Aristotle's Empiricism: Experience and Mechanics in the 4th Century BC
by Jean De Groot

Las Vegas/Zurich/Athens: Parmenides Publishing, 2014. Pp. xxvi + 442. ISBN 978–1–930972–83–4. Paper $127.00

Reviewed by
Sylvia Berryman
University of British Columbia
sylvia.berryman@ubc.ca

The early history of the discipline of mechanics—arguably one of the least well-understood aspects of the history of the natural sciences in antiquity—is receiving more attention in recent scholarship. Aristotle's contribution to that history is one of the least clear of all its chapters. Jean De Groot's *Aristotle's Empiricism* is thus timely in its subject matter. This book attempts a synthetic account of Aristotle's engagement with questions of the causes and dynamics of motion, viewed against the background of the mathematics and natural philosophy of the period. Its strength is that it canvasses Aristotelian texts as disparate as the *Categories* and *Poetics*, and gives serious attention to relevant passages, such as *Problemata* 16, that have been little studied. This is a considerable undertaking and it is to be hoped that De Groot's work inspires closer attention to this relatively neglected aspect of Aristotle's thought.

The book is, unfortunately, torn between two rather different projects, which seem somewhat in tension with one another. The first is to uncover the sources of inspiration for the emergence of mechanical thinking in the fourth century BC, that is, to examine the insights into the nature of the action of the lever and the attempts to explain it mathematically at that time. On this, the book offers a number of promising suggestions for inquiry. De Groot's extensive knowledge of the history of science is employed to good effect and her sensitivity to the possible empirical inspirations for abstract concepts leads to some illuminating suggestions.

The second project, an attempt to read Aristotle's biological work as infused with ideas about δύναμις or power construed by De Groot sees as applying mechanics in some 'more expansive' sense [161], is, in this reviewer's opinion, less successful. This project is based on the idea that mechanics shows

ISSN 1549–4497 (online)
ISSN 1549–4470 (print)

how power or δύναμις can amplify effects [124], thus licensing inferences about hidden powers and their abilities to produce large changes from small changes. It is, as she acknowledges, an unfamiliar reading of Aristotle [50, 160–162, 366] and one that risks erasing his distinction between natural and artificial form [133].

De Groot, however, sees both kinds of form as 'mechanical' and as pervading Aristotle's work, her central thesis being that the work on the lever and its properties licensed a kind of inference to natural powers, and that Aristotle took this insight into various domains, including biology. The difficulty is that there are different ways to read De Groot's ascription of 'powers'. We might take her to mean that a central insight of the mathematical investigation of devices—such as that found in the Aristotelian *Mechanica*—is that something analogous to a modern concept of 'force' must be posited as a finite and conservative factor in mathematical explanations of motion. De Groot seems to intend just this when she claims that for Aristotle 'powers' are an 'empirical concept closely linked to a universalizing mathematical rule' [15]. Yet, she also poses a dichotomy between 'a powers model and a matter-in-motion model' [16], as though powers are seen as doing rather more than just explaining motion.

De Groot's suggestion that Aristotle imported the insights of mechanics into biology by a kind of 'topological deformation' [249–250] does not avert the suspicion that this second project leaves behind any meaningful conception of mechanics. If the lever is merely 'an analogy for the enhancement of effect' [108], the license for inference surely risks going poetic [110, 124, 133, 148–149]. A central text used to argue that Aristotle intends to apply the 'moving radius principle' as a systematic explanatory tool in his biology is *De motu animalium* 7, where he notoriously refers to devices in discussing the ability of the sensitive faculty to cause a large movement of the limbs from a small expansion of the *pneuma* around the heart. But the crucial question is surely not whether Aristotle *uses* artifact analogies—who does not?—but whether he takes them to be a *sufficient* explanation. The fact that he introduces the mysterious *pneuma* to account for this ability in *De motu an.* 10 should at least be considered.

The other notorious analogy to working artifacts is in *On the Generation of Animals* 2.5. De Groot's chapter 6 reads this passage as evidence of a programmatic account of biological development. She seems to think that the thrust of the artifact analogy is to *delimit* the role of δύναμις [148–149]. But how it does so is not clear. Nor does she make clear the extent to which her reading of Aristotle's biology leaves behind natural form: at one point, she suggests that the powers are 'latent in materials' [156]; but elsewhere the powers in question are said to be 'proper to the entity under examination' [113]. It is a speculative account and the author recognizes this. (The treatment of the secondary literature in this chapter is particularly sparse.)

Even those unconvinced by this will be interested in her contributions to the first project, that of recovering the early history of the discipline of mechanics. De Groot focuses on what she calls the moving radius principle and collects the evidence for this from throughout the works generally ascribed to Aristotle himself. The principle itself, as De Groot explains it, is a *mathematical* rule describing a relationship between the geometry of circles and the (linear) motions described by points on these circles when they rotate. She presents this principle in two ways:

(1) '[P]oints moving circularly at different distances from a common center are covering different distances in the same time' [25], and
(2) '[R]evolving concentric circles are traveling at different speeds' [27].

De Groot focuses on this principle because of its role in making manifest the ways that δύναμις is at work in the world [126–127] and presumably also the ways in which it is subject to proportional limits. De Groot claims that Aristotle 'understands the moving radius principle to index natural powers' [12], where 'indexing' is explained as according ontological import: since '[w]hat produces action is real'[13], there are grounds for acknowledging the work of 'powers' in producing action.

Understanding the history of the notions of power or force is central to the history of the discipline of mechanics and its contribution to the development of mathematical methods for studying physical motions. De Groot has some promising contributions to this kind of 'cognitive history' [cf. Netz 1999], especially in her examination of weight or her suggestion that the kinesthetic experience of sensing the different quantities of effort required to move weights in various contexts contributed to the recognition of forces as finite quantities. Her analysis of the pre-Aristotelian material here is helpful, as is the reading of *De motu an.* 4 with its recognition that forces can be used to account for inaction as much as motion. There may also have been other factors that encouraged quantification, such as the importance of weight-lifting technology for massive building projects, where logistical estimates would have been important, or the use of mathematical scaling-up in early ballistic devices. The analysis of the lever is not the only mathematical consideration concerning the causes of motion that we find in the surviving evidence for early mechanics: a full treatment of Aristotle's thought would want to pay more attention, for example, to issues such as Aristotle's treatment of the composition of powers [Hussey 1991].

De Groot's subject is very definitely Aristotle and, as with any work on that enigmatic thinker, it needs to take sides on questions about the state of the corpus. The question is particularly acute in reconstructing the history of mechanics since a key exhibit, the *Mechanica*, is not widely thought to be written by Aristotle himself. De Groot argues that *Problemata* 16 is contemporaneous with Aristotle, as part of her claim that 'mechanical phenomena underlay his scientific thinking more generally' [163]. She acknowledges that the *Mechanica* is likely written several decades after Aristotle's time and contains unAristotelian elements. The figure often taken to be the author of the *Mechanica*, Strato of Lampsacus, is only mentioned in passing as the compiler of *Problemata* [165]. The possibility that the *Mechanica* reflects ideas from early third century Alexandria is not considered, nor is its markedly unAristotelian treatment of natural and nonnatural motion given much consideration.

This is a large and ambitious project. Clarity of exposition is rather hampered by book's organization, with some critical expository chapters only coming at the end. The treatment of the secondary literature is often cursory and some idiosyncratic notions like active receptivity [135ff] or gnomonic complementarity [340] are hard to grasp. Some of its range might well have been sacrificed for a more detailed account of particular issues, e.g., Archytas' contributions; intriguing suggestions such as the role of Aristoxenus in Aristotle's thought [298] are only hinted at in footnotes. This book covers a lot of ground and it is unfortunate that its range and unevenness means that some of its insights could be missed.

Nonetheless, the key ideas, especially as they are developed in chapters 10 and 11, suggest a synthetic vision of Aristotle's engagement with the project of mathematizing natural philosophy and the possible role of mechanical devices in inspiring that vision. Those inclined to a more cautious approach would have appreciated a more systematic articulation of that argument, distinct from the more speculative material about the application of powers in other domains. Yet this is a difficult topic, given the scattered nature of the evidence and the challenges of reconstructing the world picture of thinkers from a different era. Revising the early history of science requires imagination and the willingness to take intellectual risks. The ambition of De Groot's work is admirable and there is much here that may contribute to a more precise account of a critical chapter of the history of mechanics and natural philosophy.

BIBLIOGRAPHY

Dijksterhuis, E. J. 1961. *The Mechanization of the World Picture*. Translated by C. Dikshoorn. Oxford, UK.

Hussey, E. 1991. 'Aristotle's Mathematical Physics: A Reconstruction'. Pp. 213–242 in L. Judson ed. *Aristotle's Physics: A Collection of Essays*. Oxford, UK.

Netz, R. 1999. *The Shaping of Deduction in Greek Mathematics: A Study in Cognitive History*. Cambridge, UK.