CHAPTER 1

Introduction

David Ebrey

Aristotle thought that it was possible to acquire scientific knowledge of the natural world but that none of his predecessors had the philosophical theories needed to develop such knowledge. One task he took for himself, then, was to provide a foundation for natural science. However, he did not simply argue that in principle one could acquire this sort of scientific knowledge; he put his theories into practice. More than 750 pages of his scientific works survive. These works are fascinating in their own right and have the power to help us understand central features of his natural philosophy. His practice sheds light on his theory and this theory, in turn, sheds light on his practice. His scientific works can, among other things, help us better understand his accounts of matter, necessity, teleology, definition, and proper scientific methodology.

Aristotle wrote a number of works that, in different ways, provide a theoretical foundation for the study of the natural world. His *Physics* is devoted precisely to this task. The first book of *Generation and Corruption* provides general accounts of different types of change, which Aristotle thought were applicable across different parts of the natural world. By contrast, his *Posterior Analytics* has a broader scope than either of these works: it is meant to explain methodology relevant to any science, not necessarily natural science. Thus, for example, the *Posterior Analytics* is supposed to apply equally to mathematics, which Aristotle does not consider a natural science. The first book of the *Parts of Animals* provides a foundation for natural science, but with an emphasis on the study of biology. Similarly, the *de Anima* (*On the Soul*) is an inquiry into and account of the soul and its activities, which is directly relevant to the biological sciences, since Aristotle thinks that the soul is the principle of life.

Aristotle's scientific works are an ambitious attempt to explain most aspects of the natural world. The non-biological works take us from the whole cosmos (*de Caelo* I and II) to the elements (*Generation and Corruption* II, *de Caelo* III and IV, *Meteorology* IV), and through meteorology

(*Meteorology* I–III). The lion's share of the works is biological, in particular animal biology. Aristotle's *History of Animals* is the longest work in his corpus; it is now widely thought to provide a systematic account of animal parts and features that could be drawn on in causal treatises. By contrast, *Parts of Animals*, *Generation of Animals*, *Movement of Animals*, and *Progression of Animals* are each causal treatises: they each set out to determine the explanation for why animal parts have the features that they do, why animals generate in the way that they do, etc. A third and final group of works are known as the *Parva Naturalia*, which Aristotle says comes after his examination of the soul (436a1–5); these discuss topics such as memory and sleep. These are causal treatises and, at the same time, more closely related to *de Anima* than the other causal biological works. They are a reminder that Aristotle himself does not operate with a strict division between theory and practice and so we should be careful not to treat it as a fundamental divide in his works.

Most people come to Aristotle from an interest in the history of philosophy, rather than the history of science, and so Aristotle's scientific works have received less attention than his other works. However, over the last thirty years scholars have steadily increased their interest in his scientific works, in part because these can help us answer long-standing questions about his philosophical theories, making this a very exciting time in Aristotle scholarship. Despite this recent interest, the last volume of essays whose scope included all of Aristotle's natural science is more than thirty-five years old: *Articles on Aristotle, Vol.* 1*: Science*, eds. Barnes, Schofield, and Sorabji. Since then groundbreaking work has been done, especially on Aristotle's biology and its relation to the scientific method in the *Posterior Analytics*. The most important volume on this is *Philosophical Issues in Aristotle's Biology*, edited by Gotthelf and Lennox, which includes seminal essays at the foundation of much of the current research on Aristotle's biology.

This volume builds on the last thirty years of scholarship, broadening it in two ways: (i) it includes chapters on both Aristotle's biological and non-biological works and (ii) it includes a number of chapters that emphasize connections between scientific treatises and foundational treatises other than the *Posterior Analytics*, such as the *Physics*. The volume does not aim to provide a comprehensive approach to the topic, but rather to be a collection of important new work. Each chapter raises a new and important issue or proposes a new way to approach a classic question. One surprising feature of the contributions is that, despite the diversity of questions and approaches, they intersect to an unusually high degree. This overlap was not by design; these simply are the issues that scholars are excited about and

find most pressing. The chapters naturally fall into three groups, organized around three key topics: matter, teleology, and methodology. Some address more than one topic, so those interested in one of these topics should read the descriptions below to see if chapters in other sections are relevant. There are a number of other recurring topics that could have been used to organize the volume, such as necessity, definition, form, soul, and cosmology.

Aristotle was the first person to develop the concept of matter; he thought matter was vital for a proper understanding of the natural world. The first three chapters in this volume tackle fundamental questions about matter. What sort of explanation does matter provide? What sorts of things does Aristotle identify as matter? Does he treat matter as fundamental in his explanations? How does matter relate to so-called material necessity? And what is the role of matter in scientific definitions?

In "The 'Matter' of Sleep," Alan Code uses Aristotle's *Metaphysics* H4, to shed light on what the material cause of sleep is in the *de Somno* (*on Sleep*), a question that has received a number of very different answers. According to H4 non-substances do not have matter but have an analogue to matter, the central features of which, Code argues, are that it underlies a given change and it is receptive to the relevant opposites in this change. According to Code current interpretations of *de Somno* have not identified the material cause as the primary thing that undergoes the given change, sleep. In H4 Aristotle says that the matter-analogue is not the whole animal, but the primary part of the animal that undergoes sleep. Code argues that in the *de Somno* the heart is the relevant part for blooded animals, and hence it is the matter-analogue. He uses this account to show how Aristotle in the H4 passage extends his four causes from sensible substances to the attributes of substances, such as sleep.

In "Are Facts about Matter Primitive?" Jessica Gelber argues against recent scholars who claim that Aristotle in his biology treats "facts about matter" – facts such as the degree of heat or amount of fluidity in an organism's material constitution – as explanatorily basic or primitive. Gelber presents three considerations for rejecting this recent consensus, which she claims is in tension with Aristotle's general commitment to the causal and explanatory priority of form over matter. First, she argues that Aristotle in fact does explain certain facts that others have described as unexplained, such as an organism's degree of heat, dryness, and fluidity. Second, she argues that in certain cases, such as human intelligence, it would be quite implausible to suppose that Aristotle considers an explanation in terms of degrees of heat to be a primitive starting point. Finally, Gelber argues that in order for facts about matter to be the primitive basis for explanations

Aristotle would need a specific way of thinking about relevant causal processes. But Aristotle does not characterize the relevant causal processes in the requisite way in the *Generation of Animals*.

In "Blood, Matter, and Necessity," I argue that in the *Parts of Animals* Aristotle thinks of matter and necessity in a way that makes it highly misleading to describe his views in terms of "material necessity," as most recent scholars do. Aristotle rarely discusses matter in the *Parts of Animals* and when he does he typically identifies blood as matter. This, I argue, is because he thinks of matter as what things properly come to be from and he thinks that the body concocts blood precisely to be what things come to be from. Blood, far from being linked to necessity, is connected to divergent possibilities: it can come to be, nourish, or grow different parts of the body. By contrast with his occasional references to matter, Aristotle frequently explains things in terms of necessity in the *Parts of Animals*. I argue that he does not distinguish between different kinds of necessity in his explanations and that in some cases the necessity has nothing to do with matter. Aristotle groups all cases of necessity together; what he thinks is important is how these explanations differ from teleological explanations.

Aristotle famously thinks that we should understand natural entities and their changes in terms of each thing's end or goal (*telos*). The next four chapters in the volume address crucial questions about Aristotle's teleology: How does he integrate his teleological explanations with those in terms of necessity? How should we understand Aristotle's distinction between two different kinds of end, that for the sake of which and the beneficiary? Does teleology only work at the level of individual organisms, or does it also provide explanations at the level of kinds? How do an organism's soul and faculties relate to its end?

In "'And These Things Follow': Teleology, Necessity, and Explanation in Aristotle's *Meteorologica*," Margaret Scharle argues that while teleology is not mentioned in the *Meteorologica*, it is implicitly presupposed there. In particular, the *Meteorologica*'s explanations depend on Aristotle's view that there are two elemental cycles, an earth–fire cycle and an air–water cycle, which Aristotle ultimately explains in terms of teleological processes outside of the *Meteorologica*. Scharle argues that Aristotle's procedure in explaining meteorology is just what one would expect from *Parts of Animals* 1.1 and his practice in the biological works: he is examining the necessary by-products of teleological processes. The difference between biological and meteorological cases, she argues, is that in biology the organism can make use of necessary by-products to further the organism's ends. By contrast,

there is no way for the elements to make use of necessary by-products to further their ends because they are entirely passive and have no parts.

In "Aristotle on the Cosmological Significance of Biological Generation," Devin Henry argues that in *Generation of Animals* II.1 Aristotle does not limit teleology to what will benefit a specific organism, as is commonly thought. Instead, Aristotle thinks that there must be reproduction for the benefit of the continuous generation of the whole species, where this benefit to the species cannot be reduced to the benefit to individual organisms. Henry argues for this, in part, by drawing on parallels between Aristotle's argument in *GA* II.1 and his argument in *Generation and Corruption* II.10 for the necessity of cyclical generation. His chapter ends by suggesting a way that this interpretation can help us make headway on a very difficult argument in *GC* II.11.

In "The Two Kinds of End in Aristotle: The View from the *de Anima*," Thomas Johansen argues that Aristotle's distinction between two kinds of end, frequently dismissed as an aside, in fact helps us understand how different faculties are related to one another for the overall benefit of an organism. One kind of end is that for the sake of which a change or activity takes place; the other kind is the beneficiary of the change or activity. Johansen provides a general account of this distinction, including its Platonic precedent, and then considers its role in the *de Anima*. He argues that it explains how the soul's faculties can be defined strictly independently of one another (in terms of end as that for the sake of which), while at the same time these faculties are closely related to one another, in a way that is central to an animal's nature (in terms of end as beneficiary). The faculties have strict goals, but they also benefit the other faculties and the organism as a whole.

In "Two Conceptions of Soul in Aristotle," Chris Frey argues against the dominant interpretation of soul in Aristotle, according to which it is understood in terms of a group of capacities (which is the view defended by Johansen in this volume), and in favor of a more unified conception of the soul, according to which it is the single end of all of the organism's activities. Frey argues for this reading by examining how Aristotle accomplishes the task he sets for himself in *de Anima* II.2: to come up with a more scientific definition of the soul. On his account, Aristotle unifies the soul by creating a hierarchy of souls, with the lower souls, for example, the nutritive soul, present potentially (*dunamei*) in the higher soul. Frey uses Aristotle's account of mixture to shed light on how to understand this.

Over the last thirty years, scholars have made significant advances by using Aristotle's methodology in the *Posterior Analytics* to shed light on his

natural science. The last four chapters help make this relationship more reciprocal by using Aristotle's natural science to illuminate central topics in his *Posterior Analytics*: How are subordinate and superordinate sciences related to one another? And what are the right sorts of definitions to use in natural science? The contributions also examine important methodological issues that have been overlooked or misunderstood, in part because they are not discussed in the *Posterior Analytics*: What are the basic requirements for exercising scientific judgment? And how should the scientist proceed when lacking sufficient evidence?

In "Aristotle's Architectonic Sciences," Monte Johnson addresses two puzzles about the autonomy and subordination of sciences. He does so, in part, by comparison and contrast with Plato's views in the *Statesman* and by bringing to bear underappreciated evidence from Aristotle's *Protrepticus*. The first puzzle is that in the *Nicomachean Ethics* Aristotle treats political science as the most architectonic science whereas in the *Metaphysics* he treats metaphysics (i.e., first philosophy) as most architectonic. Johnson argues that Aristotle's considered view is that metaphysics is the most architectonic, and, in general, that Aristotle views productive sciences as subordinate to practical sciences and these, in turn, as subordinate to theoretical sciences. Johnson's second puzzle is how Aristotle can view all sciences as subordinate to a master science, or even any science as subordinate to any other, given his views on the independence of the sciences. He creates a model for how to do so, giving examples from Aristotle's practice within meteorology and politics, and showing how in both cases these sciences draw on theoretical claims from metaphysics, mathematics, and natural science.

In "Varieties of Definition," David Sedley uses Aristotle's multiple definitions of void in *Physics* IV.7 to shed new light on an important and controversial debate about the *Posterior Analytics*: Does Aristotle think that there is a separate class of nominal definitions, that is, definitions that do not presuppose the existence of the thing defined? Many scholars claim to find evidence in *Posterior Analytics* II.10 for such definitions. If nominal definitions were a distinct group in II.10, they would be distinct from definitions that correspond to the conclusion of a syllogism. However, Sedley notes that if ever there were a place for Aristotle to provide a nominal definition, it would be for void, given that he thinks that there is no such thing as void. Instead, Sedley argues that Aristotle provides multiple definitions for void using syllogisms. Moreover, these definitions, if anything, point to a way in which even void can be said to exist.

In "Empty Words," Sean Kelsey examines Aristotle's surprising claims that his predecessors are using mere empty words, with no conviction about what they are saying. Kelsey uses Aristotle's ethical works to shed light on these and similar accusations that are found across his scientific works. He argues that Aristotle does not think that his predecessors have merely failed to hit upon the truth, but rather that they are engaging in a sort of imitation and pretend version of the genuine search for truth. To make matters worse, Aristotle thinks they do not even realize that they are so far from the genuine search for truth. Kelsey argues that Aristotle thinks that this is a depressingly common mistake, not a rare error. In particular, Aristotle thinks it is easy to let one's focus on reasoning and argumentation lead to focusing on one's dialectical opponents, rather than attending to the empirical facts appropriate to the subject matter at hand and using these to discover the truth.

In "The Scientific Role of *Eulogos* in Aristotle's *Cael* II 12," Andrea Falcon and Mariska Leunissen argue that Aristotle is engaged in natural scientific inquiry when, in his natural scientific works, he uses claims that he describes as "reasonable" (*eulogos*) or unreasonable. They argue he is not merely engaged in dialectic, as is sometimes suggested. Aristotle uses these claims about what is reasonable as part of an overall method for providing the best possible scientific explanations in cases where we lack sufficient empirical evidence needed for certainty. Falcon and Leunissen apply this account of Aristotle's use of reasonable claims to *de Caelo* II 12, arguing that, despite the difficulties of the puzzles presented in II 12 and despite Aristotle's modest goals in responding to these puzzles, his responses are proper scientific explanations, not merely dialectical ones.

Together, these chapters challenge the orthodoxy on Aristotle's views on matter, clarify non-standard types and uses of teleology, and shed light on underappreciated parts of his scientific methodology. Moreover, they bring to the fore his cosmology, put forward new ways to understand the unity of the soul, and help us understand how necessity applies to the elements. They present groundbreaking work on Aristotle's natural philosophy and provide a model for how to integrate our understanding of Aristotle's theory and practice.

PART I

Matter