked out in explanations. There are many different kinds of principles at play in Aristotle's biology (as is evidenced by the wealth of examples from his *De Partibus Animalium*), but each seems to have its own specific use. The verbs of agency ascribed to the formal natures in these principles are more than mere metaphors, or reflections of the analogy between art and nature: rather, they reflect different causal patterns underlying the generation of animals and their parts. This also holds of the uses of "better" and "best" in these principles: the terms are not univocal, but whereas "for the better" picks out the operation of secondary teleology, "the best" identifies some feature as being the best solution in the "design" of a particular kind of animal relative to its specific substantial being.

In addition, I have argued that Aristotle uses teleological principles predominantly as heuristic tools in *De Partibus Animalium*, which help to determine the exact causal relationship between a part, the function it performs, and the animal to which it belongs in those cases where this relationship is not immediately discernible. The principles are not a priori postulates that cannot be refuted: they are established inductively through observation and are used – each in its own context – to help set up a framework within which inferences to the best explanation can be drawn, and thereby help Aristotle to yield the phenomena in the most plausible, coherent way.

The three basic patterns of explanation in *De Partibus Animalium* books II–IV reflect the causal differences between the operation of primary and secondary teleology. Functions are often picked out first in explanations, but references to final causes alone only rarely constitute the complete explanation provided by Aristotle, and they are never causally primary. The presence and differentiations of parts that are necessary for the animal to have are explained by reference to the functions (or functional optimizations) they perform, but these functions are ultimately referred

back to the definition of the substantial being of either the animal itself or of its wider kind. Vital and essential parts and differentiations are exhibited to be the necessary prerequisites for the realization of the animal's form. The presence of features that are "for the better" and that are not strictly necessary for the design of the animal (although the actual animal might not be able to function without it) is also explained by reference to the functions or functional optimizations served. However, what ultimately gives rise to these functions is the availability of materials with certain kinds of material potentials. Subsidiary and luxury features are exhibited to be the result of the formal nature using or co-opting materials that are already available and have often come to be by material necessity. In both cases, functions are most salient in the explanations of biological phenomena – they have explanatory priority, but the material or formal causes are to be picked out as middle terms in those explanations, because they are prior in causation.

CHAPTER 5

Making sense of the heavens: the limits of teleological explanation in the De Caelo

5.0 INTRODUCTION

In his programmatic opening to the *Meteorologica* (*Meteor* I.1, 338a20–339a10), Aristotle puts the issues discussed in *De Caelo* at the center of his science of nature. The study of "the stars ordered according to their upper motion" (*Meteor* I.1, 338a21–22), and of "the bodily elements, their number and nature, and their change into each other" (*Meteor* I.1, 338a22–24) is said to follow his examination of the first principles of nature and of natural change in general, but to precede his investigations of sublunary living nature.[1] In accordance with this outline, Aristotle first – in *De Caelo* book I – argues for the existence of a fifth, heavenly element (i.e., aether) in addition to the familiar four sublunary, changeable ones (i.e., air, water, fire, and earth), and discusses the nature and characteristics of the universe in its entirety (i.e., its size, uniqueness, and eternity). Then, in book II, Aristotle turns to the motions and features of the heavens as a whole, of the individual planets and stars, and lastly of the Earth. Next, in book III, he focuses on the nature and motions of the four sublunary elements, saving his definitions of "weight" and "lightness" associated with these elements for book IV. By engaging with the heavenly phenomena in the first two books and only then turning to the sublunary elements, Aristotle mimics the order of exposition of Plato's *Timaeus*.[2] It is this latter treatise, and the theory of cosmology presented in it, that also forms the main target of philosophical and scientific debate in the *De Caelo*.

In this chapter, my main concern will be with Aristotle's methods of discovery and the explanations he provides of the features and motions of

[1] The order outlined in the *Meteorologica* passage is presumably didactical rather than chronological. On this issue, and on the place of the *De Caelo* in Aristotle's science of nature, see Burnyeat (2004, 13–16) and Falcon (2005, 2–13).

[2] Cf. Burnyeat (2004, 15); on Aristotle's critical response to the *Timaeus* in *De Caelo*, see Johansen (2009, 1–23).

the heavenly bodies in the second book of the *De Caelo*.[3] Within this book, traces of Aristotle's teleological worldview are not hard to find. In book I, Aristotle had already argued that the nature of the sublunary elements is such that it provides these elements with an immanent capacity to exercise their specific motions to reach their natural places.[4] In book II he adds that teleology also permeates the heavenly domain of the stars and planets, as all celestial motions are said to be trying to reach "the most divine principle" as a final cause (*Cael* II.12, 292b20–25).

Although teleology as a natural tendency is thus without doubt an important part of the make-up of Aristotle's cosmology and celestial physics, his general reliance on teleology to *explain* the different motions and features of the heavenly bodies seems to be limited in comparison with the other physical and biological treatises I discussed in the previous chapters. For the whole of the *De Caelo* contains only seven instances of explicit teleological explanation, six of which pertain to the heavenly phenomena in the second book (there is only one instance of teleological explanation in book I, pertaining to circular motion in general, and there are none in books III and IV, which deal exclusively with the sublunary elements). For an overview of the explananda and the teleological principles used, see Table 5.1.

Moreover, with one exception (in *Cael* II.3, 286a8–9), none of these explanations refer directly to final causes. Instead, they all proceed through the application of teleological principles, such as "nature does nothing in vain," which – as we saw in section 4.2 – in biology are only applied in very specific explanatory contexts, namely, in those cases where the discovery of final causes by means of mere observation or use of definitions is relatively difficult. This suggests that teleology is not readily discernible in the case of the heavens.

Aristotle's use of teleological principles in the *De Caelo* is all the more remarkable because the teleological explanations are the only fully fledged physical explanations Aristotle offers in this treatise. By this I mean that the teleological explanations are the only explanations in the *De Caelo* that

[3] In *De Caelo* book II, Aristotle first discusses the features, motions, and shape of the heaven as a whole (*Cael* II.1–6: the heaven is eternal; possesses the dimensions left and right, above and below; moves forward in circular, regular motions; and is spherical in shape); then turns to the composition, shape, and motions of the heavenly bodies (*Cael* II.7–12: the heavenly bodies are made of aether; are spherical in shape; move in virtue of the spheres in which they are fixed; differ in relative speeds by which they move and in complexity of motions); and ends with an exposition of the position, motion, and shape of the Earth (*Cael* II.13–14: the Earth rests at the center of the universe and is therefore motionless; its shape is spherical).

[4] Left to their own devices, the four sublunary elements would naturally move to their natural places and thus constitute four separate, concentrically arranged spheres. See also Bodnár and Pellegrin (2006, 282).

Table 5.1 *The seven teleological explanations and principles used in the* De Caelo

No.	Text passage	Explananda and teleological principle used
1.	*Cael* I.4, 271a22–33	Why is there no motion contrary to that in a circle? *Teleological principle:* nature does nothing in vain.
2.	*Cael* II.3, 286a7–9	Why is there a plurality of motions of the heavens? *Teleological principle*: everything that has a function is for the sake of that function.
3.	*Cael* II.5, 288a2–12	Why do the heavens move in the direction they do? *Teleological principle:* nature always does what is best among the possibilities.
4.	*Cael* II.8, 290a29–35	Why do stars not move on their own (or, why do stars not have any organs for motion)? *Teleological principle:* nature does nothing in vain.
5.	*Cael* II.9, 291a23–25	Why do stars not move on their own (or, why is there no harmony of the spheres)? *Teleological principle:* nature does nothing in vain.
6.	*Cael* II.11, 291b10–15	Why do stars not move on their own (or, why do stars not have a shape fit for locomotion)? *Teleological principle:* nature does nothing in vain.
7.	*Cael* II.12, 292a15–b25	Why is there a difference in the complexity of the motions of the different heavenly bodies? *Teleological principle*: actions are for the sake of something.

address the nature and causes of natural phenomena and that build upon some evidence from observation. For the most part, Aristotle's cosmological treatise consists of statements of fact and of dialectical arguments building upon mathematical or numerological principles, which mainly address the number, shape, and possible motions of the heavenly bodies.[5]

The purpose of the present chapter is to shed light on the specific nature of the teleological explanations in Aristotle's cosmology and on the problems related to their application within this particular branch of the science of nature.[6] In particular, I shall argue that the way in which Aristotle uses

[5] On this type of "dialectical" argument in *De Caelo*, see Bolton (2009).

[6] The issues that I should like to discuss in this chapter have received relatively little attention in the scholarly literature on Aristotle. Scholars who have studied teleology in Aristotle's cosmology have focused almost exclusively on the role of the Prime Mover as a final cause in Aristotle's *Physica* and *Metaphysica*. See, in particular, Kahn (1985). Other studies on cosmology have either left out the question of teleology completely (Falcon 2005), or have subsumed it under the "normal" use of teleology (Johnson 2005). On the other hand, Leggatt, in his commentary on the *De Caelo*, claims that Aristotle consciously played down the role of teleology in his cosmological treatise, because

teleological principles to generate explanations of heavenly phenomena is proper to the natural sciences and builds upon their – very successful – heuristic usage in biology.[7] This chapter thus traces Aristotle's heuristic use of teleological principles outside the immediate context of biology and shows how these principles are operative throughout Aristotle's natural treatises. The fact that the heavenly domain – as opposed to the biological realm (see, e.g., *PA* I.5, 644b23–645a4) – is empirically underdetermined, limits the explanatory force of these explanations (hence Aristotle's "warning" that the explanations he will offer are at most reasonable), but this does not mean that the explanations themselves are not *phusikôs* or scientific: they generate the best causal accounts of the features and motions of the heavenly bodies Aristotle can offer.

In section 5.1 I shall say more about the scientific status of cosmology. In sections 5.2–5.4, I shall discuss three representative examples of Aristotle's use of teleological principles to generate explanations in the second book of the *De Caelo*.

5.1 COSMOLOGY AS SCIENCE OF NATURE

The approach to the study of the heavens taken by Aristotle's predecessors and contemporaries had often been mathematical in nature. (In the *De Caelo*, Aristotle refers to them as "mathematicians concerned with ἀστρολογία" – where ἀστρολογία is best rendered by "astronomy" – or simply as "mathematicians.")[8] The theory reportedly put forward by Eudoxus and revised by Callippus represented the apparent motions of the stars and planets as outcomes of systems of concentric rotating spheres. This theory as reported did not explain the physical mechanics and causes underlying those motions, perhaps because neither Eudoxus nor Callippus was concerned with those issues. In *Ph* II.2, 193b22–194a12, Aristotle distinguishes this theoretical manner of studying the heavens

of his alleged dissatisfaction with the type of intentional and psychological teleological explanation deployed by Plato in the *Timaeus*; see Leggatt (1995, 18, 36–37, 207). Hence, Leggatt offers little analysis of the teleological explanations actually provided in this treatise, because he believes them to be of little importance.

[7] The possible relative chronology of Aristotle's works (according to which the *De Caelo* is an early work and the biological works are late) does not affect my claim: since none of these treatises were published during Aristotle's lifetime, he may well have adjusted and revised them continuously in the light of new discoveries or conceptual distinctions made. For a defense of this view (based on a pedagogical interpretation of the cross-references in Aristotle), see Burnyeat (2004, 21–22).

[8] See *Cael* II.14, 297a2–4 (Μαρτυρεῖ δὲ τούτοις καὶ τὰ παρὰ τῶν μαθηματικῶν λεγόμενα περὶ τὴν ἀστρολογίαν; "what the mathematicians say in *astrologia* also testifies to this"); *Cael* II.10, 291a29–b9; and *Cael* II.14, 298a15.

from the proper study of nature by pointing out that astronomers – like mathematicians – study the properties of bodies not *qua* properties of those bodies, but *qua* separable from them.[9]

For Aristotle, however, just as for Plato in the *Timaeus*[10] and for some of the Presocratics before him, the study of the heavens is *also* part of the investigation of nature,[11] and thus the heavenly bodies and their features will have to be studied not only *qua* spheres but also in a manner that takes their nature fully into account – nature in the sense of both form and matter. Aristotle intends his *De Caelo* to be a treatise in natural science, not in mathematics or mathematical astronomy. This physical approach to the study of the heavens is evidenced, for instance, in Aristotle's claim that each of the spheres in his system is corporeal, and thus not simply a mathematical construct (*Cael* II.12, 293a7–8): "For each sphere is some kind of body (σῶμά τι τυγχάνει ὄν)."

Therefore, if for Aristotle cosmology is part of the science of nature, and if cosmological phenomena are – at least for the most part – teleological in nature, as Aristotle seems to believe,[12] then scientific knowledge of these phenomena will involve knowledge of all four causes.[13] A merely

[9] See also *APo* I.13, 78b39; *Meta* I.8, 989b33–990a15; *Meta* III.2, 997b16–998a1; and *Meta* XIII.2, 1076b39–1077a4, where Aristotle describes astronomy as not dealing with perceptible magnitudes or with the heavens above. Cf. Simplicius *In Ph*. 293, 7–10 and 290, 20–24 on the Greek conception of astronomy as being part of mathematics, not physics; Mueller (2006, 179–181).

[10] Cf. also Pl. *R* 529a–530e.

[11] Aristotle emphatically introduces his study of the heavens as a part of the study of nature: see for instance *Cael* I.1, 268a1: Ἡ περὶ φύσεως ἐπιστήμη; *Cael* III.1, 298b2–3: τῆς περὶ φύσεως ἱστορίας; and *Meteor* I.1, 338a20–5.

[12] Aristotle repeatedly offers the a fortiori argument that if one agrees that animals and plants neither come to be nor exist by spontaneity (but for the sake of something), then the claim that spontaneity is the cause of the heavens – which are most divine and exhibit the greatest order – must be absurd, and that one has to conclude that final causality pertains to the heavenly realm as well. See *Ph* II.4, 196a24–b5; *Ph* II.6, 198a1–13, and *PA* I.1, 641b10–23:

> In addition, natural science can pertain to nothing abstract, because nature makes everything for the sake of something. For it seems, just as in artifacts art is present, so too in things themselves there is some other principle and such cause, which like the hot and the cold we have from the universe (ἐκ τοῦ παντός). This is why it is more likely that the heavens have been brought into being by such a cause – if they have come to be – and are due to such a cause, than that the mortal animals have been. Certainly the ordered and definite are far more apparent in the heavens than around us, while the fluctuating and random are more apparent in the mortal sphere. Yet some people say that each of the animals is and comes to be by nature, while the heavens, in which there is not the slightest appearance of chance and disorder, were constituted in that way by chance and the spontaneous.

[13] Note that Aristotle does not believe *all* heavenly phenomena to be teleological, but only those that involve natural substances: knowledge of phenomena such as eclipses will therefore only involve knowledge of material-efficient causes. For scientific knowledge involving knowledge of all four (or at least of all possible) causes, see, e.g., *APo* I.2, 71b9–13; *APo* II.11, 94a20–27; *Ph* I.1, 184a10–16; *Ph* II.3, 194b17–23; and *Meta* VIII.4, 1044a33–b20; cf. also Falcon (2005, 15).

mathematical approach – such as that favored by the astronomers and by Aristotle himself in many of the arguments in the *De Caelo* – will not be sufficient to generate complete knowledge concerning the heavens. For instance, by its very nature, mathematical reasoning cannot yield understanding of final causes (there are no final causes in mathematics, because there is no change or good in that domain; see *Meta* II.2, 996a21–b1). Astronomy therefore only yields understanding of the shape and size of the heavenly bodies, and of their distances from each other and from the Earth. This gives important information about the quantitative properties of the heavenly bodies and their motions, especially if combined with arguments drawing from principles of physics. However, as a natural philosopher, Aristotle is also interested in the nature of the heavenly bodies, in their material composition, and in the causes of their motions. The opening words of the *De Caelo* are significant (*Cael* I.1, 268a1–4): "The science of nature (ἡ περὶ φύσεως ἐπιστήμη) is patently concerned for the most part with bodies and magnitudes, the affections and motions of these, and further, with all the principles that belong to this kind of substance."

Because the natural sciences are typically concerned with identifying all four types of cause, and since for teleological phenomena such as the heavenly features and motions the understanding of final causes is especially crucial, Aristotle needs an additional strategy to extend scientific knowledge as he understands it to the domain of the heavens. This strategy involves the application of teleological principles of the sort he employs in his biology precisely as a heuristic means for finding final causes when they are not immediately observable. Since these teleological principles are generalizations – based on observations of actual natural phenomena – over the goal-directed actions of formal natures (or souls) of living beings, Aristotle can use these principles as a possible means of discovering the underlying causal mechanisms in cases where the causally relevant factors are *not* open to visual inspection: this, of course, on the assumption that nature acts in a similar goal-directed way in all cases. However, whether the explananda at hand are actually similar enough to the phenomena that have known, observable causes, and thus whether the application of the teleological principle will be successful, is an open question: there will be cases where a teleological principle is applied but no final cause is found (cf. the question of why some octopuses have one row of suckers whereas others have two; see *PA* IV.9, 685b12–16 and sections 4.2–4.3 above). In short, Aristotle uses teleological principles in the *De Caelo* to discover purposes and functions among the heavenly

phenomena, and thereby tries to turn his study of the heavens into a proper natural science.[14]

As outlined in section 3.1, scientific research comprises for Aristotle two stages of enquiry: the first stage consists in the systematic collection of observations of the phenomena, and the second one in the attempt to detect correlations and to give causal explanations of those phenomena. However, as Aristotle makes clear several times in the *De Caelo* (see his introductions to teleological explanations discussed below in section 5.2), it is not at all an easy undertaking to give such explanations of cosmological phenomena. The central problem is the limitedness – or even lack – of empirical evidence: the observations of the heavens we have are too few, and the objects of observation are too far away to offer any certain evidence (cf. *Meteor* I.7 and *APr* I.30). The only observation that seems to be rock solid is that of the rotation of the heavens (*Cael* I.5, 272a5–6: "we see the heavens turning about in a circle"). Notwithstanding the many methodological caveats we find in *De Caelo*, Aristotle remains confident that it is still possible to give explanations of cosmological phenomena that go beyond the mere fact that the heavens rotate, and also beyond the conclusions mathematical or numerological reasoning yields about numbers, sizes, shapes, and distances, for instance.

My contention is that Aristotle's use of teleological principles, by analogy with their use in the biological domain,[15] forms an important part of his strategy to increase the possibility of gaining scientific knowledge of the heavens. Thus, when Aristotle does proceed to give "physical" or

[14] Aristotle's treatment of cosmology as part of the study of nature also explains why the teleological explanations are mainly found in the second book of the *De Caelo*. For it is this book that deals most specifically with the heavenly bodies *qua* subjects of motion, that is, with the plurality, direction, and complexity of their motions, the physical mechanisms underlying those motions, and the shape of the heavenly bodies required to perform those motions. On the other hand, we find no teleological accounts regarding Aristotle's views on the nature of the heavens as a whole (discussed primarily in book I), or regarding the motions and features of the four terrestrial elements (dealt with in books III and IV), which are not part of cosmology properly speaking. Aristotle's use of causal language in the *De Caelo* also reveals that the second book is more concerned with Aristotle's *own* attempts to provide physical explanations than any of the other books: of the twenty-eight occurrences of the term *aition* in the whole of the *De Caelo*, ten can be found in the second book (as opposed to four in the first book; three in the third, and eleven in the fourth book), and of the twenty-eight occurrences of the term *aitia*, twenty-one can be found in the second book (as opposed to none in the first and the third book, and seven in the fourth), while the references to causes and explanations in the fourth book are often (i.e., in *Cael* IV.1, 308a25; *Cael* IV.2, 309a5; *Cael* IV.2, 309a10; *Cael* IV.2, 309a28; *Cael* IV.2, 310a2; *Cael* IV.6, 313a22) – although not exclusively – used in descriptions of views entertained by Aristotle's predecessors.

[15] Pace Falcon (2005, 101), who argues that "Aristotle is reluctant to extend the results achieved in the study of plants and animals to the imperishable creatures populating the celestial world."

"scientific" explanations in the *De Caelo*, he is unremittingly teleological in his approach. The explanations thus presented will not qualify as demonstrations in a strict sense (i.e., not as demonstrations approaching the model as described in the *Analytica Posteriora* or in the first book of the *De Partibus Animalium*),[16] since they do not attempt to demonstrate necessary truths; they rather attempt to show the reasonableness of supposing certain causal scenarios. However, they go a long way towards taking away some of the puzzlement pertaining to the heavenly realm and thus in making sense of the heavenly phenomena. And, as Aristotle has indicated elsewhere,[17] "making sense" in such difficult circumstances entails giving an account of the heavens that is free of impossibilities.

Let us finally turn to some examples of the actual teleological explanations Aristotle provides in the *De Caelo*. Broadly speaking, Aristotle gives two kinds of teleological explanations. The first kind consists of explanations that stand on their own (that is, they do not form part of an interrelated sequence of arguments), and that set out to explain the *presence* of certain features and motions of the heavens. In these cases (i.e., *Cael* II.3, 286a7–9; *Cael* II.5, 288a2–12; and *Cael* II.12, 292a15–b25), Aristotle explains the presence of some observed fact by reference to the function it serves within the heavens as a whole. The basic teleological assumption is that whatever can be seen to be present must be there because it has a function or is good or better that way.

The second kind consists of those teleological explanations that explain the *absence* of heavenly features (this kind is used in *Cael* I.4, 271a22–33; *Cael* II.8, 290a29–35; *Cael* II.9, 291a23–25; and *Cael* II.11, 291b10–15). They usually follow a series of mathematical or numerological arguments following the style of the astronomers. While the latter point out that it is, for instance, mathematically impossible for some motion or feature to be present, the teleological explanation is set up to provide a counterfactual argument claiming that those motions or features in reality could not exist in the heavenly realm, because if they did, they would be in vain. The teleological principle invoked in all of these cases is that nature does nothing in vain.

In the next three sections, I shall discuss two examples from the first group and one example from the second group.

[16] Cf. Lloyd (1996, 182).

[17] *Meteor* I.7, 344a5–7: "We consider a satisfactory explanation of phenomena inaccessible to observation to have been given when we reduce them to what is possible."

5.2 EXPLAINING WHY THERE IS A PLURALITY OF MOTIONS OF THE HEAVENS (EXAMPLE 1)

A first example of a teleological explanation in the *De Caelo* pertains to the plurality of the heavenly motions: different heavenly bodies are observed to move in different directions – why is it that they do not all move in the same direction? Aristotle introduces his explanation as follows (*Cael* II.3, 286a3–7):

> Since there is no motion in a circle contrary to motion in a circle, we must examine why there are several locomotions, though we must try to conduct the inquiry from far off – far off not so much in their location, but rather by virtue of the fact that we have perception of very few of the attributes that belong to them [i.e., the motions]. Nonetheless, let us speak of the matter. The explanation concerning these things must be grasped from the following [considerations].[18]

This text shows that Aristotle is very well aware of the fact that it is problematic and difficult to offer explanations of what is present in the heavens, given the lack of empirical evidence. We are simply too far removed from the objects of inquiry in distance.[19]

It is significant that Aristotle nevertheless is confident that there is a way of answering this particular question, and that this answer follows from a *teleological* consideration. As we will see shortly, the consideration "from which the explanation must be grasped" is the supposition of the teleological principle that everything that has a function must exist for the sake of that function. By positing a teleological principle, and hence by setting a framework within which one can search for the possible functions of those very features that have been observed, one might be able to find the explanation of why those features are present. On the other hand, the implication also seems to be that this kind of knowledge cannot be gained by other means: observation is certainly ruled out (observation in this case will only yield knowledge of the fact that there are several motions, not

[18] Ἐπεὶ δ' οὐκ ἔστιν ἐναντία κίνησις ἡ κύκλῳ τῇ κύκλῳ, σκεπτέον διὰ τί πλείους εἰσὶ φοραί, καίπερ πόρρωθεν πειρωμένοις ποιεῖσθαι τὴν ζήτησιν, πόρρω δ' οὐχ οὕτω τῷ τόπῳ, πολὺ δὲ μᾶλλον τῷ τῶν συμβεβηκότων αὐτοῖς περὶ πάμπαν ὀλίγων ἔχειν αἴσθησιν. Ὅμως δὲ λέγωμεν. Ἡ δ' αἰτία περὶ αὐτῶν ἐνθένδε ληπτέα.

[19] Cf. Burnyeat (2004: 15–16) who observes that "*De Caelo* I contains an unusually high number of occurrences of words like εἰκότως and εὔλογον which express epistemic modesty: this or that is a *reasonable* thing to believe." I should like to add to this observation that words of "epistemic modesty" are even more abundant in book II where the explanation of the presence and absence of heavenly features properly speaking is at stake (I counted only two occurrences of the word εὔλογον and none of the word εἰκότως in book I; in book II, I counted fifteen occurrences of the word εὔλογον and two of the word εἰκότως).

of the reason why), but also mathematical arguments will not do, again because they cannot yield the reason why there are several motions.

Interestingly, the other two teleological explanations that stand on their own and that explain the presence of heavenly phenomena are also immediately preceded by a discussion of the methodological problems related to this very enterprise of providing explanations in the strong sense for phenomena at such a remove (see *Cael* II.5, 287b29–288a2, II.12, 291b24–28 and II.12, 292a14–18). In all these methodological introductions, Aristotle expresses his conviction that, even though the empirical evidence is scanty, it is still possible to state the phenomena; and given all the limitations, the explanations offered are the best ones possible.[20] For that reason, he says, one should not criticize the person conducting the investigation for being overly ambitious or for not providing more accurate and necessary truths (*Cael* II.5, 287b29–288a2); rather one should be content with "small solutions in things in which we have the greatest difficulties" (*Cael* II.12, 291b28). The explanations that follow these introductions are all teleological in nature, which shows that Aristotle also has great confidence in the explanatory force of teleology in these difficult cases.[21]

Returning to our example from *Cael* II.3, the teleological principle from which "the explanation of why there are several locomotions of the heavens must be grasped," is that "each thing that has a function is for the sake of that function" (*Cael* II.3, 286a8: Ἕκαστόν ἐστιν, ὧν ἐστιν ἔργον, ἕνεκα τοῦ ἔργου). This is a common principle in Aristotle's biology (see, e.g., *PA* I.5, 645b15–18), where it is claimed that each part of the body is for the sake of the performance of some function. By stating it here, Aristotle makes explicit that, in his view, teleology extends to the heavenly domain, and that hence some of the puzzling cosmological phenomena can be explained by reference to teleology. Aristotle also *must* refer to teleology here, since material causes alone cannot account for the differences in

[20] Pace Guthrie (1939, 165).

[21] This point is also made by Lloyd (1996, 171) with regard to the explanations in *Cael* II.5 and II.12: "Thus it is surely significant that both on the problem of why the heavens revolve in one direction rather than in the other – in II 5 – and on the difficulty of the complexities of the motions of the non-fixed stars – in II 12 – his positive speculations invoke teleology." I disagree, however, with Lloyd's interpretation of the significance of this connection between Aristotle's methodological disclaimers on the one hand and his use of teleology on the other. According to Lloyd (1996, 161, 173, 175, 180), Aristotle's main interest in cosmology follows from his concern to establish his teleology, and especially the orderliness of the heavens. However, I do not believe that Aristotle's epistemological hesitations are not genuine here, or that Aristotle's concern for the establishment of teleology is all that prominent in the *De Caelo*. On the contrary, I believe that Aristotle uses his teleology, already firmly established on the basis of the abundance of empirical evidence discussed in the biological works, to extend – where possible – his knowledge of the heavens.

locomotion in the heavens (for all spheres appear to be made of the same material, which is aether),[22] and there are no other kinds of explanation available. The assumption that everything that has a function is present for the sake of that function allows a series of inferences that ultimately yield the explanation of why there are several motions of the heavens: if this principle applies, then each of the motions must serve its own function.

Aristotle continues his explanation by identifying the function of the first motion in the following way (*Cael* II.3, 286a8–11):

> The activity of god is immortality, and that is everlasting life. In consequence it is necessary that an eternal motion belongs to the divine (ὥστ' ἀνάγκη τῷ θειῷ[23] κίνησιν ἀΐδιον ὑπάρχειν). Since the celestial sphere is such (for its body is a divine thing), for that reason it has a circular body, with which it naturally moves in a circle for eternity.

The reasoning is that, if the function of the divine is immortality, and if the heavens are divine, then the function of heaven is immortality. Furthermore, if being immortal is the defining function of heaven, then it is a necessary prerequisite for it to possess an eternal motion. That is, for heaven as a whole to be able to perform its defining function or its activity of being immortal, it has to perform at least one kind of eternal motion. And the only kind of motion capable of uniform eternal continuity is motion in a circle.

This explanation, curious as it may sound, resembles a particular type of explanation that Aristotle frequently offers in his biological works (see sections 3.2 and 4.3). Consider the following example taken from *De Partibus Animalium*, where Aristotle provides an explanation of why birds have wings (*PA* IV.12, 693b6–14): "For the substantial being of the bird is that of the blooded animals, but at the same time it is also a winged animal . . . and the ability to fly is in the substantial being of the bird."[24] Aristotle takes the essence, or the substantial being of the animal, as a starting point, and derives from this essence the necessary prerequisites for the animal to have in order to be able to perform its defining function. Just as birds must have wings because they are essentially flyers (and the only way for birds

[22] Cf. Simplicius, quoting Alexander, *In Cael* 396, 6–9: "it is not possible to make either natural or material necessity responsible for these things, since both spheres have the same matter, but it is necessary to give an account of the difference in terms of some divine governance or ordering." For an analysis and defense of Aristotle's arguments for the existence of aether, see Hankinson (2009).

[23] Here I follow Leggatt in reading θειῷ instead of θεῷ with most manuscripts; see Leggatt (1995, 227). I believe Aristotle's argument to be that the celestial sphere is *like* a divine being in the sense that both partake in eternal motion, not that it itself is a god.

[24] τῶν γὰρ ἐναίμων ἡ τοῦ ὄρνιθος οὐσία, ἅμα δὲ καὶ πτερυγωτός . . . τῷ δ' ὄρνιθι ἐν τῇ οὐσίᾳ τὸ πτητικόν ἐστιν. Cf. *PA* IV.13, 697b1–13 and *PA* III.6, 669b8–12.

to perform their defining function is by having and using their wings), so too the heavens must have a spherical body and move eternally in a circle because they are essentially immortal. According to this argumentation, eternal motion in a circle is the proper attribute of an immortal body such as the heavens.

However, Aristotle has not yet explained why there are *several* motions of the heavenly bodies. The second part of the explanation of why there are several motions consists of a complicated chain of arguments, based on a total of six assumptions. The starting point of this chain is the conclusion of the first part of the explanation, which is the necessity of there being an eternal motion of the outer sphere in order for the heaven to be immortal. The reasoning Aristotle employs is deductive, but the type of necessity to which Aristotle refers is sometimes that of a necessary consequence, while at other times it is the necessity of something having to be present first if something else is to be present (the latter is what Aristotle calls conditional necessity).[25] Let me give a summary of the chain of arguments (*Cael* II.3, 286a13–286b2):

(a) If there is to be a body that moves in a circle eternally, it must have a center that remains at rest.
(b) For there to be a fixed center, the existence of the element earth is a necessary condition (i.e., since whatever is made of aether cannot remain at rest, there must be a second element next to aether, the natural motion of which is to move towards the center and then to remain at rest in the center).
(c) If there is to be earth, then it is a necessary consequence that there is also fire (for earth and fire are contraries, and if one exists, so does the other).
(d) If there is to be fire and earth, then it is a necessary consequence that the two other elements exist (for water and air are in a relation of contrariety to each of the other two elements).
(e) From the existence of the four elements, it necessarily follows that there must be generation (for none of the four sublunary elements can be everlasting).
(f) If there must be generation, then it is necessary that there exists some other motion.

[25] The formula "ἀνάγκη . . . εἶναι" is repeated six times: in *Cael* II.3, 286a13; II.3, 286a20; and II.3, 286b2 (see (a), (b), and (f) in the following summary) the necessity is conditional; in *Cael* II.3, 286a22; II.3, 286a28; and II.3, 286a32 (see (c), (d), and (e) in the summary) the necessity indicates a necessary consequence.

According to this account, generation is a necessary consequence of there being sublunary elements, whose existence is a necessary condition for there to be an eternal, cyclical motion of the outermost sphere of the heavens carrying the fixed stars. However, having established that it is necessary for there to be generation (as a consequence of there being four sublunary elements), Aristotle turns the argument around, and reasons that if there is to be generation, then it is conditionally necessary for there to be other motions, because the motions of the outermost sphere alone cannot cause generation. Accordingly, generation is that for the sake of which all the other motions (namely, the motions of the planets) take place. This is how Aristotle summarizes his explanation (*Cael* II.3, 286b6–9):

> For the moment so much is clear, for what reason there are several bodies moving in circles, namely because it is necessary that there is generation (ὅτι ἀνάγκη γένεσιν εἶναι), and generation [is necessary], if there also has to be fire, and that one and the others [are necessary] if there also has to be earth, and that one because it is necessary that something always remains at rest, if there has to be something that is for ever in motion.

The complete explanation of why there are several motions of the heavens is thus that there are different functions that require the presence of different motions. There is one eternal motion in a circle (performed by the outer sphere carrying the fixed stars) that is required for the sake of realizing the immortality of the heavens, and there are other motions (performed by the inner spheres carrying the planets) that must take place, if there is to be generation.

Here, the use of the teleological principle allows Aristotle to draw an organic picture of the cosmological system in which all the observed motions can be explained by the purpose they serve.[26] Arguably, this picture and the type of reasoning behind it are not without problems,[27] but at least Aristotle is able to give some rationale for some phenomena the astronomers did not explain. The plurality of the motions of the heavenly bodies makes sense in the light of the need for the heavens as a whole to perform an eternal motion, if they are to be truly immortal, and – as a corollary – of the need for there to be generation, if this eternal motion is to be at all.

[26] Cf. Aristotle's – perhaps even less satisfactory – analogy of the cosmos with a household in *Meta* XII.10, 1075a19–22, which equally depicts the sublunary realm (the slaves and animals in the analogy) as a necessary condition for the heavenly realm (the freemen in the analogy).

[27] For instance, it does not establish an explanation for *each* of the individual motions of the planets, or for the need for there to be generation; this latter point is well brought out by Hankinson (2002–2003, 31–32); see ibid. for further criticisms of the argument.

5.3 EXPLAINING WHY THE HEAVENLY BODIES MOVE WITH DIFFERENT COMPLEXITIES (EXAMPLE 2)

Let me now turn to a second example from the first group of teleological explanations, which is part of Aristotle's solution to the first problem under scrutiny in *Cael* II.12, and pertains to the number of movements each of the heavenly bodies undergoes. The example is particularly representative for Aristotle's "tentative" explanatory strategy in the *De Caelo* in that it relies heavily on analogical reasoning and employs a thought experiment.[28]

Aristotle states that among the many cosmological problems "the one that is most amazing" (*Cael* II.12, 291b29) is that, while one would expect the heavenly bodies that are nearer to the outer sphere to undergo fewer motions than the ones further away, observations[29] and old sources both give evidence that there is in fact no correlation between the distance of a heavenly body to the outer sphere and the complexity of its motions. For the Sun and the Moon, although further away from the outer sphere, perform fewer motions than some[30] of the other planets that are closer to it. Aristotle introduces his solution as follows (*Cael* II.12, 292a17–22):

> About these things it is well to seek more understanding, even though we have very few resources to start from and are at such a great distance from their attributes. Nonetheless, by beginning our study from the following [sort of consideration], the present difficulty will not appear as anything absurd. We think about them as if they are bodies only, and units with a certain order, but being altogether without soul; but it is necessary to suppose that they partake in action and life: for in that way the outcome will seem to be nothing unreasonable.[31]

[28] Aristotle frequently relies on thought experiments (usually in the form of counterfactuals) in the *De Caelo*. The most interesting one is perhaps in *Cael* II.2, 285b1–7, where he asks us to think of the body of the heavens as a thing (i) in which left and right are functionally differentiated (even though this is not obvious to perception, as it is covered by a sphere) and (ii) as having an origin of motion from where it would have started to move (even though, since the heavens are eternal, there is no actual chronological beginning or end of motion). On this thought experiment, and on the teleological explanation of the direction in which the heavens move in *Cael* II.5, see Lennox (2009). For a general discussion of thought experiments in antiquity, see Ierodiakonou (2005).

[29] *Cael* II.12, 292a2: "it is clear also to observation (τῇ ὄψει) that that happens with some of them."

[30] Modern commentators point out that Aristotle's claim in *Cael* II.12, 291b34–292a1 that "the Sun and the Moon undergo fewer movements than some (ἔνια) of the planets" is problematic, since whatever version of the theory of concentric spheres one accepts, the Sun and the Moon undergo fewer movements than *all* of the other planets. See Leggatt (1995, 246) for an outline of and a possible solution to this problem.

[31] Περὶ δὴ τούτων ζητεῖν μὲν καλῶς ἔχει καὶ τὴν ἐπὶ πλεῖον σύνεσιν, καίπερ μικρὰς ἔχοντας ἀφορμὰς καὶ τοσαύτην ἀπόστασιν ἀπέχοντας τῶν περὶ αὐτὰ συμβαινόντων· ὅμως δ' ἐκ τῶν τοιούτων θεωροῦσιν οὐδὲν ἄλογον ἂν δόξειεν εἶναι τὸ νῦν ἀπορούμενον. Ἀλλ' ἡμεῖς ὡς περὶ σωμάτων αὐτῶν μόνον, καὶ μονάδων τάξιν μὲν ἐχόντων, ἀψύχων δὲ πάμπαν, διανοούμεθα· δεῖ δ' ὡς μετεχόντων ὑπολαμβάνειν πράξεως καὶ ζωῆς· οὕτω γὰρ οὐθὲν δόξει παράλογον εἶναι τὸ συμβαῖνον.

As in example 1 discussed above, the methodological caveat is followed by the proposition to think about the motions of the heavenly bodies within a teleological framework (as we saw in section 4.2, ὑπολαμβάνειν is the technical verb for positing principles). If we think of the heavenly bodies as living beings, which act and move for the sake of ends and do so in virtue of possessing an internal principle of movement (i.e., their soul), the observed phenomena will make sense.

Before applying the notion of goal-directed action to the motions of the heavenly bodies, Aristotle first explicates two "rules" that govern this type of action. The first pertains to the number of actions needed to achieve the good (*Cael* II.12, 292a22–24): what is in the best state possesses the good without action; what is close achieves it by few motions or even by one; and what is further away achieves it by many motions. Aristotle uses an analogy of the number of exercises a body needs to undergo in order to acquire a healthy condition: a person who is already in good condition does not need to exercise; those who are not in such good condition need to perform one or more kinds of exercises to achieve a good condition; and some can never achieve a healthy condition at all, but only some substitute for it. The second "rule" states that the higher the number of intermediate goals that need to be achieved, the more difficult it is to achieve the ultimate end; Aristotle illustrates this with an analogy drawn from the game of knucklebones (*Cael* II.12, 292a28–b1). Because these are the correlations that exist between the number of actions needed to reach the good and the initial distance of the agent from this good, this is how we should think (δεῖ νομίζειν)[32] of the actions of the stars and planets (*Cael* II.12, 292b1–2): "This is why it is necessary that we consider also the action of the stars as being of the exact same sort as the action of living beings and plants."

Subsequently, Aristotle fills in the details of this analogy between the actions of sublunary living beings on the one hand and the motions of heavenly bodies on the other hand (*Cael* II.12, 292b2–19; see Table 5.2 for an overview). In the world around us (*Cael* II.12, 292b2: ἐνταῦθα), different kinds of beings perform a different number of motions and have different levels of access to the good. And just as in the case where health is the ultimate good, different people require a different number of actions to achieve the good, or, if they cannot achieve it, try to get as close to their goal as possible, since "a thing is better the nearer it is to the best" (*Cael* II.12, 292b18–19). Thus we get the following base domain of the analogy: a person in the best state performs no actions, because he already

[32] For the terminology, see Bogen and McGuire (1986–7, 424–425).

Table 5.2 *The analogy between the actions of sublunary beings and the motions of the heavenly bodies*

Kinds of sublunary living beings	Number of actions needed to achieve the good	Kinds of heavenly bodies	Number of motions needed to achieve the good
Humans	Need many actions, but are able to achieve the good	Other planets	Need many motions, but are able to achieve the good
Person in the best state	Needs no actions, already possesses the good	Outer sphere	Needs one motion, but is able to achieve the good
Animals	Need few actions, but only have limited access to the good	Sun and moon	Need few motions, but only achieve the good to a certain degree
Plants	Need few actions, but are only able to achieve intermediate goods	Earth	Performs no motion, and is unable to achieve the good.

possesses the good. Humans who are not already in the best state perform many motions, and have full access to the good. Animals perform few actions, which allows them to achieve only an intermediate good (performing more actions would serve no purpose, since animals will never achieve the highest good). And, finally, plants perform few actions, but they are completely unable to achieve the ultimate good.

Next, Aristotle is in a position to apply these general patterns to the target domain of the analogy, i.e., to the motions of the heavenly bodies (*Cael* II.12, 292b19–25):

> And because of this the Earth does not move at all, and the ones that are close [i.e., the Sun and the Moon] have only few movements: for they do not reach the end, but they are able to reach the most divine principle only to a certain point. The first heaven attains it immediately through one movement. The ones in between the first and the last [i.e., the other planets] reach it, but they reach it through several movements.

In other words, Aristotle urges us to think of the Earth as plants: the Earth is like plants in that it is unable to achieve the good, and therefore does not move at all. The Sun and the Moon are like animals, in that they have only limited access to the good, which is supposed to explain why they perform few motions – it is no use performing more motions, as they will

never achieve the highest principle. The outer sphere is like a person who is already in the best condition; but unlike the person in the best state who does not need to perform any actions, the outer sphere performs one motion, which allows it to reach the highest principle. And finally, the intermediate planets are like humans: they are able to achieve the highest principle, but need many motions to do this.

Aristotle seems to believe that this reasoning suffices to make the differentiation regarding the complexity of the motions of the heavenly bodies less perplexing, as he moves on in the next lines to deal with the second problem introduced at the beginning of the chapter.

If my reconstruction is correct, however, Aristotle must have meant this analogy to work quite loosely.[33] As is clear from my summary above, the Earth is not really like plants, because the Earth does not move at all, and the outer sphere is not really like the person who is in the best state, because the outer sphere performs one (eternal) movement. The thought experiment cannot fully explain the differentiation (the causal model of the different motions of the heavenly bodies is not literally that of goal-directed actions, nor are there any functional differences between the heavenly bodies),[34] but it does reduce the puzzlement, and that is all Aristotle set out to achieve. As was the case in example 1, lack of empirical evidence makes it hard to provide fully fledged physical explanations in cases like these, but through the use of teleological principles Aristotle at least succeeds in mitigating some of the perplexities pertaining to the heavenly motions.

5.4 Explaining why stars have no feet (example 3)

I shall now turn to an example of the second type of teleological explanations, where Aristotle uses some form of the teleological principle that nature does nothing in vain in order to explain the *absence* of heavenly features, usually after a series of mathematical arguments or discussions of the available empirical evidence.

The explanandum to be discussed concerns the question whether or not the stars and planets possess a motion independently of the motion of the spheres. One explanation is given in chapter II.8, where Aristotle tries to show that the heavenly bodies most likely do not possess a motion of their own, but are carried around fixed in concentric spheres. The basic idea is

[33] Pace Johnson (2005, 139) who interprets the analogy in a strong causal sense, arguing that its point is "that the motion of the heavens is purposeful activity."

[34] For the distinction between a "strong" and a "weak" use of analogy, see Hankinson (1998, 22).

that if the stars possessed their own motion, they would be self-movers, and this would make them in principle capable of stopping their motions, which would threaten the eternity of the heavens and life as we know it. First, Aristotle sketches three possible scenarios of the motions of the heavenly bodies and their spheres (*Cael* II.8, 289b1–3). As both are observed to move as a whole, it is necessary that the change of position takes place with both the heavens and the stars being at rest, or with both moving, or with the one moving and the other at rest. Aristotle then refers to empirical evidence (*Cael* II.8, 289b5 and b10) and gives mathematical arguments (*Cael* II.8, 289b27–28) in order to show that the scenario in which the spheres move while the heavenly bodies are at rest is "the least absurd" (*Cael* II.8, 289b34–35: μόνως γὰρ οὕτως οὐθὲν ἄλογον συμβαίνει). In addition to this, Aristotle offers a final teleological argument in favor of this theory, arguing for the unlikelihood of the stars and planets possessing a motion on their own. The argument runs as follows (*Cael* II.8, 290a29–35):

> In addition to these arguments, it would be absurd that nature gave them no organ for motion (since nature does nothing as a matter of chance), and that she should care for animals, but disregard such honorable beings; rather, it seems that nature, as though deliberately, has taken away everything by means of which they might possibly in themselves have effected forward motion, and that she set them at the greatest distance from those things that possess organs for motion.[35]

In a way, Aristotle's explanation here parallels that of Plato in the *Timaeus*. In this dialogue, Timaeus explains that the divine craftsman did not think it to be necessary to equip the heaven – self-sufficient and perfect as it is – with hands or feet for walking (*Ti* 33d–34a):

> For he thought that a being which is self-sufficient would be much better than one which is in need of other things. And he did not think it was necessary to attach hands to it to no purpose – hands for which there would be no need either to grasp or to defend itself against anything; nor had it any need of feet, nor of the whole apparatus of walking (χειρῶν δέ, αἷς οὔτε λαβεῖν οὔτε αὖ τινα ἀμύνασθαι χρεία τις ἦν, μάτην οὐκ ᾠ̓ετο δεῖν αὐτῷ προσάπτειν, οὐδὲ ποδῶν οὐδὲ ὅλως τῆς περὶ τὴν βάσιν ὑπηρεσίας). For he assigned to it the motion that is most suited to its body, [the motion] which, of the seven, is the most appropriate to mind and to thinking. And therefore he caused it to move in the same manner and on the same spot and revolving in a circle within its own limits. All other six [motions] he took away (τὰς δὲ ἓξ ἀπάσας κινήσεις ἀφεῖλεν) and it was made not to partake

[35] Πρὸς δὲ τούτοις ἄλογον τὸ μηθὲν ὄργανον αὐτοῖς ἀποδοῦναι τὴν φύσιν πρὸς τὴν κίνησιν (οὐθὲν γὰρ ὡς ἔτυχε ποιεῖ ἡ φύσις), οὐδὲ τῶν μὲν ζῴων φροντίσαι, τῶν δ' οὕτω τιμίων ὑπεριδεῖν, ἀλλ' ἔοικεν ὥσπερ ἐπίτηδες ἀφελεῖν πάντα δι' ὧν ἐνεδέχετο προϊέναι καθ' αὑτά, καὶ ὅτι πλεῖστον ἀποστῆσαι τῶν ἐχόντων ὄργανα πρὸς κίνησιν.

in their deviations. And as this circular motion required no feet, the universe was created without legs and without feet.

In this passage, Plato describes how the heaven was created and was given its circular motion, which is most appropriate for its spherical shape. The other types of motion – forwards/backwards, to the left/to the right, and up/down – were taken away from it. However, instead of this mythological account for why the stars have no feet, Aristotle opts for a naturalistic explanation.

The structure of Aristotle's argument is quite complex. In short, it consists of a *reductio ad absurdum* followed by an alternative account proclaiming the purposiveness, or perhaps even the providence, of nature. The first part of the argument builds upon the implicit counterfactual assumption that if the stars "were intended by nature" to be moving on their own, it would be absurd for nature not to have given them organs for motion, given the fact that nature did provide such organs to "lesser" beings. I take the expression that "nature does nothing as a matter of chance" to be equivalent to the principle that nature does nothing in vain: living beings always have the parts that they need, and if the heavenly bodies lack organs for motion, that lack must be for the sake of something. Or, to put it the other way around, if the organs for motion are absent in heavenly bodies it must be because their presence would have been in vain (they would have had no function to fulfill in this particular kind of being). The reference to the honorable status of heavenly beings implies that Aristotle takes the teleology of nature to apply even *more* to them than to the sublunary beings.

The *implicit* underlying teleological principle here is that each capacity (in this case the capacity for locomotion) requires an organ (cf. *GA* I.2, 716a24–25) and that thus locomotion of the stars is possible if and only if they have organs for locomotion. The absurdity lies in the fact that nature *did* provide less honorable beings with organs for motion, and that we would have to conclude, were we to accept this account as true, that nature purposely neglected more honorable beings such as the stars. Since this account is of course unacceptable within Aristotle's view of the way nature operates, the opposite scenario, set out in the second part of the argument, must be the case: nature has *taken away* every means of locomotion, and thereby set a distance between the heavenly bodies and the sublunary beings equipped with organs for motion.[36] As Aristotle explains, spherical

[36] Aristotle considers it to be better for the superior to be separated from the inferior; cf. *GA* II.1, 732a6–8.

bodies are least fit to effect forward motion on their own, because they lack "points of motion" (*Cael* II.8, 290b5–8): "[F]or forward motion it is least fit, since it is least like to those things that produce motion on their own; for it does not have any appendage or projection, as does a rectilinear figure, but stands most apart in shape from those bodies equipped for locomotion."

The core of this teleological argument for why the heavenly bodies do not have a motion of their own, and hence must be fixed in spheres, is thus the assumption (presented as a fact) that heavenly bodies do not have feet or any other organs for locomotion. For, if nature – for the most part – does nothing in vain and the heavenly bodies have no feet, then the conclusion is reasonable that nature must have "designed" the heavenly bodies not to be able to move on their own.

The teleological argument Aristotle offers here is again in many ways similar to explanations we find in the biological works. In biology, Aristotle holds that all animals that are capable of locomotion must have organs for motion and that animals without organs for motion are not capable of locomotion.[37] These two "laws" are exhaustive with regard to all blooded land-walkers. The one and only exception to this rule is formed by the footless snake, which obviously does not have organs specifically designed for locomotion, but moves forward by bending itself. Just as in our example concerning the heavenly bodies, we saw that Aristotle explains the absence of feet in snakes by invoking the principle that nature does nothing in vain (*IA* 8, 708a9–20; quoted above in section 4.2).

In section 4.2, I argued that in the case of the footless snake, Aristotle invokes the principle that nature does nothing in vain in order to set up the counterfactual argument that if nature had equipped snakes with feet, snakes would move very badly and the feet would have been next to useless. The cause of the uselessness of the feet is the extraordinary body-length of the snake: no kind of animal whose length is out of proportion to the rest of its body can have four feet, because having four feet makes such animals completely immobile; and snakes are animals that have such a body size. Given the principle that nature does nothing in vain (*and* that

[37] *PA* IV.10, 686a35–b1: "all (animals) that walk must have two hind feet" and *IA* 3, 705a19–25: "That which moves always makes its change of place by the employment of at least two organic parts, one as it were compressing and the other being compressed. And so nothing that is without parts can move in this manner; for it does not contain in itself the distinction between what is to be passive and what is to be active." Cf. *GA* II.3, 736b22–24: "for it is clear that the principles of which the activity is bodily cannot exist without a body, such as walking [cannot exist] without feet" (οἷον βαδίζειν ἄνευ ποδῶν).

nature cannot give snakes more than four feet, since, in that case, the snake would not be blooded), snakes do not have feet.[38]

There is, however, an important difference between the explanatory force of the use of this principle in biology as opposed to its use in cosmology, and this difference derives directly from the lack of observational evidence in the latter domain.[39] For in the biological domain *observation* determines the possibilities of what nature does and does not produce.[40] The design possibilities that Aristotle allows to enter into thought experiments are thus also strictly limited by the range of features that can actually be observed to be available in nature. In the case of the footless snake, observation shows that all other blooded animals that live on land have feet; blooded land-dwellers share to a certain extent the same formal nature, which explains the occurrence of certain co-extensive features like the possession of a maximum of four feet. The snake also possesses all the properties that belong to blooded land-dwellers, except for one. It is therefore rational to ask why this particular property is absent in snakes, and, in the thought experiment, to imagine feet to be present. It is not rational to ask why snakes lack wings, telescopic eyes, or any other part that cannot be observed to belong to the wider class to which snakes belong, or to imagine these features to be present in snakes. As there is a virtual infinity of properties that any animal does not have, it only makes sense for a natural scientist to explain the absence (by means of imagining the presence) of those properties that belong to the "natural possibilities" of that animal; and what those natural possibilities are can be established inductively, on the basis of observation and through comparison with related beings.

In the cosmological domain, on the other hand, the range of possible ways in which a certain feature or motion could be present is only partly determined by observation. What cannot be observed might still be present, and what can be observed might be the result of a visual illusion. Aristotle often struggles with this question of how much credence we must attribute to our observations of the heavens, and of which observations we should

[38] However, the fact that snakes do not have organs for motion does not mean that they are not capable of locomotion: they move forwards by bending themselves (see *IA* 7, 707b6–31; *IA* 8, 709a25–b4; and *IA* 10, 709b27–28). This may point to a problem for Aristotle's argument concerning the heavenly bodies: for the absence of *organs* for locomotion as such does not provide conclusive evidence that the stars in fact are not capable of locomotion. Of course, as the remainder of *Cael* II.8 points out, Aristotle is actually committed to the stronger claim that spherical bodies do not only lack organs for motion, but also "points of motion," which (at least given Aristotle's laws of sublunary mechanics) rules out any possible way of locomotion.

[39] For the question whether or not principles from biology can be applied legitimately in cosmology, see *Cael* II.2, 284b6–24 and its discussion in Lennox (2009).

[40] Lennox (2001a, 214–215).

explain and which we should explain away. His general strategy is to explain the phenomena and hence to save them, but on occasion, especially where there are contradictory observations, the observations that conflict with the theory of the stars moving around fixed in concentric spheres are rather explained away. This is exactly what happens in the paragraphs leading up to the explanation of why stars have no feet in *Cael* II.8, 290a12–29. Before giving his teleological argument demonstrating the likelihood of the absence of feet in stars, Aristotle argued that if the heavenly bodies were to move on their own, they would either roll or rotate, but that neither of these motions is observed to take place. The impression that the Sun rotates in rising and setting[41] is then explained away: according to Aristotle, the rotation is merely a visual illusion, caused by the weakness and unsteadiness of our vision.

What this makes clear is, first of all, that while in biology observations clearly show that snakes lack feet, observational evidence of the heavens gives much less certainty about the absence of feet in the heavenly bodies. For all we can tell, the heavenly bodies might be too far away for us to see their organs of motion. Second, observations of the heavens will not tell us whether there are any *natural* limitations to the possible ways in which nature could have "designed" stars in order to make them able to move on their own. The absence of feet in the heavenly bodies in itself seems hardly enough to establish the reasonableness of the alternative theory that they do not effect any forward motion at all.

This difference between the reliability and applicability of observational evidence in biology and cosmology is important, because Aristotle's explanation in the case of the heavenly bodies is not *prompted* by the observation that they do not have organs for motion, as it is in the case of snakes.[42] There are no observations of the heavens that would reasonably lead to the expectation of heavenly bodies having feet in the first place. (One might object, however, that in this case the philosophical tradition within which Aristotle is working prompts this question.[43]) Rather, Aristotle works the other way around: because he wants to make the theory that the stars do

[41] Xenophanes might have observed the same phenomenon, and gives it a similar explanation; see *DK*21A41a: δοκεῖν δὲ κυκλεῖσθαι διὰ τὴν ἀπόστασιν; "[the sun] seems to turn in a circle due to its distance."

[42] As I argued in section 4.2, Aristotle uses the principle in *De Partibus Animalium* typically when he discovers that an animal lacks a part that is present in all other members of its wider class. For examples, see *PA* IV.12, 694a13–20; *PA* IV.12, 694a16–18; *PA* IV.13, 696a10–15 and *PA* IV.13, 696a12.

[43] On this tradition, see Cornford (1975, 55–56); besides Plato, Empedocles also seems to have argued for the footlessness of the celestial sphere (*DK*31B29: οὐ γὰρ ἀπὸ νώτοιο δύο κλάδοι ἀίσσονται, οὐ πόδες, οὐ θοὰ γοῦν(α), οὐ μήδεα γεννήεντα, ἀλλὰ σφαῖρος ἦην καὶ <πάντοθεν> ἶσος ἑαυτῶι).

not move on their own as reasonable as possible, he uses the teleological principle that nature does nothing in vain to argue for the likelihood of the absence of the organs of motion in the heavenly bodies (cf. *Cael* II.11, 291b11–17, where Aristotle repeats the argument in a slightly modified way).

In sum, it seems that in this example Aristotle goes out of his way to establish the reasonableness of the assumption that the heavenly bodies do not have a motion of their own, and hence must be carried around while being fixed in concentric spheres. In the biological realm, the observation of what happens always or for the most part in nature is what allows us to draw inferences about cases in which the goal-directedness is less evident. In a domain such as cosmology, which is empirically underdetermined, such inferences are necessarily of a conjectural nature. However, if teleology extends to the heavenly realm, and Aristotle assumes that it does, then the use of teleological principles allows Aristotle to make the most sense of the phenomena, and to provide explanations appropriate to the science of nature, rather than merely astrological or mathematical ones.

5.5 CONCLUSION

In the ears of a modern audience, Aristotle's teleological explanations of heavenly phenomena may sound rather unusual, but what I hope to have made clear in this chapter is that they make perfect sense within Aristotle's conception of natural science. If the heavens are part of nature, then we need at least to attempt to state all possible causes for their motions and features, even if the investigation has been made difficult because of the scarcity of empirical data. Aristotle's use of teleological principles thus follows from his treatment of the study of the heavens as part of the study of nature, and we have seen that this approach is especially prominent in the second book of the *De Caelo*, where Aristotle searches for explanations of the features and motions of the heavens as a whole and of the heavenly bodies. The scientific investigation of an empirically undetermined domain such as the heavens is difficult, and as his methodological reflections show, Aristotle is mostly well aware of all the problems involved. However, if one wants to gain knowledge of the heavens and its bodies, one has to try and give explanations that at least make the phenomena – both in terms of what can and of what cannot be observed – seem as reasonable as possible.[44]

The strategy that Aristotle employs to generate these plausible accounts is to posit teleological principles as a means of finding causal factors in

[44] Cf. Irwin (1988, 34).

difficult cases. As I argued in Chapter 4, the principles used are not a priori postulates, but suppositions derived from empirical evidence. They are generalizations over the actions of the formal nature of beings, based on numerous observations made in the biological domain. Just as the use of these principles helped Aristotle to find final causes in cases where these were not immediately observable in biology, in the same way Aristotle hopes to find explanations for natural phenomena in the cosmological realm. This gives a very central role to Aristotle's scientific practice in biology: one could say that where Aristotle's philosophy of science as described in the *Analytica Posteriora* offers the student of nature his scientific toolbox, the accessible and rich domain of biology is the student's main workplace. The experience and knowledge acquired in studying the biological phenomena may then – of course with suitable adaptations and refinements – be applied to other, less accessible domains of nature, such as the heavens.

The application of teleological principles to the cosmological domain is itself based on the assumption that the heavens are no less teleological – and perhaps even more teleological – than the sublunary realm is. However, as I have pointed out above, the lack of empirical evidence in the cosmological realm also weakens to some extent the inferences Aristotle draws within this teleological framework:[45] the explanations are plausible, but not as "conclusive" as the ones we can find in the biological works.

For the *De Caelo* this means that Aristotle argues as much from as towards teleology: starting from the assumption that the heavens as a whole are goal-directed, Aristotle tries to give a coherent, plausible, and reasonable picture of the heavens in which things are present or absent for a reason. This is Aristotle's main goal in the *De Caelo*: even if it is not possible to give deductions that demonstrate why the heavens and the heavenly bodies have the features they have, one can still offer plausible physical accounts that take away some of the puzzlement concerning the heavens.

[45] Cf. Falcon (2005, ix): "there are features of the celestial world that outrun the explanatory resources developed by Aristotle for the study of the sublunary world."

CHAPTER 6

Aristotle's model of science: formalizing teleological explanations in the Analytica Posteriora

6.0 INTRODUCTION

In the *Analytica Posteriora*, Aristotle defines scientific knowledge as knowledge of the reason why. Knowing why something is the case amounts to being able to provide a scientific demonstration (*apodeixis*), which consists in a valid syllogistic argument in the mode Barbara (i.e., AaB, BaC, ∴ AaC). Such demonstrations typically deduce the necessity of an attribute belonging per se to a certain subject through a middle term that picks out the cause of that necessary relationship. Thus, if formalized in accordance with the recommendations of the *Analytica Posteriora*, causal explanations (i.e., linguistic expressions that identify the cause of some phenomenon) will constitute scientific demonstrations. However, despite the long tradition of Aristotelian scholarship on this treatise, many details concerning the precise nature and syllogistic structure of demonstration remain enigmatic, and are subject of much controversy.[1]

In this chapter, I aim to shed light on Aristotle's pivotal discussion of the integration of the four types of causal explanation into the syllogistic framework of demonstration in *APo* II.11, and specifically on his suggestions on how to formalize teleological explanations. In the first part of this chapter (sections 6.1–6.3), I shall clarify the examples Aristotle provides to illustrate his theoretical remarks about how to formalize causal explanations into the syllogistic structure of scientific demonstration. In particular, I hope to make sense of the teleological example of walking after dinner for the sake of health. In the second part (section 6.4) of the chapter, I shall juxtapose these findings with conclusions from the previous five chapters concerning Aristotle's practice. In particular, I shall focus on the structure of three of the most common types of actual teleological

[1] For present purposes, I leave aside the question of whether the *Analytica Posteriora* is supposed to present a theory of scientific methodology and investigation or a theory of the organization and presentation of the finished scientific system. On this matter, see among others Barnes (1993, xi–xix).

explanations provided in Aristotle's *De Partibus Animalium*. This will show that Aristotle's theory and practice of teleological explanation are in agreement with each other, and that both are more flexible and comprehensive than has been acknowledged so far.

6.1 CAUSES, EXPLANATIONS, AND MIDDLE TERMS

The problem: the middle terms of the examples in APo *II.11 do not pick out all four causes*

In *APo* I.2, Aristotle explains that demonstrations are syllogistic in form and causal in content. A demonstration is a special kind of deductive argument that produces scientific knowledge (*APo* I.2, 71b17–19), where scientific knowledge is defined as knowledge of why things are the case (*APo* I.2, 71b9–13):

> We think we have <scientific> knowledge (ἐπίστασθαι) of each thing without qualification (and not in the sophistic way, incidentally), when we think we know the explanation because of which the state of affairs is the case (ὅταν τήν τ' αἰτίαν οἰώμεθα γινώσκειν δι' ἣν τὸ πρᾶγμά ἐστιν), that it is its explanation, and also that it is not possible for this [state of affairs] to be otherwise. It is clear that something of this kind is what it is to have <scientific> knowledge.

At the beginning of *APo* II.11, Aristotle specifies – and, from our perspective, complicates – this assertion by introducing his "doctrine" of four *aitiai* or causal explanations, which, he claims, are all to be demonstrated[2] through the middle term (*APo* II.11, 94a20–27):

> Since we think we have <scientific> knowledge when we know the explanation, and there are four types of explanation: one, what it is to be a thing, and another, given what things being the case it is necessary for that to hold; another, what first initiated the motion; and fourth, the for the sake of what – all of them are demonstrated through the middle term.[3]

After this short introduction to the topic of this chapter, Aristotle moves on to give syllogistic examples of how each of the four explanations (*aitiai*) is indeed demonstrated through the middle term.

[2] I follow Barnes (1993, 282) in translating both forms of *apodeiknunai* and *deiknunai* with the verb "to demonstrate," and forms of *epideiknunai* and *dêloun* with the verb "to show."

[3] Ἐπεὶ δὲ ἐπίστασθαι οἰόμεθα ὅταν εἰδῶμεν τὴν αἰτίαν, αἰτίαι δὲ τέτταρες, μία μὲν τὸ τί ἦν εἶναι, μία δὲ τὸ τίνων ὄντων ἀνάγκη τοῦτ' εἶναι, ἑτέρα δὲ ἡ τί πρῶτον ἐκίνησε, τετάρτη δὲ τὸ τίνος ἕνεκα, πᾶσαι αὗται διὰ τοῦ μέσου δείκνυνται. See the appendix for a complete translation of *APo* II.11, 94a20–94b26.

In contrast to the apparent clarity of structure and argument in this chapter, its content has raised many interpretative problems for modern scholars, most of which pertain to the general purpose of the chapter and to the nature of the individual syllogistic examples. The sentence stating that "all the *aitiai* are demonstrated through the middle term" has traditionally been interpreted as meaning that all four Aristotelian causes can or even must be picked out by the middle term in scientific demonstrations.[4] However, under this interpretation the syllogistic examples Aristotle gives to illustrate his introductory sentence present us with two major difficulties. In the first place, contrary to the expectations of many interpreters, the syllogisms posited in no way constitute typical Barbara demonstrations where the predicates hold universally and necessarily of the subjects.[5] In the second place, it is not immediately clear how the middle terms in the given examples refer to the causes in question. In particular the section that shows how final causes are demonstrated through the middle term is notorious, because the final cause is not picked out by the middle term, but by the major or predicate term.[6] Some scholars have taken up Aristotle's own suggestion that things will become clearer if we "change the *logoi*" (94b21–22: *metalambanein tous logous*), taking it to mean that we as readers are supposed to rearrange the syllogism so that the middle term picks out the final cause after all.[7] However, it is not an easy undertaking to construct such a syllogism, let alone to do so while remaining close to the Aristotelian

[4] This interpretation ultimately goes back to Philoponus, who criticizes this chapter in his commentary on the *Analytica Posteriora* (*In APo* 376, 12–14; 376, 16–18; 376, 31–2; 377, 21–22 and 377, 26–27). He thinks that the examples are wrong and rebukes Aristotle for having set out the syllogisms in a confused way (*In APo* 378, 16–19; 379, 4–9; 379, 33–380, 3). In order to correct Aristotle, Philoponus rearranges the examples and thereby maneuvers the causes into the preferred position of the middle term (*In APo* 378, 19–22; 379, 33–380, 3; 381, 35–36).

[5] Cf. Barnes (1993, xvi) ("In chapters B11–12 the syllogism is, alas, a positive embarrassment and a bar to understanding") and (1993, 228) and Ross (1949, 647) (Ross calls Aristotle's examples "quasi-syllogisms").

[6] For the difficulties modern commentators encounter in this section, see Barnes (1993, 225, 229); Detel (1993, 695, 707); and Ross (1949, 642). The problem is expressed most emphatically in Detel (1997, 65–66):

> The syllogistic reconstruction of the first of these [two teleological] examples Aristotle seems to offer in the subsequent passage (94b12–20) turns out to be, at first sight, extremely problematic, though, since he represents the aim of being healthy, not by the middle term, B, but by the major term, A. This is *clearly incompatible* with his general claim, expressed in 94a20–24, that the aim too must be proved through the middle term (the italics are mine).

[7] See in particular Detel (1993, 684–716; 1997, 65–67). Recently, Johnson (2005, 52–55) argued that "changing the terms" should be read as entailing that "health" and "good digestion" are convertible in this explanation. This, however, is only possible if the terms were coextensive, which seems unlikely in this case. Bolton (1997, 115), saves the example, but suggests that ultimately what is picked out by the major term (the final cause) is "in its primitive definition" equal to what is picked out by the middle term (the material cause).

original. On the whole, the verdict of interpreters on this chapter has been very negative.[8]

The hypothesis: the causality of the explanation and of the explanatory middle term can be different

The hypothesis that I put forward in order to solve the problem outlined above is a fairly simple one. I submit that it is not the examples that are wrong, but rather our interpretation of what Aristotle means by saying that "all the *aitiai* are demonstrated through the middle term." What is crucial for the understanding of this chapter is that within an Aristotelian demonstration there can be a difference between the type of causality expressed in the *explanation* of a phenomenon (i.e. the type of causality expressed by the whole demonstrative syllogism), and the type of causality expressed in the middle term that picks out the explanans or cause of this phenomenon. In the case of demonstrations of teleological phenomena, I shall even argue for the stronger case that the type of causality expressed by the middle term *must be* different from that expressed in the explanation that is being formalized into a demonstration. The upshot of this distinction for Aristotle's theory of demonstration is that all the four types of explanation will be demonstrated through the middle term (because it is through the middle term that a demonstrative syllogism is construed), but that the middle term itself will *not* have to refer to the corresponding cause in all four cases.

I shall give an example to illustrate this distinction. Consider the *dia ti* question of what is ice. Aristotle takes this question (as presented in *APo* II.12, 95a16–21; cf. *Meta* VIII.2, 1043a9–10) to be about the essence of ice – about what ice *is*. An adequate explanation thus needs to be a formal one. By assuming (the nominal definition) that ice is solidified water Aristotle makes a first move towards such a formal explanation. However, this preliminary answer does not qualify as a demonstration yet, because we do not know why it is that "solidified" belongs per se to "water", or why there is ice. This is where the explanatory middle term comes in: the middle term picks out the explanans of why solidified belongs to water. The explanatory middle term that Aristotle proposes for this particular example is a complete cessation (*ekleipsis*) of heat: ice comes about when there is a complete cessation of heat. The middle term, which picks out

[8] This might explain why the chapter has largely been ignored by some recent studies on the *Analytica Posteriora*, including those of Byrne (1997); Goldin (1996) and McKirahan (1992).

the efficient cause[9] of the solidification of water, reveals the essence of ice: ice is solidified water resulting from a complete cessation of heat in water. While the explanation that is being formalized is thus a formal explanation (because it answers the question "what is ice?"), the middle term bringing out this explanation picks out an efficient cause.

In sum, Aristotle's claim that "all the *aitiai* are demonstrated through the middle term" means under this scheme that all the four types of explanations are demonstrated through the middle term, but that these demonstrations may proceed through middle terms that pick out causes of a different type.

The semantic distinction between hê aitia *and* to aition

Within the context of the *Analytica Posteriora* this philosophical distinction is supported by a semantic distinction between the term *hê aitia* (fem.; pl. *aitiai*) and the term *to aition* (neut.; pl. *aitia*). Frede has argued that the two terms were used differently in the original legal context in which they arose: *to aition* (which is the neuter noun formed from the adjective *aitios*, originally meaning "culpable" or "responsible") designated the agent responsible for a state of affairs, while *hê aitia* designated the accusation – i.e., a propositional item expressing the charges.[10] This distinction between *aition* as the thing responsible or cause and *aitia* as causal account or explanation seems to be preserved in Plato's *Phaedo*, and perhaps also in Chrysippus and in Diocles.[11]

Outside the *Analytica Posteriora*, there is little or no evidence that Aristotle also endorsed this distinction,[12] but within the *Analytica Posteriora* I believe there is. The semantic distinction is not crucial for the philosophical distinction, but a short sketch of the semantic distinction might help to get a clearer view of the theory Aristotle is setting out in *APo* II.11.

First *to aition*: usually, *to aition* is characterized as a condition for knowledge.[13] More specifically, in "demonstrations of the reason why"

[9] I here follow Charles (1999, 233–235), who identifies *ekleipsis* as a process (the suffix *–sis* indicates a *nomen actionis*) and as an efficient cause.

[10] Frede (1980, 222–223). [11] Diocles, fr. 176 (Van der Eijk, 2001 edn).

[12] In other treatises the distinction may only be preserved in "technical discussions" of demonstrations such as *DA* II.2, 413a11–21; this, however, requires further research. Interpreters of the *Analytica Posteriora* usually take the terms to be semantically equivalent, and translate them more or less randomly as cause, reason, or explanation.

[13] Knowing why is to know *by means* of *to aition* (*APo* I.6, 75a35); this knowledge proceeds *from aitia* (*APo* I.9, 76a19–20) that are primitive (*APo* I.13, 78a25–26). See also *APo* II.8, 93a4–8; *APo* II.8, 93b19; *APo* II.9, 93b21–26; *APo* II.12, 95a10–12; *APo* II.12, 95a22–25; and *APo* II.12, 95b14.

the middle term must always refer to an *aition*.[14] This is what Aristotle points out at the end of the following passage (*APo* II.2, 89b37–90a9):

> When we seek the fact or if something is without qualification, we are seeking whether or not there is a middle term for it. And when, having come to know either the fact or if it is – either partially or without qualification – we again seek the reason why or what it is, we are then seeking what the middle term is . . . Thus it results that in all our searches we seek either if there is a middle term or what the middle term is. For the middle term is the *aition* (τὸ μὲν γὰρ αἴτιον τὸ μέσον), and in all cases it is this which is being sought.

The middle term must pick out whatever is responsible for the connection between the two terms it mediates. In this way, the middle term clarifies the causal relation between the two terms by providing the real cause (and not merely the epistemic reason) of why the one extreme term holds of the other. I therefore translate the noun *to aition* as "cause."[15]

The term *hê aitia* is used less frequently in the *Analytica Posteriora*, and is usually part of the definition of scientific knowledge. Scientific knowledge is always knowledge of *hai aitiai*.[16] For instance, in *APo* I.2, 71b20–33 Aristotle first picks up on his definition of scientific knowledge as being knowledge of *hê aitia* of something, and then continues by stating that this knowledge can be reached through things that are, among other things, *aitios* of the conclusion (αἰτίων τοῦ συμπεράσματος). Other passages (especially *APo* I.13, 78b28–31) point out that Aristotle conceives of these *aitiai* as being larger linguistic or syllogistic formulas that state the reason why in answer to the question "why" (*to dioti* or *to dia ti*).[17] At least within the *Analytica Posteriora* it is thus implied that *hê aitia* itself is a kind of *syllogismos* containing an explanatory middle term, where *to aition* is a subordinated element of *hê aitia*.[18] I therefore translate the noun *hê aitia* as

[14] The middle term in demonstrations of the reason why always picks out the *aition* that is immediate and primitive (*APo* I.34, 89b15; *APo* II.2, 90a7–9; *APo* II.8, 93a4–8; *APo* II.12, 95a10–12; *APo* II.12, 95a17; *passim* in *APo* II.16–18). If the deduction does *not* proceed through the *aition*, but through the more familiar of the (non-explanatory) converting terms, then the demonstration that follows is not a demonstration of the reason why, but of the fact (*APo* I.13).

[15] See, for example, *APo* I.13, 78b17; *APo* I.24, 85b22; *APo* II.12, 94b8; *APo* II.12, 94b18; *APo* II.12, 95b20; *APo* II.12, 95b28; *passim* in *APo* II.16–18.

[16] See *APo* I.2, 71b9–13; *APo* I.2, 71b30–31; *APo* I.31, 87b40; and *APo* II.11, 94a21–4.

[17] These are explanations of the reason why, picking out *to aition* through the middle term (cf. *APo* I.13, 78b12–34; *APo* I.24, 85b23–27 and 85b35–36). In *APo* II.10, 93b33, *hê aitia* indicates a non-syllogistic causal account.

[18] One might object that in *APo* I.24, 85b24–27 Aristotle uses the expressions "of the *aitia* and of the *dia ti*" and "of the *aition* and of the *dia ti*" interchangeably. However, the first expression applies to the nature of the demonstrative syllogism (what is demonstrated is the explanation and the reason why), while the second applies to the nature of the universal premise, which is more explanatory in the sense that it shows the *aition* more clearly (cf. *APo* I.31, 88a5–6).

"explanation," and the adjective *aitios* as either "causative" or "explanatory," depending on the context.

Assuming that this semantic distinction between *aition* and *aitia* illustrates a philosophical distinction between the type of causal explanation that is demonstrated through the middle term and the type of causality picked out by the middle term, I shall now present a new reading of *APo* II.11.

6.2 TOWARDS A NEW READING OF *APO* II.11

Making sense of the opening statement and the examples in APo *II.11*

In his opening statement of the chapter, Aristotle first recapitulates his definition of scientific knowledge. That is, we know something when we know its explanation, which is the syllogistic formula stating the *aition* of the state of affairs to be explained. He then specifies four kinds of explanations, which are formulated as four different questions as to the reason why: formal explanation is an explanation of *what* it is to be a thing. Material explanation – if we can indeed speak of *material* explanation in this case[19] – is an explanation of *given what* things being the case it is necessary for that to hold. Efficient explanation is an explanation of *what* initiated the movement. And teleological explanation is an explanation of the for the sake of *what*. As the "since" (Ἐπεὶ) indicates, this should all be common knowledge.

The new information is that all of these explanations are demonstrated through the middle term. This is the process of demonstration: the explanations of the reason why are demonstrated through middle terms that explain why the predicate holds of the subject in the conclusion. The middle term thus reveals a causal connection underlying the per se relation between these two terms (on the causal notion of per se, see *APo* I.4, 73a10–17). The point is that it is only by setting out the whole syllogism and thereby expressing explicitly the cause of why the predicate holds of

[19] The expression Aristotle uses to refer to material causation in *APo* II.11 (i.e., τὸ τίνων ὄντων ἀνάγκη τοῦτ' εἶναι) is puzzling, but cf. perhaps *GA* V.3, 782a22–23 (τίνων δ' ὑπαρχόντων καὶ διὰ τίνας ἀνάγκας συμβαίνει); *PA* I.5, 645b32–33 (ὧν ὄντων ἀναγκαῖον ὑπάρχειν); and *PA* IV.2, 677a17–18 (ἀλλά τινων ὄντων τοιούτων ἕτερα ἐξ ἀνάγκης συμβαίνει διὰ ταῦτα πολλά). I believe Aristotle to imply that material causes for the most part necessitate their results, or at least do so in the case of phenomena that are the subject of demonstrations. Here I treat the expression and the example discussed below as "canonical" examples of material explanation, taken in the broad sense as an explanation stating "that out of which." For the problems involved (which do not affect the interpretation presented here), see Barnes (1993, 226–227); Detel (1993, 685 and 690–694); and Ross (1949, 638–642).

the phenomenon picked out by the subject term that we come to reach true understanding of something.

Aristotle then works out three examples of explanations (material, efficient, and final) that are demonstrated through the middle term. He gives no separate example of formal explanation, supposedly because this "has already been demonstrated" (*APo* II.11, 94a35–36) in earlier chapters.[20] For the sake of completeness, I shall supply a formal cause explanation from an earlier chapter in my discussion below.

My reconstruction of the four examples and their formalizations into syllogisms is as follows:

Example 1: Material explanation (*APo* II.11, 94a27–35; cf. Euc. *El* III.31)

Explanandum:	i. [Why (*dia ti*) is there a right angle?]	[Why A?]
	ii. Why is the angle in a semicircle a right angle?	[Why A of C?]
A = right; B = half of two rights (*aition* = *material cause*); C = angle in a semicircle		
AaC because of B: right holds of the angle in a semicircle because of being half of two rights.		

Example 2: Formal explanation (*APo* II.8, 93b8–13; *APo* II.11, 94b34–36)

Explanandum:	i. What is thunder?	[What is A?]
	ii. Why (*dia ti*) is there noise in the clouds?	[Why A of C?]
A = thunder (a sort of noise); B = extinction of fire (*aition* = *efficient cause*); C = cloud		
AaC because of B: thunder is noise in the clouds because of fire being extinguished.		

Example 3: Efficient explanation (*APo* II.11, 94a36–b8)

Explanandum:	i. [Why (*dia ti*) is there a Persian war?]	[Why A?]
	ii. Why did the Persian war come upon the Athenians?	[Why A of C?]
A = war; B = being the first to attack (*aition* = *efficient cause*); C = Athenians		
AaC because of B: being warred upon holds of the Athenians because of being the first to attack.		

[20] I take Aristotle to refer to *APo* II.8, which is part of his larger investigation into the relation of definition and causal explanations in *APo* II.8–10.

Example 4: Teleological explanation (*APo* II.11, 94b8–26)

Explanandum:	i. Why (*dia ti*) does he walk?	[Why C?]
	ii. [Why does healthy hold of walking?]	[Why A of C?]
A = being healthy; B = food not floating (*aition* = *material cause*); C = walking after dinner		
AaC because of B: being healthy holds of walking after dinner because of the food not floating.		

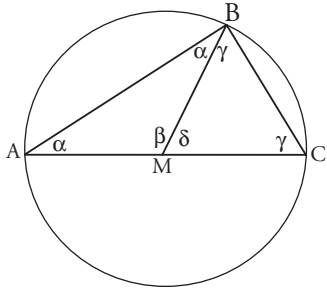
Before turning to an analysis of these examples, let me state from the outset that contrary to the traditional interpretation I see no decisive indications in the text as to why Aristotle should only be concerned with syllogisms in the mode Barbara. I submit that the introduction of the four types of explanations in *APo* II.11 rather shows that Aristotle is concerned with laying out a general syllogistic structure in which *every* causal relation can be fitted. Reading the chapter in this way, the contingency and singularity of the examples noted by critics of Aristotle need no longer constitute a lingering problem. They can be accounted for within the larger framework of causal relations Aristotle is interested in, and so can the other examples Aristotle mentions in the remainder of the chapter (*APo* II.11, 94b27–34).[21]

The example of material explanation

The first example of material explanation is developed in the context of a discussion of the necessary nature of demonstrative syllogisms (*APo* II.11, 94a24–27).[22] The example can be analyzed as follows (for the proof see Figure 6.1). The *dia ti* question Aristotle poses is "because of what is the angle in a semicircle a right angle." An adequate explanation should thus state the geometrical proof showing "that out of which" it follows that the angle in a semicircle is right. This example of material explanation is in

[21] These latter examples are rather more fanciful than serious, such as the Pythagorean belief that it thunders in order to frighten the inhabitants of Tartarus, or they report scientific views that Aristotle rejects elsewhere, such as the explanation of thunder as being the extinction of fire in the clouds (this explanation is explicitly rejected in *Meteor* II.9, 369b12–24). For a discussion of these examples, see Wians (1996, 137).

[22] Here Aristotle states that, given a middle term shared by two propositions, it is necessary for the conclusion of the syllogism to hold. The middle term, or the two premises taken as one, literally bring about the conclusion, and are therefore in a sense the material causes of the conclusion (cf. *Ph* II.3, 195a18–19).



Demonstration: ∠ABC = 90°

∠MAB = ∠MBA (α)

∠MCB = ∠MBC (γ)

(i) β + δ = 180°

(ii) 2α + β = 180°; 2γ + δ =180°

(iii) 2(α + γ) + β + δ = 360°

(iv) 2(α + γ) = 180°

(v) α + γ ("the angle in a semicircle") = 180° ("two rights") divided by 2 ("half") = 90° ("right")

Figure 6.1 Material explanation in *APo* II.11, 94a27–35

fact reflected in a theorem from Euclid (*El.* III.31), and the proof might be so as well.

Here Aristotle induces the search for the middle term by rephrasing the question explicitly in terms of material necessity: "given what being the case is it a right angle?" What we are looking for is a condition that necessitates the rightness of the angle in a semicircle – a condition, incidentally, that will be immediately evident once the right mathematical figure has been discovered (cf. *Meta* IX.9, 1051a21–29). Aristotle then formalizes the explanation, while introducing "half of two rights" as the middle term (B) that explains why "right" (A) holds of "angle in a semicircle" (C).

The rationale Aristotle offers in this section is somewhat obscure, but is not too problematic once we presuppose the familiarity of Aristotle's readership with the relevant mathematical figure and the proof of the proposition as we know it from Euclidean geometry (Aristotle hints at both of them in the above mentioned passage in *Meta* IX.9). Important in this proof is that the geometrical relations between "right angle" and "angle in a semicircle" are discovered by *division*.[23] It is this division that Aristotle refers to when claiming that "[the term B] is equal to A, and C to B, because it [C] is of two rights – half."[24] It is this "being half" that necessitates the angle in a semicircle being a right angle. In sum, the angle in a semicircle is a right angle because it is half of two rights; "being half of two rights" is the material cause of "right" holding of "the angle in a

[23] Cf. *Meta* IX.9, 1051a22–23: "mathematical figures, too, are discovered by actualization; for they find them by dividing [the figures] (διαιροῦντες)."

[24] Note the word order in the Greek: while B is defined as $^{1}/_{2}$-2R (*APo* II.11, 94a29: ἡμίσεια δυοῖν ὀρθαῖν; 94a32–33: ὄντος ἡμίσεος δύο ὀρθῶν, C is explained as 2R-$^{1}/_{2}$ (*APo* II.11, 94a32: δύο γὰρ ὀρθῶν ἡμίσεια).

semicircle." The angle in a semicircle is by necessity a right angle *given that it is two rights – divided in half*.

In this case, both the causation expressed by the explanation and the explanatory middle term that brings out this explanation are of the material type.

The example of formal explanation

The second example of formal explanation (taken from *APo* II.8, 93b8–13) can be analyzed as follows. The *dia ti* question Aristotle poses is why there is thunder. This is a reformulation of the question "what is thunder," which is a question for the definition of thunder (Aristotle answers the "what is" question by stating that it is the extinction of fire in cloud, which is not a demonstration of the essence of thunder yet). For Aristotle, the question why there is thunder is equivalent to the question what thunder is, except that the first is a question for a demonstration and the latter for a definition (see *APo* II.10, 94a1–8). An adequate explanation of why there is thunder thus needs to be a formal explanation expressing the essence of thunder through a middle term that brings out this essence.

However, as Aristotle indicates in another text where he discusses the same example (*Meta* VII.17, 1041a24–32),[25] the only way to get a demonstration is by converting the explanandum into a predicative relation.[26] This can be done, first, by taking the nominal definition of thunder (as being "a sort of noise in the cloud"; *APo* II.8, 93a22–23). Second, one can do this by turning the request for a definition into a *dia ti* question for a demonstration, in which the object of inquiry is "a something of something else" (i.e. why is there thunder in the clouds). Because the explanation in this case is already known (i.e. thunder comes about through the extinction of fire in the cloud), Aristotle sets out immediately to formalize the example: the subject term (C) is "cloud"; the middle term (B) is "extinction of fire"; and the predicate term (A) is "thunder." Now, B holds of C, because the extinction of fire takes place *in* the cloud (the cloud is the locus in which the phenomenon typically resides), and A – "thunder" (i.e. a sort of noise) – holds of B, because B is a definition of A.

In this case, the explanatory middle term picks out an efficient cause of why there is thunder or noise in the clouds: the origin of motion of the noise lies in the extinction of fire. It is through this efficient cause that

[25] For the thunder examples in the *Analytica Posteriora* and the *Metaphysica*, see Charles (1999, 233–239).

[26] Lennox (2004, 90n2).

the essence of thunder, and thereby the formal explanation of why there is thunder, is revealed: thunder is noise in the clouds caused by fire being extinguished.[27]

The example of efficient explanation

The third example of efficient explanation (*APo* II.11, 94a36–b8) is fairly straightforward. Here Aristotle picks a historical example in asking why it is that the Persian war came upon the Athenians, rephrased as what the explanation is for the Athenians being warred upon. As in the other examples, it is not clear from the outset which type of explanation will be demonstrated.[28] However, the short explanation Aristotle offers first ("because the Athenians attacked Sardis with the Eretrians") shows that he is looking for some state of affairs that initiated the movement, which is an efficient cause (and not for that for the sake of which, such as the desire of the Persians to gain an empire). Aristotle then formalizes the example in the following way: "War, A; being the first to attack, B; Athenians C." It is significant that Aristotle here adds the notion of "first" to the attack: it is being the *first* to do wrong that is explanatory for being wronged, and this is the origin of motion.

In this case, the middle term picks out the efficient cause of why war came upon the Athenians: for "people make war on those who first began," which is why being warred upon holds of those who first began. The Athenians were the ones who first began (they fall under this formal description), and this explains the origin of the Persian war.[29]

The example of teleological explanation

Aristotle introduces the section on teleological explanation (*APo* II.11, 94b8–26) with a somewhat puzzling clause: Ὅσων δ' αἴτιον τὸ ἕνεκα τίνος. From what follows it is clear that the explanations that are at stake

[27] Charles (1999, 239); Lennox (2001b, 141).

[28] A similar example in *Ph* II.7, 198a18–19 ("[for the why ultimately leads back either] to the first source of motion, e.g., why did they go to war? Because they were plundered, or to that for the sake of which, e.g., in order to rule") points out that the question why there is war can be answered in different ways.

[29] Note that in all three examples the primary explanandum is the occurrence of a certain phenomenon (i.e. "rightness," "thunder," and "war") that can be expressed in a predicative relation with a subject in which the phenomenon typically and for the most part inheres (i.e. "angle in a semicircle," "cloud," and "Athenians"). The demonstration that follows reveals that there is some aspect of this subject that explains the holding of its attributes.

are teleological ones: Aristotle gives two parallel examples ("For what reason does he walk? In order to be healthy. For what reason is there a house? In order to protect possessions"), and identifies the final cause or the purpose in each example ("In the one case it is in order to be healthy, in the other in order to protect"). He also explains that in these cases there is no difference between a "because of what" question and a "for the sake of what" question. However, it is not immediately clear whether or not Aristotle means that the final cause has to be picked out by the middle term.

The introductory clause (*APo* II.11, 94b8) has often been read as implying just that (i.e., that in these cases the cause is that for the sake of which),[30] but it does not have to be read in this way. The Greek has τὸ ἕνεκά τίνος, which means something different from τὸ οὗ ἕνεκα. The latter (i.e., *to hou heneka*) is the more common expression and is used more or less as a stock phrase designating the end (literally, "that for the sake of which," in which οὗ is a relative pronoun).[31] In contrast, the first expression (i.e., *to heneka tinos/tou*) designates the teleological relation of one item being for the sake of something else (literally, "that which is for the sake of something," where τινος is an indefinite pronoun). Here, the τό is not used as a definite article to substantivate the prepositional phrase, but is used to identify either the item that is for the sake of something, or the teleological relation that exists between two items.[32]

Under this interpretation, the point Aristotle makes here is not that the explanatory middle term in this case is the final cause, but that the causal relation involved is teleological, and that the middle term must pick out the causal factor that explains how one item is for the sake of something else. The teleological explanation is demonstrated through a middle term that need not itself be a final cause, but that rather shows how an end can hold of some subject. This causal relation is then illustrated by the two examples: walking is for the sake of health, and a house is for the sake of protection. The middle term that we are looking for needs to pick out a state of affairs that shows why this teleological relation between walking and being healthy obtains.

[30] E.g., Apostle (1981, 59): "Lastly, there is a final cause [or, that for the sake of which]," and Barnes (1993, 60): "suppose it is the purpose which is explanatory."

[31] Cf. *Ph* II.2, 194a27–30 "Further, that for the sake of which (τὸ οὗ ἕνεκα), or the end, as well as whatever is for the sake of these (ὅσα τούτων ἕνεκα), belong to the same study. But nature is an end and a 'that for the sake of which' (τὸ οὗ ἕνεκα)." *Cael* II.12, 292b6–7: "for action always consists in two factors, when there is that for the sake of which (οὗ ἕνεκα) and that which is for the sake of something (τὸ τούτου ἕνεκα)."

[32] Cf. *Ph* II.5, 196b17 and b20–22; *DA* III.12, 434a32; *GA* I.1, 715a4; *GA* V.1, 778b13; *MA* VI, 700b26–27; and *Meta* XI.8, 1065a31.

In a simplified version of the demonstrative syllogism, the predicate term (A) is being healthy, the middle term (B) is the food not floating, and the subject term (C) is walking after dinner. In this case, the middle term picks out the material cause of why being healthy holds of walking after dinner, because it identifies the physiological condition that is healthy – a condition that itself is initiated by walking that brings about health as an efficient cause.[33] For the identification of "the food not floating" as a material cause, compare Aristotle's qualification of the boiling of the blood surrounding the heart as a material cause of anger in *DA* I.1, 403a25–b1.

In all four examples, the different explanations that are at stake are revealed through the middle term, which picks out a cause for the holding of the predicate term of the subject term. However, in my analysis of the example of teleological explanation, I have left two important questions unanswered. First, if Aristotle did not intend the final cause to be picked out by the middle term, what does he mean by "changing the *logoi*"? Second, one might wonder what it is about this example – or about teleological explanations in general – that makes it so hard to rewrite the demonstrations in such a way that the final cause is actually picked out by the middle term. The following sections address these questions.

6.3 THE FORMALIZATION OF THE EXAMPLE OF TELEOLOGICAL EXPLANATION

Why walking is for the sake of health

The argument of the section on final causes is fairly long compared to the illustration of the other types of explanation, and it proceeds in quite a complicated way. Here I shall first separate the different steps in the argument and give a detailed interpretation of each; next, I shall propose two possible interpretations of "changing the *logoi*". Let me start by introducing the way Aristotle originally formulates the terms of the explanation (Table 6.1). For the sake of clarity, I also add the alternative formulations of the terms that Aristotle uses during the argument (Table 6.2).[34]

The argument itself proceeds roughly in the following four steps. First Aristotle asks us to suppose that to make the food not floating (B_2), holds of C, walking after dinner, and that this is healthy (A_2). Note that Aristotle changes the formulations of the terms A and B, presumably to show that

[33] As Bolton (1997, 113–15) suggested.

[34] I shall retain the numbering in my discussion of the example of teleological explanation; where it is not clear which formulation Aristotle has in mind the term is not numbered.

Table 6.1 *The original formulations of the terms in* APo *II.11, 94b8–26*

A_1	Being healthy	τὸ ὑγιαίνειν	Condition	Final cause
B_1	The food not floating	τὸ μὴ ἐπιπολάζειν τὰ σιτία	Condition	*Aition*
C	Walking after dinner	περίπατος ἀπὸ δείπνου	Activity	Explanandum

Table 6.2 *The alternative formulations of the terms in* APo *II.11, 94b8–26*

A_2	Healthy	ὑγιεινός	Productive of condition
B_2	To make the food not floating	τὸ ποιεῖν μὴ ἐπιπολάζειν τὰ σιτία	Activity productive of condition

walking (which is an activity) holds of another activity that produces the condition of the non-floating of food. It is this latter activity that Aristotle calls healthy, for healthy is just that which produces (or is useful to) the condition of being healthy. This is in fact the way Aristotle characterizes "healthy" in the *Ethica Eudemia* (*EE* I.8, 1218b16–22):

> And that the end stands in a causal relation to the means subordinate to it is shown by teaching. For, having defined the end they show, regarding other things, that each of them is a good, because "that for the sake of which" is the cause (αἴτιον γὰρ τὸ οὗ ἕνεκα). [Note that Aristotle uses "*to hou heneka*" here, and not "*to tou heneka*"]. For example, since "being healthy" is such and such a thing, then necessarily this other thing will be what is useful for it. And what is healthy will be the efficient cause of health (τὸ δ' ὑγιεινὸν τῆς ὑγιείας αἴτιον ὡς κινῆσαν), though only the cause of its being, but not of health being a good.

By characterizing walking as an activity that is productive of the food not floating, and the latter as being productive of health, Aristotle implies that C is an efficient cause of A_1, being healthy: walking is productive of a healthy condition (cf. *Rh* I.6, 1362a31–34). Walking and health are thus causes of each other: while walking is the efficient cause of health, health is the final cause of walking (cf. *Ph* II.3, 195a8–11). Now, if walking is a health-producing activity, it remains for the teleological demonstration to exhibit why it is that walking effects a change that is directed towards health. Health, as the final cause of walking, explains why there is walking after dinner, but apparently, this is not sufficient for a complete demonstration of this phenomenon: we also need to know why this teleological relationship between walking and health obtains (for, as we saw in section 1.1, final causes never operate in a vacuum). Accordingly, Aristotle continues the

argument – and this is step 2 – by explaining that it is thought that B_1, the material condition where the food is not floating on the surface, holds of C, walking, and healthy (A_2) holds of B (B_1). This opinion points towards the causal role of the phenomenon picked out by B_1.

Indeed, Aristotle now (third) poses the question of what the *aition* is that causally connects C, walking, and A, which picks out the "that for the sake of which."[35] The answer is B_1, the not floating. Aristotle adds that "this is like a definition of that" (*APo* II.11, 94b19–20). Probably the first "this" refers to B_1, the not floating, while "that" refers to A_1, being healthy, "for," Aristotle explains, "in that way the A will be explained." The not floating of the food is like a definition of being healthy in the sense that it shows how being healthy in this context (i.e. in the context of a person who just had dinner) is to be understood. Part of what it means to be healthy in this case is to be in a condition where the food is not floating on the surface of the stomach.[36]

Finally, Aristotle turns to an account of the minor premise: "For what reason does B hold of C?" He answers that the reason is "because that is what being healthy is: to be in such a condition." The formulation of this response suggests that we have touched upon a premise that is not further analyzable but is immediately evident (i.e. the premise is immediate). At this point, Aristotle ends his discussion of this particular example of teleological explanation.

Two possible interpretations of "changing the logoi*"*

The section is completed by the enigmatic statement (Barnes called it the "Delphic injunction")[37] that one needs to "change the *logoi*", and that "in that way each of them will become clearer" (*APo* II.11, 94b21–22). The traditional interpretation reads this sentence in an apologetic way: Aristotle realizes that his example of the final cause is ill-chosen and messy, and that by mistake the middle term does not pick out the final cause. In order to make sense of this example, we should therefore (stipulate that the terms are coextensive and) rearrange the order of the terms or of the premises in such a way that the middle term will pick out health as the final cause. However, I see two problems with this reading that strongly suggest that we should look for a different interpretation.

[35] The apposition "the for the sake of which" in *APo* II.11, 94b18 belongs to A, not to the *aition*.

[36] Other definitions of health are "having one's body in a uniform state" (*Meta* VII.7, 1032b6–8), or "having fasted for a while" (*Ph* II.3, 194b36).

[37] Barnes (1993, 229).

First, Aristotle spends quite some time expounding the example of teleological explanation, and it seems not very charitable to assume that this is not the example he actually would have liked to present to his readers. In fact, the explanation that walking is for the sake of health is a stock example in the Aristotelian corpus, and the rationale Aristotle provides for health holding of walking in this chapter is perhaps not entirely transparent, but very much in line with other accounts of the example. If my interpretation holds, then we might say that Aristotle succeeds quite well in demonstrating how the middle term, i.e. the food not floating, exhibits the teleological relation between walking and health (and does so without using the psychological language of desires or wants, which Aristotle evades in this example as well). There is thus no need to rearrange the example.

Second, Aristotle uses the verb μεταλαμβάνειν as a technical term in the *Prior Analytics* and in the *Topics*, where it means without exception "to substitute for."[38] This suggests that we should expect μεταλαμβάνειν τοὺς λόγους to mean something like "substituting the *logoi* (for something else)." In fact, the use of μεταλαμβάνειν as some kind of technical procedure of substitution in these texts presents two options for how to interpret the expression in the context of the *Analytica Posteriora*, neither of which implies a rearrangement of the example.

One possible interpretation[39] is that the substitution concerns the formulations (*logoi*) of the terms. This reading is based on Aristotle's use of μεταλαμβάνειν in the following passage of the *Analytica Priora* (*APr* I.34, 48a1–27):

> Mistakes frequently will happen because the terms in the premise have not been well set out . . . The reason for this is that the terms are not set out well with regard to formulation, since if the terms for being in the conditions are substituted [for the terms for the conditions themselves], there will not be a deduction; for example, if instead of "health" "healthy" is posited, and instead of "disease" "diseased." For it is not true to say that being healthy cannot hold of someone diseased. But if this is not assumed, there is no deduction, except in respect of possibility: and that is not impossible. For it is possible that health holds of no man . . . It is evident then that in all these cases the fallacy results from the setting out of the terms; for if the terms for being in the conditions are substituted, there is no fallacy. Thus, it

[38] Smith (1989, 137, 261). See *APr* I.17, 37b15; *APr* I.20, 39a27; *APr* I.22, 40a34–35; *APr* I.23, 41a39; *APr* I.29, 45b12–20; *APr* I.34, 48a1–27; *APr* I.38, 49b1–2; *APr* I.39, 49b3–6; *APr* II.4, 56b7–8; *APr* II.8, 59b1–11; *Top* II.2, 110a4–9; *Top* V.2, 130a29–b10; *Top* VI.4, 142b3; *Top* VI.9, 147b12–14; and *Top* VI.11, 148b24–149a7 (*passim*).

[39] Already suggested by Fortenbaugh (1966, 192).

is clear that in such premises the term for being in the condition always needs to be substituted and posited instead of that of the condition itself.[40]

In this passage, Aristotle deals with fallacies that occur when the terms of the syllogisms have not been set out well with regard to formulation (48a9: κατὰ τὴν λέξιν).[41] The problem is solved by substituting terms "for being in the conditions," that is, adjectives such as "healthy" (ὑγιαῖνον) and "diseased," instead of the terms for the conditions themselves, that is, nouns such as "health" (ὑγίεια) and "disease." We might postulate that a similar kind of substitution of the formulation of the terms has taken place in *APo* II.11: the terms indicating the conditions are substituted by terms indicating what is in the condition, or rather, by terms indicating what is productive of the condition. We have seen that Aristotle substituted "healthy" (A_2) for "being healthy" (A_1), and "to make the food not floating" (B_2) for "the food not floating" (B_1). Through these substitutions A and B could be predicated of C (a term indicating an activity), and also the causal relations (in this case, both material causal and efficient causal ones) between the three terms would become more evident.

Another possible interpretation[42] is that the substitution concerns the replacement of words by their definitions. This is the stock use of the expression in the context of the *Topica*, and, accordingly, we should supply ἀντὶ τῶν ὀνομάτων in the passage in *APo* II.11. One context in which the expression "to substitute the definitions for the words" is used in the *Topics* is in that of the fallacy of repeating the word that is being defined or predicated in the definition or predication. The failure pertains to not having used the prior or better-known term in the definition or predication. The procedure of substituting definitions for words is one of the recommended ways to detect the fallacy (*Top* VI.9, 147b12–14; VI.4, 142a34–b6):

[40] πολλάκις δὲ διαψεύδεσθαι συμπεσεῖται παρὰ τὸ μὴ καλῶς ἐκτίθεσθαι τοὺς κατὰ τὴν πρότασιν ὅρους . . . τούτου δ' αἴτιον τὸ μὴ καλῶς ἐκκεῖσθαι τοὺς ὅρους κατὰ τὴν λέξιν, ἐπεὶ μεταληφθέντων τῶν κατὰ τὰς ἕξεις οὐκ ἔσται συλλογισμός, οἷον ἀντὶ μὲν τῆς ὑγιείας εἰ τεθείη τὸ ὑγιαῖνον, ἀντὶ δὲ τῆς νόσου τὸ νοσοῦν. οὐ γὰρ ἀληθὲς εἰπεῖν ὡς οὐκ ἐνδέχεται τῷ νοσοῦντι τὸ ὑγιαίνειν ὑπάρξαι. τούτου δὲ μὴ ληφθέντος οὐ γίνεται συλλογισμός, εἰ μὴ τοῦ ἐνδέχεσθαι· τοῦτο δ' οὐκ ἀδύνατον· ἐνδέχεται γὰρ μηδενὶ ἀνθρώπῳ ὑπάρχειν ὑγίειαν . . . Φανερὸν οὖν ὅτι ἐν ἅπασι τούτοις ἡ ἀπάτη γίνεται παρὰ τὴν τῶν ὅρων ἔκθεσιν· μεταληφθέντων γὰρ τῶν κατὰ τὰς ἕξεις οὐδὲν γίνεται ψεῦδος. δῆλον οὖν ὅτι κατὰ τὰς τοιαύτας προτάσεις ἀεὶ τὸ κατὰ τὴν ἕξιν ἀντὶ τῆς ἕξεως μεταληπτέον καὶ θετέον ὅρον.

[41] For parallels for this method of *metalêpsis* in the ancient grammar tradition, see Sluiter (1990, 111ff).

[42] Suggested by Pieter Sjoerd Hasper (in personal correspondence).

Another [failure] is, if one has used the term that is itself being defined. This passes unnoticed when the actual name of the object being defined is not used, e.g., supposing anyone had defined the Sun as a star that appears by day. For in bringing in day he brings in the Sun. To detect errors of this sort, substitute the definition for the word (μεταλαμβάνειν ἀντὶ τοῦ ὀνόματος τὸν λόγον), e.g., the definition of day as the passage of the Sun above the Earth.

The expression is also used in the context of examining the correctness of definitions rendered of a complex term. For the definition to be correct, the words of the complex term have to be replaced by the definitions of the words (*Top* VI.11, 149a1–3). The substitution of definitions of words used in definitions also helps to clear up whether or not the predications hold non-accidentally (*Top* II.2, 110a4–9):

One should substitute definitions also for the words contained in the definitions (λαμβάνειν δὲ καὶ ἀντὶ τῶν ἐν τοῖς λόγοις ὀνομάτων λόγους), and not stop until one comes to something familiar; for often when the definition is given as a whole, the thing looked for is not cleared up, (οὕπω δῆλον) whereas if for one of the words used in the definition a definition be stated, it becomes obvious (κατάδηλον).

Under this interpretation, we need to replace the words set out in the syllogism – such as "walking," or "being healthy" – by their definitions (perhaps just as Aristotle did himself), until we find the more familiar terms,[43] and in that way the predications will become clearer. A striking parallel is provided by Galen, who – plainly following Aristotle – uses μεταλαμβάνειν in this exact same way while discussing scientific demonstrations.[44]

The expression μεταλαμβάνειν τοὺς λόγους may be too elliptical to help us decide which of the two possible interpretations we should favor, but this problem need not concern us too much. Both uses seem to be at play in the *Analytica Posteriora* context: Aristotle probably meant some technical procedure of substitution that he applied himself in discussing the example, and through which the causal relations between the terms and the predications became clearer.

[43] This type of substitution might be connected to the one Charles observes in the *Analytica Posteriora* concerning the example of thunder: the predicative term "thunder" is replaced by its nominal definition "noise in the clouds," which both gives us more familiar terms and indicates how thunder is to be understood in the relevant syllogism. See Charles (1999, 240).

[44] See Galen, *Meth Med* X.39, 5–10: "that with regard to every inquiry one needs to substitute the definition for the word" (ὡς ἐπὶ πάντων τῶν ζητουμένων εἰς λόγον χρὴ μεταλαμβάνεσθαι τοὔνομα). I am grateful to Jim Hankinson for bringing this parallel to my attention.

Ends cannot be picked out by middle terms

If my interpretation is right, then Aristotle has offered us an example of teleological explanation where the middle term picks out a material cause, while the final cause is picked out by the predicate term. This leaves us with the question why Aristotle did not simply provide us with an example of teleological explanation where the middle term picks out a final cause.

I believe that Aristotle indirectly addresses this question in the passage where he brings up the order of causation in different types of demonstrations (*APo* II.11, 94b23–26):

> Here the events occur in the opposite order from the cases where the causes are according to motion. For in the latter the middle term must occur first, while here C, the ultimate term, [must occur first] and last the for the sake of which.[45]

In this passage, Aristotle contrasts the order of causation in demonstrations of efficient causal explanations with that of teleological explanations. As we saw earlier, the middle term in the example of efficient explanation (i.e. being the first to attack) picked out an event that *later* initiated the war against the Athenians. The efficient cause picked out by the middle term thus precedes the explanandum in time. However, in the example of teleological explanation, we saw that the action picked out by the subject term (i.e. walking) occurred first. The final cause, health, came about last. It seems that in demonstrations of teleological explanations the final causes are literally, in a temporal sense, the *telos* or the end (and culmination) of the events to be explained.

Aristotle returns to this issue in the next chapter (*APo* II.12), where he discusses the syllogistic features of demonstrations of processes, i.e., of attributes *coming to hold* of certain subjects.[46] Unlike demonstrations of being, which are typically illustrated by mathematical examples in which the attributes hold always and necessarily of their subjects, the premises of demonstrations of processes do not pick out relations between universals that are timeless and necessary without qualification. Instead, they track causal developments over time and pick out relations between attributes and subjects that hold only for the most part. For the syllogistic structure of such demonstrations this means, first, that the terms get tensed: the

[45] αἱ δὲ γενέσεις ἀνάπαλιν ἐνταῦθα καὶ ἐπὶ τῶν κατὰ κίνησιν αἰτίων· ἐκεῖ μὲν γὰρ τὸ μέσον δεῖ γενέσθαι πρῶτον, ἐνταῦθα δὲ τὸ Γ, τὸ ἔσχατον, τελευταῖον δὲ τὸ οὗ ἕνεκα.

[46] I discuss the models of demonstration outlined in this chapter and their possible influences on Aristotle's methods in his biological works in Leunissen (2010). On demonstrations of processes, see also *APo* I.8, *APo* I.30, and *APo* II.16.

processes picked out by the major and middle terms have to be characterized as either past, present, or future happenings. This is, for instance, how Aristotle formalizes the example of the *coming to be* of an eclipse (*APo* II.12, 95a14–16):

> For instance, because of what did an eclipse come about? Because the Earth came in the middle; and it is coming about because [the Earth] is coming [in the middle], and it will come about because [the Earth] will come in the middle, and there is [an eclipse] because [the Earth] is [in the middle].[47]

Second, Aristotle explains that the state of affairs picked out by the middle term has to be either *simultaneous* with the states of affairs it explains in the case of "simultaneous processes" (*APo* II.12, 95a10–24), or *precede* it in the case of "consecutive processes" (*APo* II.12, 95a24–95b1 and *APo* II.12, 95b13–b37). Simultaneous processes are processes in which attributes come to hold of their subjects simultaneously with the operation of the cause picked out by the middle term, i.e., A comes to hold of C at the same time as B comes to hold of C. For instance, the eclipse comes to hold of the Moon at the same time as the Earth moves in between the Moon and the Sun. Consecutive processes are processes in which attributes come to hold of their subjects some time after the (start of the) operation of the cause picked out by the middle term, i.e., A comes to hold of C sometime after B has come to hold of C. As an example of the latter, Aristotle states that the coming to be of a house is demonstrated through a middle term that picks out a state of affairs that is chronologically prior to the explanandum: i.e., the earlier coming to be of a foundation (*APo* II.12, 95b38: ἔσται γὰρ θεμέλιος πρότερον).[48] Demonstrations such as these are thus to reflect the – chronological – order of causation in the real world,[49] which means that the relevant type of causal priority pertaining to the middle terms picked out in demonstrations of processes is "priority in generation," not "priority in nature."

Now, from Aristotle's earlier treatment of the walking-for-the-sake-of-health example, we can infer that teleological processes are consecutive processes (health comes about some time *after* walking has made our food no longer float on the surface of the stomach), whose demonstrations

[47] οἷον διὰ τί γέγονεν ἔκλειψις; διότι ἐν μέσῳ γέγονεν ἡ γῆ· γίνεται δὲ διότι γίνεται, ἔσται δὲ διότι ἔσται ἐν μέσῳ, καὶ ἔστι διότι ἔστιν.

[48] Note that Aristotle typically depicts the causal sequence involved in house-building as a proper and paradigmatic case of an (artificial) teleological causal chain. See, e.g., *Ph* II.9, 200a24–29; *PA* II.1, 646a27–28; and *PA* III.5, 668a13–24.

[49] Cf. Charles (2000, 198–204) on the dependence of the practice of definition on the order of causation.

should satisfy the formal requirements outlined in *APo* II.12. The upshot of this is that, unlike material, formal, and efficient causes (which can all be prior in generation), final causes of processes cannot be picked out by the middle terms in demonstrations (ends that constitute final causes are never prior in generation, but come about when the necessary prerequisites have been fulfilled), but must always be part of the conclusion that is being demonstrated.[50] A teleological explanation explains that some feature is present or comes to be for the sake of some end, where that end is the final cause of that feature; demonstrations of teleological phenomena show that this end in fact comes to hold of that subject through the operation of some other type of cause. That is, demonstrations of teleological phenomena show that there is a genuine and intrinsic teleological relationship between the end and the feature of which it is the end. This is exactly what Aristotle has shown us, namely that the action of walking in fact leads to health, because walking is what makes the food not floating, and being in a condition of having the food not floating is what being healthy is (i.e., health comes to hold of walking once – after some walking around – walking has made the food not floating). On this account, ends are part of the conclusion that needs to be demonstrated, and cannot be picked out by the middle term through which the conclusion is demonstrated.

The question I shall focus on below is how this picture of the structure of demonstrations of teleological phenomena as described in the *Analytica Posteriora* relates to the structure of the actual teleological explanations offered by Aristotle in his *De Partibus Animalium*. I shall first return briefly to his discussion of demonstration in the natural sciences, and then analyze three predominant types of explanation in biology that involve final causality. Without going into too much detail, I shall show that the structure of the actual teleological explanations illustrates our findings about the theory of explanation rather well.[51]

[50] This might explain why in the case of the teleological explanation in *APo* II.11 the explanandum is picked out by the subject term ("why does walking after dinner occur?"), rather than by the predicate term as in the other three types of explanation.

[51] This question touches upon the important debate on the relation between the ideal of scientific investigation and demonstration set out in the *Analytica Posteriora* (the "theory") and the methodological reflections and actual explanations Aristotle offers in his treatises on natural science (the "practice"). Although I cannot defend my position here, I am more sympathetic to the approach defended *passim* in the works of Lennox and Gotthelf, who hold that Aristotle builds upon and elaborates his scientific standards for the different sciences, than to the approach defended by Lloyd (1996), who argues that Aristotle is a methodological pluralist, and that theory and practice cannot be reconciled with each other.

6.4 THE STRUCTURE OF ACTUAL TELEOLOGICAL EXPLANATIONS: EVIDENCE FROM *DE PARTIBUS ANIMALIUM*

The structure of demonstration in the natural sciences according to PA *I.1*

Aristotle brings up the issue of demonstration in the natural sciences in the first book of *De Partibus Animalium*. As we saw in more detail in Chapter 3, Aristotle argues there that the modes of demonstration in the theoretical sciences and in the natural sciences are different, because the modes of necessity and the direction of the causal inference are different (*PA* I.1, 640a3–6):

> For the starting point is in some [i.e. the theoretical sciences] what is, but in others [i.e. the natural sciences] what will be. For, "since health or man is such, it is necessary that this is or comes to be," but not "since this is or has come about, that from necessity is or will be."[52]

The causal mode of necessity operative among sublunary (non-circular) natural phenomena is identified as conditional necessity, which Aristotle explains as the necessity of certain things being present first, if the end is to come to be (*PA* I.1, 639b26–30). Demonstrations in the natural sciences thus pertain to linear, causal – typically, teleological – sequences in which the causally relevant items are separated in time (and not to timeless or eternal phenomena, which are the objects of demonstration in the other theoretical sciences), and they will thus have to track the order of causality in the natural, sublunary world. However, since those causally relevant items never necessitate their outcomes without exception, but only for the most part,[53] the direction of the inferences that pertain to them can never be from the prior to the posterior. Rather, the necessity that governs the deduction in the natural science kind of demonstration has to be conditional too, and move – one-directionally – from the posterior (which is the end that already has come to be) to the prior (which are the antecedent causes of the coming to be of that end). In other words, the proper mode of reasoning has to be that, if the end has come to be or is (such and such), then its necessary prerequisites have had to come to be or be present

[52] Ἡ γὰρ ἀρχὴ τοῖς μὲν τὸ ὄν, τοῖς δὲ τὸ ἐσόμενον· ἐπεὶ γὰρ τοιόνδε ἐστὶν ἡ ὑγίεια ἢ ὁ ἄνθρωπος, ἀνάγκη τόδ' εἶναι ἢ γενέσθαι, ἀλλ' οὐκ ἐπεὶ τόδ' ἐστὶν ἢ γέγονεν, ἐκεῖνο ἐξ ἀνάγκης ἐστὶν ἢ ἔσται.

[53] This is because, as Aristotle explains (in *PA* I.1, 640a6–9 and *GC* II.11), the relation between the cause and effect in the natural, sublunary world is never one of unqualified necessity and the necessity involved in these cases does not convert.

first (its necessary prerequisites cannot not be; cf. *Ph* II.9, 200a19–22). The deduction is not of the consequences of a certain starting point, but of the antecedents of the end.[54]

These remarks about the nature and structure of demonstrations in the natural sciences present the following picture of what these demonstrations in practice would look like. First, it is clear that the predominant form of demonstration in the natural sciences will be teleological in nature. The main project of the *De Partibus Animalium* is, as we saw, to explain why particular parts and their differentiations belong to the animals that have them, and Aristotle's first move in answering these questions is usually to identify the function the part performs. It is the function that constitutes the part's final cause and that explains its presence.

Second, we ought to expect the explanations Aristotle provides (which are potentially transformable into demonstrations of the natural science kind) to do more than just identify the final causes of natural phenomena. Aristotle's discussion of demonstration in *PA* I.1 puts the ends that constitute the final causes of natural phenomena in the position of (observational) starting points for demonstration in the natural sciences. It is from knowing the realized end that we can then deduce its necessary antecedents, which the realization of this end demands. This inference scheme implies, I submit, that the ends that constitute the final causes will be picked out by the major terms in the demonstration, and that they are part of the conclusion that is being demonstrated, whereas the necessary antecedents will figure as middle terms in the demonstration. In other words: a certain animal part is present in the animal that has it for sake of the function it performs, but it is through specifying the necessary antecedents that Aristotle demonstrates the teleological relationship between the animal, the part, and its function. Indeed, *De Partibus Animalium* is not a treatise that simply lists parts of animals and their respective functions. Aristotle also specifies why, for instance, this particular animal needs to perform this function (or at least benefits from being able to perform it), why it performs this function with only one kind of part rather than with two kinds (as some of its related species do), why the part can perform the function it performs, etc.

I take it that this picture is largely consistent with the example of why one walks after dinner in *APo* II.11. The question why one walks after dinner parallels the biological question why a certain part is present in a certain

[54] Lloyd (1996, 32); as Lloyd rightly points out, the antecedents that are deduced are antecedents of the final cause in a chronological or ontological sense, not in a logical one.

animal. The question is answered by identifying the final cause: in the case of walking, health; in the case of biological parts, the function of the part. In both cases, the middle term will have to pick out the conditionally necessary antecedents that for the most part will bring about the end that constitutes the final cause.

I shall strengthen this general picture by an analysis of the three most common types of teleological explanation that Aristotle uses in his *De Partibus Animalium*.[55]

The place of final causes in actual teleological explanations

(1) The explanation of the presence of vital and essential parts: functions are subsumed under the formal cause

The most common question in *De Partibus Animalium* is why a certain part belongs to a certain animal, and Aristotle typically answers this question by pointing to the function that part plays within the particular animal kind that has that part. The presence of parts is thus explained teleologically through reference to their function (which is the part's final cause), but usually the need to perform these functions is explained by reference to the definition of the substantial being of the animal. It is the definition of the substantial being of the animal that specifies, among others, the functional features that are to be realized and that is thus causally primary in the explanation of the presence of those features.

Let me explain this by returning to a by now familiar example. The question why birds have wings is answered by reference to the function of flying as a part of the definition of the substantial being of birds (*PA* IV.12, 693b6–14, quoted above in section 5.2): birds are essentially flyers, and flyers necessarily have wings. In a formalization of this example, the middle term would be "flyers" (which picks out a functionally defined form), not "flying," which would pick out the function or final cause. That "being a flyer" is causally prior to "flying" in the explanation of the presence of wings in birds is evidenced by the fact that there are also kinds of birds that have wings but are not actually able to fly: these birds, too, have wings in virtue of being flyers, even though those wings cannot be said to be present for the sake of flying.[56] It is thus the definition of the substantial being of birds that is causally primary, and which is picked out to explain why such necessary parts as wings with certain functions hold of

[55] These three types of teleological explanation coincide with patterns I, III, and VIII discussed in section 4.3.

[56] See, e.g., *PA* IV.12, 694a6–13. Cf. Aristotle's discussion of sedentary insects in *PA* IV.6, 682b12–17.

all birds. Note that from the definition of birds as blooded flyers not only can the presence of wings be demonstrated, but also many of the bird's other features, such as the possession of two feet (rather than four, or six).

Additionally, Aristotle sometimes explains the presence of parts in subspecies by reference to the functions that are part of the definition of the substantial being of the wider kind. The fact that birds are essentially flyers explains according to Aristotle why ducks have wings for the sake of flying. Here, the functions tend to be subsumed under the definition of the substantial being (or the formal cause) of the animal's wider kind. Wings belong to ducks because ducks are essentially birds, and all birds necessarily have wings (even if those wings do not actually enable the bird to fly).

In these cases, functions are picked out by the predicate term and only "indirectly" through the middle term as being part of the definition of the substantial being of something – that is, as being included in the formal cause.[57] Final causes of parts are demonstrated to belong to parts through the functionally defined substantial being of an animal (i.e., the ends that constitute the final causes are exhibited as being the realization of a preexisting potential for form), and it is this formal cause that has causal primacy.

(2) The explanation of the coming to be and presence of subsidiary and luxury parts: secondary teleology

A second type of explanation that is fairly common in Aristotle's *De Partibus Animalium* is the so-called "double-barreled" explanation. In these cases, Aristotle explains the *presence* of a part or its differentiation by reference to the function it performs (he sometimes merely states that the part or its differentiation is "for the better"), whereas he explains their *coming to be* by reference to material necessity. This type of explanation usually pertains to features that are not of vital or essential importance to the animal, either because the functions these features perform are already performed by some other part (where this other part can be exhibited to be the necessary prerequisite for the performance of that function), or because the functions themselves are not strictly necessary for the animal's life or identity. In both cases, nature theoretically *could* have designed the animal without the possession of these features. Instead, Aristotle indicates that these features are present because they contribute to the well-being of the animal.

[57] *PA* I.1, 640a33–35: "hence we must in particular say that since this is what it is to be a human being, on account of this it has these things; for it cannot be without these parts." Cf. *Ph* II.9, 200a14 and *PA* I.1, 639b13–14.

One category of such parts consists of horns, spurs, hoofs, nails, teeth, hair, and eyebrows; these parts all serve the luxury function of defense or protection. The doubleness of the explanation indicates that these parts are due to what I have called "secondary teleology." That is, the *coming to be* of the materials out of which the luxurious parts are constituted is entirely due to material necessity (see, e.g., *PA* IV.3, 677b22–29 and *PA* IV.4, 678a3–10). The *presence* of these parts, on the other hand, and their organization and distribution in an animal's body are due to the goal-directed actions of the formal nature of the animal. Aristotle describes the action of the formal nature of the animal in these cases as *using* materials that are present of necessity for a good purpose, rather than as *producing* those materials for the sake of the realization of some function.

Let us return to the example of horns (*PA* III.2; see also sections 3.2 and 4.3). First, Aristotle summarizes his account that horns are present in the animals that have them for self-defence and attack (*PA* III.2, 663b21–22). Next, he poses the following question (*PA* III.2, 663b22–24): "We must say what the character of the necessary nature is, and how nature according to the account has made use of things present of necessity for the sake of something."[58] The necessary nature of the animal indicates, as I argued above in Chapter 3, the amount and kind of materials that come to be as a result of material necessity, as a by-product or surplus of conditionally necessitated processes (without being themselves conditionally necessary). As Aristotle explains, large animals seem to produce more earthen material than is conditionally necessary (and necessitated) for the production of their bones, and it is this residue which is then "used by nature for protection and advantage" (*PA* III.2, 663b25–35). There is no potential for form that directly necessitated the coming to be of extra materials, and, had there not been a surplus of material available, the formal nature of the animal would not have been able to use it for the production of horns.

In cases like this, the function to which the formal nature of the animal puts the part is highly *determined* by the potentials the available material has. The earthen residue is used by the formal nature of an animal to produce parts like horns, *because* this kind of material has a defensive

[58] πῶς δὲ τῆς ἀναγκαίας φύσεως ἐχούσης τοῖς ὑπάρχουσιν ἐξ ἀνάγκης ἡ κατὰ τὸν λόγον φύσις ἕνεκά του κατακέχρηται, λέγωμεν. Here Ogle's translation (1912; "Let us now consider the character of the material nature whose necessary results have been employed by rational nature for a final cause") is grammatically closer to the Greek than Lennox's translation is (2001b; "Since there is a necessary nature, we must say how the nature according to the account makes use of things present of necessity for the sake of something"). *Pôs* should be taken with *echousês* in the genitive absolute, *and* with *katakechrêtai*: as soon as we know what kind of thing the necessary nature is, we can explain how nature makes use of the things that are present on account of this necessary nature.

potential.[59] Formalizations of examples like these are not easy, but for our purposes, it suffices to notice that again a function is demonstrated to belong to some feature through another more basic feature, in this case the availability of materials with certain material potentials due to material necessity.

(3) The explanation of differentiations of parts: differentiae *or residues are causally primary*

A third common question in Aristotle's *De Partibus Animalium* is why a part has the structural and material properties it has in the particular kind of animal that has it. Or, in other words, Aristotle seeks to explain why the part is differentiated in the way it is in this particular animal, relative to the realization of other parts with the same name and approximately the same function in other animals.

Take the example of eyes: both birds and insects have eyes for the sake of vision, but birds have eyes made of fluid eye jelly, while insects have hard eyes. This material differentiation of eyes cannot be explained by reference to the function of vision as such, which only requires eyes to be made of some transparent stuff (the generic function only explains the presence of parts, not their differentiations). Aristotle explains these differentiations by claiming that they are either for the better or necessary for the animal's way of life (or some other *differentia* that is part of their specific substantial being). In both cases, they are present for the sake of the functional optimization of that part within the particular animal kind. Thus, in *PA* II.2, 648a13–19 (quoted above in section 4.2), Aristotle explains the (relative) fluidity of the eyes of birds as being for the sake of *better* vision in birds: birds have fluid eyes to be better able to see.

However, Aristotle explains the need for functional optimizations like these by reference to the specific nature, habitat, and needs of the animal in question, for which he believes they are either necessary or subsidiary. That is, in the case of necessary differentiations, the causally primary feature in these explanations will be one of the four kinds of *differentia* of the animal kind, which are the other parts (and functions) the animal has, the animal's *bios* (lifestyle and habitat), its activities, and its disposition. These four *differentiae* immediately necessitate the variation among parts through conditional necessity. The *differentiae* demand a functional fine-tuning of the part, and this will in its turn conditionally necessitate

[59] Pace Lennox (2001a, 194–195), who holds that "such material is present for the sake of constituting parts which must have a material propensity suitable for defense."

material-structural changes or a relocation of the part. This is clear in the following example (*PA* II.13, 657b22–29):

> The four-footed, egg-laying animals do not blink in the same way [as the birds], because it is unnecessary for them to have moist and accurate vision since they are terrestrial (ὅτι οὐδ' ὑγρὰν αὐτοῖς ἀναγκαῖον ἔχειν καὶ ἀκριβῆ τὴν ὄψιν ἐπιγείοις οὖσιν). But for the birds it is necessary (τοῖς δ' ὄρνισιν ἀναγκαῖον): they use vision to see from a great distance. Accordingly, crook-taloned birds have sharp vision (for they search for their food from above, which is also why these most of all birds soar to the heights), while those which are terrestrial and incapable of flight, such as domestic fowl and the like, do not have sharp vision. For nothing related to their way of life requires them to have it (οὐδὲν γὰρ αὐτὰ κατεπείγει πρὸς τὸν βίον).

A reconstruction of the premises involved in this example shows that the fact that crooked-taloned birds search for their food from above explains why they need accurate vision, and it is this need for accurate vision that conditionally necessitates the moistness of the eyes of these birds (crooked-taloned birds have moist eyes for the sake of better vision, because better vision is required for their way of life).[60]

However, in the case of differentiations that are for the better, Aristotle indicates that what primarily caused their coming into being is the availability of extra materials, usually due to material necessity. The potentials of this material then determine for what purpose the formal nature of the animal *can* use the material, where the ultimate function is determined relative to the animal's specific substantial being. Water-birds have webbed feet, for instance, because by using the available earthy residues in this way, nature improves the animal's way of life and thereby improves its well-being (*PA* IV.12, 694a22–b11); had the residues not been earthy, nature would have to have used them for some other purpose or would have had to discard the residues. The function for which nature can use the available materials is guided and limited by the material potentials that material has, which indicates that these potentials are causally primary. In both cases, the final cause is part of the conclusion of the demonstration, while the middle term refers to formal or material-efficient causes.

Let me end this exposition of common types of teleological explanation in the *De Partibus Animalium* by pointing out that although the actual explanations are more complicated than the example of walking after dinner in the *Analytica Posteriora*, the basic structure and the role of final causes

[60] For the identification of habitat as a causally basic feature, see Gotthelf (1997a, 85–89) and Charles (1999, 249–250).

seem to be the same. In biology, Aristotle attributes functions to (differentiations of) parts in order to explain the presence of the latter. However, the holding of these functions follows from other, more basic features, such as the animal's essence (which comprises functions), its lifestyle, or the availability of certain material potentials. It thus seems that in practice too Aristotle picks out final causes as part of the explanation, but not as the causally primary feature in the complete explanation.

6.5 CONCLUSION

In the preceding sections, I have argued that *APo* II.11 shows how each of the four types of explanation is demonstrated through an explanatory middle term, which need not express the same type of causality as the explanation does.

This interpretation, supported by the lexical difference between *aitia* and *aition*, takes away the need to rearrange Aristotle's syllogistic example of walking after dinner for the sake of health. Nothing in the text of the *Analytica Posteriora* suggests that final causes *must* be picked out by the middle term in a teleological demonstration. A comparison with the use of μεταλαμβάνειν in the *Prior Analytics* and the *Topics* shows that the expression μεταλαμβάνειν τοὺς λόγους should be taken as referring to some kind of procedure of substitution that Aristotle has applied himself while setting out his example, rather than as an admonition to us to change the order of the terms or premises. The fact that ends that constitute the final causes of natural phenomena are chronologically speaking the last to come to be, together with Aristotle's requirement that demonstrations of processes have to reflect actual causal sequences and track priority in generation, explains why it is impossible to construct a syllogism in which the middle term picks out this end as a final cause.

A short analysis of Aristotle's methodological remarks about demonstration in the natural sciences and of his actual practice of teleological explanation in *De Partibus Animalium* confirms the general picture found in the *Analytica Posteriora* with regard to the structure of teleological explanations. Functions explain the presence (or differentiations) of parts in the animals that have those parts, but the coming to be of these functional parts is itself explained further by reference to either the definition of the substantial being of the animal (which specifies the potentials for form that conditionally necessitate the coming to be of the vital and essential parts), or the availability of extra materials (which are used by the formal nature of the animal for the production of subsidiary or luxury parts). Final causes

are the starting points from which the conditionally necessary antecedents are to be traced back, but it is the presence of these prerequisites that necessitates – for the most part, and if nothing interferes – the coming to be of ends.

In sum, final causes form important and necessary ingredients of teleological explanations, but the ends that constitute the final causes are themselves demonstrated to come to be because of other causally prior facts, and these need to be picked out in the complete explanation as well.

APPENDIX

Translation of Aristotle's Analytica Posteriora II.11, 94a20–94b26

Since we think we have <scientific> knowledge when we know the explanation, and there are four explanations – one, what it is to be a thing, and another, given what things being the case it is necessary for that to hold; another, what first initiated the motion; and fourth, the for the sake of what – all of them are demonstrated through the middle term. For, "given what thing being the case it is necessary for this to hold" does not occur when one proposition is assumed, but when at least two are. This is the case when they have one middle term. Thus when this one is assumed, it is necessary for the conclusion to hold. It is clear too in the following way. Because of what is the angle in a semicircle a right angle? Given what thing being the case is it a right angle? Suppose then that right is A, half of two rights B, the angle in a semicircle C. Thus of A's – right – holding of C – the angle in a semicircle B is the cause. For this [B] is equal to A and C to B, because it [C] is of two rights – half. Thus given B, half of two rights, being the case, A holds of C (for that was it that [necessitates] the angle in a semicircle being a right angle). And that [B] is the same as what it is to be it, since the definition signifies this [i.e. what it is to be it].

Now it has also been shown that the middle term is explanatory of the essence.

For what reason did the Persian war come upon the Athenians? What is an explanation of the Athenians' being warred upon? Because they attacked Sardis with the Eretrians. For that initiated the movement. War, A; being the first to attack, B; Athenians C. B holds of C, the Athenians being the first to attack, and A holds of B, because people make war on those who have wronged them first. Therefore A holds of B, being warred upon to those who first began, and this, B, holds of the Athenians – for they first

began. And in this case, too, the cause, that what initiated the movement, is the middle term.

Regarding the cases in which the causal relation is that something is for the sake of something – for example, for what reason does he walk? In order to be healthy. For what reason is there a house? In order to protect the possessions. In the one case it is in order to be healthy, in the other in order to protect. There is no difference between for what reason it is necessary to walk after dinner and for the sake of what it is necessary. Call "walking after dinner" C, "the food not floating on the surface" B, and "being healthy" A. Suppose then that to make the food not floating on the surface at the mouth of the stomach holds of walking after dinner, and suppose the first is healthy. For it is thought that B, the food not floating on the surface, holds of to walk, of C, and that thereof (of B) A, healthy, holds. What then is the causal factor for C of A's – the for the sake of which – holding of it? B, the not floating. This is like a definition of it <of A>; for A will here be explained in this way. And for what reason does B hold of C? Because that is what being healthy is: being in such a state. Surely one must substitute the definitions, and in that way each of them will become clearer. Here the events occur in the opposite order from the cases where the causes are according to motion. For in the latter the middle term must occur first, while here C, the ultimate term, [must occur first] and last the for the sake of which.

CHAPTER 7

Conclusion

Aristotle appeals in a variety of ways to his theory of natural teleology in order to generate explanations of biological phenomena. At the most basic level, living beings are explained to have the capacities of the soul they have in virtue of those capacities being necessary for the sake of *living*, and in the case of the more complex and less widespread capacities, in virtue of being necessary for *living well*. At the more complex level, Aristotle explains that living beings – and also the heavenly bodies – have the bodily parts and features they have for the sake of exercising their vital and essential capacities, or for contributing to the performance of those vital and essential capacities, or because they serve their well-being in some other way.[1]

What unifies these teleological explanations is that they all pick out a function or beneficial end as that for the sake of which some feature is present. In addition, the presence of this function or end is identified as the outcome of the operation of a goal-directed efficient cause (i.e., as being due to the goal-directed actions of the formal nature or soul of a natural being), where this process of coming to be either consists in the realization of a potential for form, or in nature making good use of excess materials.

Aristotle characterizes the first process of coming to be as being due to teleology and conditional necessity. This kind of causation, which I call

[1] As for the token questions I raised in the introduction, we have found the following teleological explanations: organisms reproduce for the sake of preserving their own kind such that they can participate in the eternal and the divine. Birds have wings because they are essentially flyers (being a flyer is part of the substantial being of birds), and wings are a necessary prerequisite for being a flyer. Neither snakes nor stars have feet, because in these beings the presence of feet would have been in vain, and nature does nothing in vain. Most of the hoofed life-bearing animals have horns, because there is an excess of earthen material present in their bodies, and because of the defensive potentials this material has, nature uses it for the better to make horns in all the males. In the females, however, the excess of material is excreted, because females are not strong enough to be able to use the horns, and nature never includes any features in the actual design of an animal that it would not be able to use.

"primary teleology," is responsible for the coming to be and presence of those features that can be exhibited to be the necessary prerequisites for the performance of vital and essential functions. The end that constitutes the final cause in these cases is prior "in nature" and "in definition," and is causative in virtue of being formally one with the formal and efficient causes of the living being in question, such that the realization of the form is the end state towards which the efficient cause is intrinsically directed and by which its operation is confined.

Aristotle characterizes the second process of coming to be as "the nature according to the account making use of what is present of necessity." This kind of causation, which I call "secondary teleology," is responsible for the presence and sometimes also for the shaping of subsidiary and luxury features that increase the well-being of living beings; the coming to be of their constitutive materials, and sometimes even of entire structures, is due to material necessity. Both causal patterns are teleological for Aristotle, since in either case it is the operation of a goal-directed efficient cause that ensures the intrinsic and regular connection between natural processes and their beneficial outcomes.

In the sections below, I conclude my account of the merits and limits of Aristotle's use of teleology to generate explanations by specifying (1) the priority Aristotle attributes to teleological explanations, (2) their syllogistic structure, (3) the way they integrate references to final causes and necessity, and finally (4) their explanatory power.

7.1 THE PRIORITY OF TELEOLOGICAL EXPLANATIONS

Aristotle considers it the foremost task of natural philosophers to state teleological explanations such as the ones cited above, because he is convinced that these explanations are the most effective at serving the function of providing scientific knowledge.

For Aristotle, who is a realist concerning causal explanation, the discovery of explanations supplies scientific knowledge. We know something when we know its causal explanation, and there are four types of this: i.e., formal, material, efficient, and teleological explanation. In natural philosophy, we have seen that Aristotle stresses the importance of teleological explanations. Apparently, the most important way of explaining the presence, absence, or differentiation of natural phenomena is by picking out the final causes of these phenomena under their causally relevant and appropriate description, and then (and this step is crucial) to show how the ends that constitute the final causes come to hold of the phenomena under explanation.

The importance Aristotle attributes to teleological explanations does not derive from a denial of the causal force of the material and efficient causes in natural phenomena. Aristotle argues that the operation and interaction of *all* four causes are necessary for teleological natural phenomena to come about, and acknowledges that there are some natural phenomena (such as the coming to be of eclipses, ice, and perhaps the spleen) that only involve the operation of material and efficient causes. However, the fact that most natural (and especially, biological) processes occur regularly and have regular beneficial outcomes indicates, according to Aristotle, that there exist such things as natures and that those processes are intrinsically directed towards the realization of such outcomes. The regular coming into being and presence of natural beneficial outcomes cannot be accidental and a matter of chance. Thus, Aristotle argues, in addition to material and efficient causes operating from the "bottom up," there must be overarching formal and final causes at work that from the "top down" guarantee the regularity of those outcomes by ordering, timing, and limiting the complex sequence of natural events in general and of the stages in biological development in particular. Aristotle repudiates his materialist predecessors for treating the results of such processes as being incidental to chance interactions between material elements. They were not able to account for those results in terms of intrinsic causation. Aristotle holds that the explanation of such phenomena requires the assumption of final and formal causes *in addition to* material and efficient causes.

The importance of teleological explanations also does not lie in the fact that they pick out final causes as being the causally primary factors in the sequence of development, for final causes never are. The implicit model for explanation that Aristotle employs here is that of *demonstrations of (non-cyclical) processes*, and not that of geometric-type demonstrations of timeless and/or eternal states of affairs. This former model, as described in *APo* II.12, requires the scientist to lay bare the order and timing of events or stages of development within a causal sequence. In simultaneous processes, the item picked out by the middle term ought to be simultaneous with (and therefore have the same tense as) the process to be explained. However, in consecutive processes – such as teleological ones – the item picked out by the middle term has to *precede* the process to be explained. As Aristotle points out, the middle terms in such demonstrations have to pick out the immediately necessary prerequisite for the effect (i.e., the coming to hold of an attribute of a subject) that has come about. For demonstrations of natural phenomena of the teleological type, this means the following. First, since such demonstrations track the chronological ordering of items

involved in the processes under explanation, the middle terms of these demonstrations have to pick out that which is causally prior *in generation*. Second, since the ends that constitute final causes are – although causally prior in nature – last in generation, they cannot figure as the causally primary factors in demonstrations of teleological phenomena. Instead, ends and functions figure in the predicative position in the demonstration of natural phenomena and are therefore part of the conclusion that is being demonstrated. (Note that this is *not* to say that final causes have no causal force or ought not to be picked out in teleological explanations; I merely claim that final causes have no causal *primacy* in teleological explanations in the sense outlined above.)

The importance of final causes, then, and hence of teleological explanations that pick out those final causes, lies in their *explanatory* priority. The reason for this is that the functions and ends that constitute final causes are in most cases easy to identify: they are immediately apparent to observation. Once these functions and ends have been established, one can then proceed to determine the conditionally necessary antecedents, which will be part of the complete causal explanation. Because final causes are "closer to us," they provide the best starting points for the discovery of the other causally relevant features and developments related to the explanandum. Since all properties and developments are equally significant or insignificant from a material-efficient point of view, the boundary between essential and incidental properties can only be determined by studying natural beings as teleologically organized wholes. For Aristotle not every terminus of a continuous process is a final cause, but only that in which this process – if nothing prevents it – would typically and for the most part culminate. The end that constitutes a final cause is a "good," that is, something that contributes to the existence, essence, or well-being of the whole of which it is part. Through the investigation of natural phenomena from a teleological viewpoint, one is able to distinguish the causally relevant features of those phenomena, and thereby to discover the features that are to be included in the complete explanation of them. The identification of final causes thus helps to frame the search for material, formal and efficient causes of some phenomenon and thereby to find its complete causal explanation.

7.2 THE (SYLLOGISTIC) STRUCTURE OF TELEOLOGICAL EXPLANATIONS

The general structures underlying Aristotle's actual teleological explanations provided in the natural treatises are largely consistent with the theory

of demonstration as described in *APo* II.11. Both practice and theory, however, prove to be more complex and flexible than has traditionally been acknowledged.

Aristotle's actual teleological explanations consist for the most part of explanations that refer directly to final causes, but also of explanations that follow the use of teleological principles. In those cases where the final causes are immediately discernible, Aristotle starts by identifying that final cause and then proceeds to show why it is that this function or goal is necessary or beneficial for the natural being in question. In the case of living beings, the functions for the sake of which the parts of living beings are present are typically the realizations of the capacities of the soul, which are themselves teleologically grounded as being necessary for or otherwise contributory to the preservation of life and the reproduction of the living being in question. The "classification" of the various soul functions that living beings have and Aristotle's teleological account of their nested hierarchy in *De Anima* form the reference points for explanations of biological phenomena.

The strategy Aristotle employs to connect the function with the bearer of that function in each of these cases depends first and foremost on the type of question that needs to be answered (i.e., on whether one needs to explain the presence, absence, or differentiation of some part or feature) and, second, on the status of the part or feature in question. Parts or features that are immediately necessary for the living being that has them (and without which formal natures – hypothetically speaking – could not have designed these living beings) are shown to belong to the living being through reference to their essence, picked out by the definition of their substantial being, which includes (among other features) the necessary vital and essential functions to be realized.

Parts or features that Aristotle characterizes as non-necessary (because, again, hypothetically speaking, formal natures could have designed the animal without them), and which are "for the better" or "for the sake of well-being," are shown to belong to living beings by reference to their possession of extra materials, which are then said to have been used by their formal nature for something good. I have called such features subsidiary or luxury parts, depending on whether they contribute to the performance of a vital or essential function, or rather perform a non-necessary, "luxury" function such as defense.

Similarly, vital or essential differentiations of parts are usually shown to belong to the living beings that have them by reference to one of their specific *differentiae* (i.e., the being's way of life, its activities, character, and

the other parts it possesses), which are then shown to require a functional optimalization of the part or feature in question. Subsidiary and luxury differentiations of parts, on the other hand, are shown to be present on account of the availability of extra material that has come to be by material necessity, and which is then used by the animal's formal nature for the better.

The absence of parts or features is explained either by reference to their lack of function within this particular kind of animal (often because the animal has some other, more necessary feature that interferes with the functionality of the now missing part), or non-teleologically by reference to the absence of the constitutive material (or natural place) in this animal.

In explaining the actions of animals or human beings, Aristotle first picks out the goal of that action. He then shows how this action comes about by reference to the intermediate efficient causes, which usually take the form of the desire for an object and of the perception of that object as something good.

Teleological principles, such as "nature does nothing in vain," are generalizations over (or "causal abstractions" of) the observed outcomes of the goal-directed actions of formal natures, explicating what they "always" or "never" do or make when they are said to produce living beings and their parts. The principles, which are suppositions of Aristotle's natural science, function predominantly as heuristic tools for the identification of the causally relevant facts to be picked out in explanations, but are not part of the ultimate explanation itself. The principles provide a framework, established inductively through observation, of what is (and what is not) among the natural possibilities by which the actions of formal natures are constrained, and thereby set the natural boundaries within which the explanation of a particularly difficult phenomenon must take place, if it is to be explained teleologically.

Teleological principles are used in the following way. First, the presence of parts is explained through the use of the principle that nature does everything either because it is necessary or because it is for the better. The principle helps to determine the type of teleology responsible for the coming to be and presence of that part, and thereby makes it easier to identify the part's specific function. If the part can be observed to be present in all animals that are able to perform the function associated with that part, then the part must be necessary (i.e. be a necessary prerequisite for the performance of that function); it will be a product of primary teleology; and there will be some commonality in the form of all the animals that have that part that explains the part's presence. If the part is present only

in some animals that are able to perform the function associated with that part, then the part must be for the better; it will be a product of secondary teleology; and there will be a *differentia* in combination with the availability of extra materials that explains the part's presence in the subspecies.

The absence of parts is explained through the use of the principle that nature does nothing in vain. Aristotle constructs a counterfactual argument of the following form: if the formal nature of this particular being had designed the animal with this part, the part's presence in that animal would have been in vain, because some other, more necessary feature that being has would have interfered with its functionality. The part is absent, then, because nature does nothing in vain (and because nature could not tinker with the other, more necessary feature).

Finally, the principle that nature does what is best is mostly used for explanations of the presence of parts or of their differentiations in cases where observation shows that there are several possible natural means for nature to fulfill a certain functional need. Aristotle shows how the features an animal has are the best for it, given its specific substantial being, relative to the other natural possibilities.

In short, in all the actual teleological explanations provided in the natural treatises it is either a formal cause (e.g., an essential property specified by the definition of the substantial being of a living being, a *differentia*), an efficient cause (e.g., a desire, an action of a formal nature), or a material cause (e.g., a flow of earthen material with certain potentials) that turns out to be causally prior in generation. Ends and functions, on the other hand, which are prior in nature, are picked out as what explains the presence of features and as what guides and limits the processes of coming into being of those features. This picture is largely consistent with the *theory* of the structure of teleological explanations Aristotle provides in *APo* II.11, where he integrates his theory of four causes with the syllogistic pattern of scientific demonstrations. In this chapter Aristotle shows how there *may be* a difference between the type of causality expressed in the explanation of some feature and the type of causality expressed in the middle term that picks out the explanans of that feature. In teleological explanations, there *must be* a difference between the two. In addition, Aristotle argues that it is through the explanans that a certain type of causal relation is shown to obtain. In contrast with the traditional interpretation of *APo* II.11, I have argued that in teleological explanations final causes are never to be picked out by the middle term as being explanatory of the conclusion, but rather are themselves part of the conclusion that is being demonstrated. Walking

after dinner is for the sake of health, because walking brings about the physiological condition of having the food not floating on the surface of the stomach, which is exactly what being healthy is in the context of a person who has just had dinner. The middle term that picks out the condition of having the food not floating brings out the *teleological relation* that obtains between walking and health. Under this scheme, demonstrations of the teleological type are demonstrations in which an end that constitutes the final cause is demonstrated to come to hold of some state of affairs through the operation of other types of cause picked out by the middle term.

This scheme is consistent with the idea (mentioned earlier) that for Aristotle the structure of scientific demonstrations in the natural sciences, which pertain to processes, is to reflect the order of causation in the real world. Additionally, if the necessity that obtains in the world of change and development is conditional, then the necessity that governs deductions of natural phenomena has to be conditional as well: if the end is to come to be, then its necessary prerequisites have to come to be first. In the natural treatises, Aristotle never produces actual syllogisms, but the underlying pattern is largely the same. Phenomena are explained to be present for the sake of some end that constitutes the final cause. This end, then, needs to be demonstrated to come to hold of those phenomena through other prior necessitating factors.

This schematic picture of the structure of teleological explanations points also to the wider ramifications of this book: both the incorporation of conditional necessity into the demonstrative framework, and the room for variability between the type of explanation that is being demonstrated and the type of causation picked out by the middle term allow for a very flexible and comprehensive model of scientific demonstration, going far beyond the geometric model of demonstration pertaining to mostly mathematical states of affairs. Treating Aristotle's use of teleology in the natural sciences as one homogeneous category would inevitably obscure the richness of his explanatory and demonstrative strategies.

7.3 THE INTEGRATION OF FINAL CAUSES AND NECESSITY IN TELEOLOGICAL EXPLANATIONS

Another aspect of the structure of teleological explanations concerns the integration of references to both teleology and necessity in the explanation of living nature. I have argued that in his explanations, Aristotle picks out (roughly speaking) two types of teleology in combination with two types

of necessity: primary teleology in combination with conditional necessity and secondary teleology in combination with material necessity.

Aristotle invokes what I call "primary teleology" in explaining those parts and features of a living being that are the realizations of capacities already given with the kind of soul that being has. The parts and features are the necessary instruments for the performance of the essential and vital functions included in the definition of the substantial being of that living being. In those cases, the formal nature or the soul of that living being is the cause of both the coming to be of those parts and features, and of their presence. The necessity of the coming to be of the part or feature in question (and of its constitutive materials) is conditional upon the need of some essential or vital soul function to be realized; the part and features that are present are then exhibited as the necessary prerequisites of something being what it is and being able to lead the kind of life it does.

However, Aristotle also recognizes that some parts or features that are observed to be present among living beings are not immediately necessitated by the functions specified by the definition of the substantial being of that animal, but do give rise to the performance of functions that contribute to the well-being of the animal. In these cases, Aristotle ascribes the cause of the coming to be of the matter constitutive of those parts and features to material necessity, while ascribing the cause of their structure and presence to the goal-directed actions of the formal nature or soul of the animal. There is no capacity for the performance of a function that conditionally necessitates the realization of luxurious parts, and subsidiary parts are strictly speaking not necessary for the performance of necessary functions. Aristotle believes that, hypothetically speaking, nature could have designed the animals that have subsidiary parts in such a way that they would have been able to function without them, which is evidenced by his observation of other related animals that lack the subsidiary part in question but are nevertheless able to perform the function associated with that subsidiary part. Subsidiary parts are rather present for the animal's well-being or living well. The material processes that take place in the bodies of animals for the sake of generating the necessary parts lead *incidentally* to the generation of residues or other extra materials. These materials are then used by nature – "who, as a good housekeeper, is not in the habit of throwing away things that could be useful" – for the sake of the good of the animal. This latter process is teleological in Aristotle's view, but in a qualified way: the formal nature of the animal attributes a function to a part or to a flow of material, after this part or material has already come to be as the result of material necessity, and does so in accordance with the

available material potentials, which thus have causal priority in generation. The teleology here is secondary on the operation of material necessity.

The integration of material necessity in secondary teleological explanations gives evidence for my view that Aristotle's theory of teleology was not developed for the sake of replacing materialist explanations, which account for everything in terms of material necessity and its coincidental outcomes. In Aristotle's view, material natures usually operate under the constraints of teleology, but not always: sometimes material natures operate according to their own natures without being directed towards the realization of some end, and give rise to structures that can be and often are used for the sake of something. When Aristotle restricts unqualified necessity to the eternal realm of the heavenly bodies he does not thereby deny the existence of material necessity in the sublunary realm. He rather points out that in causal sequences that take place in the heavenly realm the prior always necessitates the coming to be of the posterior, because the coming to be of the posterior is necessary "without qualification." In the sublunary realm the prior in a causal sequence never necessitates the posterior "without qualification," regardless of whether the posterior is necessitated by conditional necessity or by material necessity. The role of material necessity in the sublunary realm is therefore not confined to the "negative" part of constraining the realizations of ends in natural beings. Material necessity also has a more positive role to play, in that it provides extra possibilities ("extra" in the sense that the possibilities are not already given with the soul and the potential for form some living being possesses) for the realization of features and functions that may contribute to the well-being of the animal in which it operates.

The distinction between "primary" and "secondary" teleology also solves some of the problems pertaining to the scope of Aristotle's teleology. For instance, it allows us to attribute an anthropocentric purpose to winter rain (i.e., the growth of crops), without having to conclude that Aristotle's theory of natural teleology is anthropocentric. In the realm of nature, formal natures make good use of what is present of material necessity; in the same way, human beings may – through the application of art – impose secondary functions upon natural phenomena such as winter rain (which occurs regularly due to material necessity), while following the material potentials and natural propensities rain has. It is the application of art that ensures the regular *beneficial* outcomes of winter rain, not a preexisting potential for form that is being realized. Aristotelian teleology pertains strictly to individual kinds of formal natures, and is not in any intrinsic way anthropocentric or cosmic.

7.4 THE EXPLANATORY POWER OF TELEOLOGICAL EXPLANATIONS

The explanatory power of the actual teleological explanations Aristotle provides of natural phenomena derives from the success of his theory of natural teleology in integrating and making intelligible phenomena that would otherwise be dissociated facts of our universe.

Aristotle's theory of natural teleology, in combination with his theory of four causes, allows him to explain natural processes, deliberative action, and artistic production as variations of one and the same basic phenomenon (but, importantly, without trying to reduce them to one abstract model). Aristotle sets up the analogy between agency and nature, and especially between art and nature (where intentionality and deliberation play no significant causal role), in order to bring out the goal-directedness of the latter through our familiarity with the goal-directedness of the former. The analogies thus serve primarily a didactic function: Aristotle reveals the causal frameworks that apply to art and agency and extends those to natural generation as far as the similarities hold. Ultimately, however, the goal-directedness of art and agency are ontologically dependent on that of nature, where goals are asserted to be present most. Living beings (humans, animals, and perhaps in some sense even the heavenly bodies) act goal-directedly, and craftsmen produce artifacts through goal-directed activity, because they *imitate* nature and are themselves endowed with natures.

The force of the analogy between art and nature remains visible also in Aristotle's explanations in the biological works, where the formal, efficient, and final causes are said to coincide in the souls of living beings. Aristotle often depicts these "formal natures" as if they are "internal craftsmen" who make, use, or redirect materials for the sake of realizing the living being's characteristic functions. The theory that nature is goal-directed thus unifies natural beings such as elements, plants, animals, human beings, and even the heavenly bodies under one ontological category. They all become teleologically organized composites of form and matter, but with widely different manifestations of organized complexity. The coming to be and presence of their bodies and features, and the occurrence of their motions and actions all involve goals, ends, and functions that ultimately contribute to their being, life, and living well. The teleological explanations Aristotle provides pick out those goals, aims, and functions, and relate them to the beings, parts, and processes of which they constitute the final cause.

Teleological explanations are most successful in biology. Aristotle provides comprehensive and detailed accounts of why parts belong to the

animals that have them, why they are differentiated in the way they are, and why some animals lack parts that one would expect to have been present. The references to functions Aristotle makes in these explanations are grounded in his theory of soul. In particular, they build upon the classification of the various capacities of the soul to perform life functions and upon the idea that the soul is the final cause of the natural body that is instrumental. Different kinds of living being are demarcated by their characteristic soul functions, and the parts and bodies they have must be necessary for or subsidiary to those functions. Any part of a living being's body is the way it is for the sake of the capacities that characterize its life, because it is causally dependent on and conditionally necessary for these capacities. Capacities and the living bodies in which they are realized are essentially connected.

The success of the use of teleological principles in biology as a heuristic tool for finding final causes where they are not immediately discernible also forms the foundation for Aristotle's use of those very same principles in his cosmology. The lack of empirical data in the latter domain makes the endeavor to explain the heavenly phenomena very difficult. Aristotle tries to integrate the study of the heavens into the science of nature, and he believes that material explanations of the mathematical properties of the heavenly phenomena are insufficient for a complete scientific understanding of them. Aristotle therefore uses teleological principles as a heuristic to find final causes, and by doing so tries to turn his cosmology into a proper natural science. The teleological principles are not a priori postulates, but suppositions derived from the numerous observations Aristotle made in the biological domain. However, because of the lack of empirical data, the teleological explanations that are provided in cosmology amount to – as Aristotle himself keeps pointing out – plausible or reasonable explanations that take away some puzzlement concerning the heavens. They do not constitute explanations that reach the same level of accuracy and necessity as the explanations provided in biology. The use of the theory of natural teleology as a means to generate explanations of natural phenomena is thus limited in those domains where our observations of the phenomena are incomplete. On the other hand, Aristotle's attempt to give teleological explanations of the features and motions of the heavens shows the comprehensiveness of his theory of natural teleology: ultimately he is trying to establish a coherent picture of the whole cosmos and all its natural beings in which (at least for the most part) things are present or absent or differentiated in the way they are for a purpose.

In sum, if my interpretation of the theory and practice of teleological explanations in Aristotle holds, then the explanatory work performed by final causes is significantly different from what has traditionally been thought. Final causes explain the presence of features, but exert no "mysterious pull" from the future. They rather function quite literally as the direction-givers and the ends and limits of developments necessitated by formal-efficient or material-efficient causation. In this way, they provide both the first component of a teleological explanation and the heuristic starting point for investigations that will lead to a statement of the *complete* teleological explanation of the phenomenon in question. This does not mean, however, that final causes have only a heuristic value: since in demonstrations of the teleological type the final causes are part of the conclusion that is being demonstrated, the practice of Aristotle's natural science demonstrates the very existence of natural teleology.

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