Materia Philosophiae

Material Dimensions of Ancient Philosophy

EUHORMOS



Edited by
William Wians and Robert Hahn

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Materia Philosophiae. Material Dimensions of Ancient Philosophy

Euhormos

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Foreword

EUHORMOS is an international book series intended for monographs and collective volumes on Greco-Roman Antiquity. Specifically, we welcome for publication manuscripts related to the concept of 'anchoring innovation' by classical scholars of all disciplines from all over the world. Books in this series will be published as much as possible in Open Access. EUHORMOS is one of the results financed by the Dutch so-called Gravitation Grant (2017), awarded to a consortium of scholars from OIKOS, the National Research School in Classical Studies. See https://anchoringinnovation.nl/, where we also list earlier results from this research programme.

The ancient world saw many examples of change and innovations. The unique accessibility of materials from and about this period in the ancient Mediterranean frequently makes it possible to analyze successful and unsuccessful 'anchoring' of change: the various ways in which 'the new' could (or could not) be connected to and embedded in what was already deemed familiar. 'New' and 'old' are mostly not used as objective labels, but also a matter of the perception, framing, and valuation by relevant social groups and actors. 'The new' is not restricted to the technical or scientific domains, but can also include the 'new information' imparted by speakers through linguistic anchoring strategies; innovations in literature and the arts; political, social, cultural, legal, military, or economic innovation; and new developments in material culture.

The name 'Euhormos' itself is well-anchored. It is the Homeric term for a harbor 'in which the anchoring is good', although the careful reader will notice that danger is never far away. This dynamic nature of 'anchoring' and the risks involved in it are embraced by our research team as part of this title. For now though we will focus on its auspicious aspect, since we are looking forward to affording 'good anchorage' to studies contributing to a better understanding of 'anchoring innovation' in Greco-Roman Antiquity.

Ineke Sluiter
Academic Director
Leiden
On behalf of the Governing Board of the Anchoring Innovation Programme

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Abbreviations

In general, names of ancient authors and titles of ancient works are spelled out in full. A small number of standard abbreviations used throughout the volume are listed below. Other abbreviations should be clear from the surrounding context.

DK	Diels, H. 1951. *Die Fragmente der Vorsokratiker*. 6th ed. by W. Kranz. Berlin: Weidmann.
KRS	Kirk, G.S., J.E. Raven, and M. Schofield, 1983. *The Presocratic Philosophers*, 2nd ed. Cambridge: Cambridge University Press.
LM	Laks, A. and G. Most, 2016. *Early Greek Philosophy*. 9 volumes. Loeb Classical Library. Cambridge: Harvard University Press.
LSJ	Liddell, H.G. and Scott, R. 1968. *A Greek-English Lexicon*, 9th ed., revised by H.S. Jones and R. McKenzie. Oxford: Oxford University Press.
Il.	Homer, *Iliad*
Od.	Homer, *Odyssey*

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Philosophical Argument and Material Realities

An Introduction

William Wians and Robert Hahn

Ever since Thales fell into the well, popular imagination has pictured philosophers as abstracted from concrete everyday reality. *Materia Philosophiae: Material Dimensions of Ancient Philosophy* counters that view. Philosophical activity in ancient Greece grew out of and remained closely connected to the material realities around it – the difficulties of travel, reliance on cumbersome scrolls, an expectation that learning would be acquired literally at the foot of a master and not through reading written work; but also the spread of coinage, contemporaneous achievements in technology and engineering, and contact with everyday household objects. By resituating philosophers in their material and technological contexts, contributors to *Materia Philosophiae* open up multiple avenues that have not before been explored in a single volume.

In doing so, *Materia Philosophiae* anchors the innovations of the early philosophers in the material world from which they arose. Something remarkable happened in Greece starting in the sixth and fifth centuries BCE. What happened wasn't confined to one polis or a single area of intellectual or creative activity. In the span of just a few decades, transformative innovations arose in art, theater, architecture, governance, and economics. With respect to the specific concerns of this volume, new approaches to the natural and human world led to what we now recognize as science and philosophy – naturalistic rather than mythological explanations, the creation of texts in prose, advances in measurement, astronomy, and navigation. Once they arose, the innovations spread across the ancient Greek world, spurring further engagement, debate, and challenges to a worldview that regarded human beings as limited and ephemeral, barred from penetrating nature's mysteries and the place of human beings in it.

There was a time when this efflorescence was termed miraculous. Modern scholarship speaks in a more measured way, with scholars recognizing the many forces operating behind those innovations.[1] Some of these forces originated in Greece: for example, a political system without a powerful priestly hierarchy that evolved hand in hand with rising standards of living following

1 Resistance to the idea of a Greek miracle is nicely summarized in Laks 2018, 54–60.

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the rise of trade. Other influences and inspirations came from older and more technologically advanced civilizations, including Egypt and Near Eastern empires. And many involved multiple interactions among practitioners in fields now typically studied in separation from one another.

Though faith in a Greek miracle has now largely been shaken – one recalls Vernant's trenchant dismissal almost seventy years ago of the view that Greek rationality was "a traveler arriving without baggage"[2] – the adaptations, innovations, and inventions of the ancient Greeks remain remarkable. *Materia Philosophiae: The Material Dimensions of Ancient Philosophy* is devoted to one pre-eminent aspect of the remarkable innovations, the emergence of philosophy, and it seeks to answer one over-arching question: How did the physical and material realities of the world inhabited by ancient thinkers condition what came to be known as philosophy and science?

Stated differently, *Materia Philosophiae* seeks to understand Greek philosophy's origins, development, and transmission in ways that are more consistent with the material turn in other fields in the humanities. Though there is probably no single standard definition of materiality, the material turn can be said to focus on the lived realities of a culture, including material objects such as tools and artifacts, built environments, and available means of transportation and communication. Material studies often draw attention to economic realities and to social hierarchies and the identity of elites within a society. For these reasons, material studies are often explicitly contrasted with more traditional scholarship that focuses on text-based ideas and theoretical frameworks of educated elites.

This, however, points to a deeper problem. If materiality is understood in terms of an alternative to the study of texts (and by implication, of arguments within texts), material studies would seem to have little to contribute to philosophy and the ideas and theories that constitute it. This points to why so many historians of philosophy have paid limited attention to the material dimensions of the texts they study. To the extent that the proper subject of philosophy and its history is precisely non-material, material dimensions tend to be viewed as non-essential features of ancient philosophical practice. This attitude is apparent in many ways in the standard literature, and is especially prominent in analytic approaches to Greek philosophy that often treat philosophy as a series of timeless arguments.[3]

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2 Vernant 2006 [1957], 371.

3 One need look no further than the introduction to Barnes 1982 [1979], xii: "Philosophy lives a supra celestial life, beyond the confines of space and time; and if philosophers are, perforce, small spatio-temporal creatures, a minute attention to their small spatio-temporal concerns

It should be recognized, however, that just as the image of the abstracted philosopher goes back to the anecdote about Thales, so too the analytic denigration of the physical and the material has ancient roots. For many ancient thinkers, the essential nature and aim of philosophy was to transcend the physical. One thinks of the Eleatic disparagement of the Way of Seeming, the ascent up Diotima's ladder toward a grasp of realities "free from all mortal nonsense", the need to turn away from shadows in order to escape from the Cave, or Plotinus's shame that he had a body. For Aristotle, genuine philosophy began only after material needs were satisfied. Whether in ethics, epistemology, or metaphysics, the telos of the knowledge being sought was more than the physical. Though Aristotle insisted on the viability of a science of nature, it was precisely Second Philosophy. His inquiries began with the physical world and things more knowable to us, but sought to move beyond the merely material, which remained unknowable apart from the unchanging form. This meta-physical orientation has shaped the canon, its interpretation, and the discipline over the centuries.

The papers in *Materia Philosophiae* resist approaching ancient philosophy as a collection of atemporal, disembodied arguments to be analyzed solely for their formal rigor and validity. Argument is central to philosophy. But arguments do not arise *ex nihilo*, anymore than any other aspect of Greek culture. To attend only to argument risks overlooking multiple aspects of a thinker's lived experience that shaped in essential ways (we contend) the formation and expression of philosophical ideas. By resituating early philosophers in their material and technological contexts, the volume intends not to challenge analytic approaches, but rather to enrich the study of ancient philosophy by drawing attention to what often has been left out of mainstream accounts: how philosophical thought emerged from and remained anchored to innovations found in the material culture of ancient Greece.[4]

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will more often obfuscate than illumine their philosophies." And from the Preface to the second edition: "In speaking slightingly of history I had two specific things in mind – studies of the 'background' … against which the Presocratics wrote, and studies of the network of 'influences' within which they carried on their researches. For I doubt the pertinence of such background to our understanding of early Greek thought. … Much of the historical detail with which scholarship likes to deck out its studies is either merely impertinent or grossly speculative" (Barnes 1982, p. xvi). Whether the contributions in *Materia Philosophiae* are impertinent, obfuscating, grossly speculative, or not its readers must decide.

4 A related sense of anchoring explains why *Materia Philosophiae* appears in the Euhormos series. Just as innovations arise from material grounds, so too they must be anchored to the familiar in order to gain acceptance. As Sluiter 2016 puts it, "Innovations may become acceptable, understandable, and desirable when relevant social groups can effectively integrate and accommodate them in their conceptual categories, values, beliefs and ambitions. This is the

The fourteen chapters of *Materia Philosophiae* explore ancient philosophy's material circumstances from a variety of perspectives, applied to different thinkers and periods. The volume is organized around four related themes. Each theme reflects an aspect of the impact of material realities on ancient philosophers, in some cases opening possibilities for new forms of thought, in other cases – and even at the same time – setting limits of what was possible to achieve:

1) Philosophy and New Technologies
2) Thinking with Objects
3) Philosophical Media and Their Messages
4) Philosophy and Ancient Embodiment

The remainder of the introduction will use these themes to provide a roadmap of the chapters and their connections with one another.

1 Philosophy and New Technologies

The first four chapters in *Materia Philosophiae* connect new philosophical ideas with innovations in technology that transformed the Greek world. As each chapter makes clear, the connections are essential rather than incidental.

In a paper of very broad scope, Robert Hahn resituates early Greek philosophers in their technological context to defend Aristotle's report at *Metaphysics* 983bff that the first philosophers were source and substance monists – that there is a unity that alters without changing. The grounds are found in case studies showing that the idea of "modular thinking" (of which "substance monism" is an example) not only surrounded these early philosophers in archaic Ionic society but interpenetrated their thoughts. Hahn examines four instances. (i) monumental temple architecture and building technologies – Anaximander's use of the architect's module of column-diameter to measure out the cosmos; (ii) Thales' and Anaximander's use of the gnomon as a substantially unchanging standard against which the distances, heights, and seasons could be measured by their structurally related shadows; (iii) coinage and the monetization of society as a vision that an abstract value underlies all

case when they can connect what is perceived as new to what they consider familiar, known, already accepted, when, that is, innovations are 'anchored'." The metaphor of anchoring is meant to capture "the dynamic through which innovations are embedded in and attached to what is (perceived as) older, traditional, or known." Though contributors to *Materia Philosophiae* express the relationship between the new and the old in different ways, it will become clear that many of the material dimensions identified here "anchor" philosophical innovations in just this way.

appearances; (iv) the production of industrial textiles – felting of wool – by which analogy Anaximenes illuminates cosmic transformations of appearances above an unchanging underlying substrate. Attributing "substance monism" to the earliest philosophers has escaped notice because scholars have neglected to review the earliest philosophers in their technological context.

In another expansive examination of ancient technology's relevance to the theme of the volume, Andrei Lebedev shows how mining and metallurgy contributed essentially to the rise of science and philosophy in Ionia. Ionian thinkers were not generally concerned with the Aristotelian problem of identifying *archai*. They sought instead to understand *physis* and the modifications of things in nature. To a remarkable degree, they found inspiration for their accounts in technologies related to the manufacture of goods for export on which the wealth of their cities depended. Lebedev begins with remarks on the nature of analogies and analogical thinking. After documenting the essential role of trade, colonization, and manufacturing on the first Ionian philosophers, he concentrates on the importance of metallurgy, including mining and manufacture, in the scientific revolution that took place in sixth-century Ionia. In different but central ways, Anaximander, Anaximenes, and Heraclitus drew inspiration from gold-washing, smelting and the shaping of objects in articulating their accounts of the cosmos. But no analogy is complete. In a telling case of the exception proving the rule, Lebedev identifies how the metallurgical model failed Anaximander and Anaximenes, prompting them to resort to a different manufacturing metaphor also related to the Milesian export trade.

A sophisticated knowledge of use and production is the subject of Andrew Gregory's contribution, "Greek Ships, Seamanship, and Cosmology." Gregory explores how early Greek philosophers and investigators of nature were influenced by the technology of shipbuilding, given that ships and seafaring played such an important role in ancient Greek commerce and warfare. Gregory points to the use of many seafaring metaphors and examples in early Greek philosophy and science, from Anaximenes' comparison of the bright colors made by oars striking the dark water to lightning and clouds, through to Plato having the cosmos bound together by *hupozômata*, the ropes tied around ships to make them stronger when faced with a storm. The crucial question for *Materia Philosophiae* is why these are inspirations and confirmations, rather than convenient illustrations. To answer this question, Gregory explores the metaphor of the helmsman and steering in Anaximander, Heraclitus, Parmenides, Diogenes, and Plato. In all cases, he finds a centrality of reference that makes the metaphors and analogies essential to the position being developed. His conclusion is that metaphors of ships and seamanship were seminal in how philosophers pictured the physical world and cosmos.

Another device of great technological sophistication was "the machine" used to enable the miraculous appearance of a god in Greek theater. Sylvia Berryman's essay "The Gods and the Machine" examines these mechanical devices to show how the material context influenced abstract thinking about theological, cosmological, and natural explanations. Because of its inherently empirical nature, the field of mechanics in antiquity is a fertile site to examine the impact of material experience on ideas about the functioning of the natural world. Famously, Archimedes built a hand-turned model of the heavenly spheres, and as in the early modern world, and ancient Greek contemporaries wondered whether the gods might have made the heavens to work 'just like that,' i.e., without intelligent direction. Texts from late antiquity show two different responses. Some suggest the cosmos might be made to run unassisted, like a wind-up device with a trigger-release mechanism. A second, more philosophically motivated response is that the analogy offered a way to conceptualize the notion that a complex sequence of causes might lead to a determinate result, as a constructed device shows how an anticipated outcome might occur through a series of pre-programmed interactions. Although the prevailing philosophical schools accepted the need for teleological explanation of the natural world, it is striking that they noted the potential of mechanical devices for offering new ways of thinking about the workings of nature.

2 Thinking with Objects

The next theme explores the way philosophers drew essential inspiration from familiar, often ordinary material objects. Four papers show how material objects and contexts were inseparable sources and inspirations for theory, the grounds from which abstract and speculative thought emerged and developed, providing the means by which it was communicated.

The humble clepsydra (literally, "water thief") is a vessel with a narrow neck and a broad base pierced with holes designed to transfer liquids. Perhaps because of its widespread familiarity, it figures in the thought of at least three ancient philosophers. In, "Using a household artefact as an epistemological tool: Comparisons with the Clepsydra in Anaxagoras, Aristotle's *De Caelo*, and Empedocles," Nathasja Roggo-van Luijn begins with a sophisticated theory of analogy that goes beyond the typical and superficial practices of many ancient scholars. Roggo-van Luijn shows that the references to the clepsydra in the three thinkers are not mere ornamental examples that could have been omitted, but form a significant part of their inspiration and respective argumentations. Although these comparisons are employed for different target

domains and in different epistemological practices (instantiations of a general claim for Anaxagoras and the *De Caelo*, and analogy for Empedocles), all are essential in the invention and/or the dissemination of the theory in question. For Anaxagoras, the clepsydra likely played a heuristic role in his demonstration that air cannot be squeezed; the reference to the clepsydra in Aristotle's *De Caelo* is persuasive because the audience can check the claims at home; and Empedocles' analogy provides a mnemonic aid and helps him to explain potential puzzles concerning inhalation by pointing to the absence of void.

Almost equally familiar to a culture whose diet revolved around grain was the millstone. In "Anaximenes and the Millstone," Dirk Couprie sets out to explore precisely how the archaic millstone may have looked to better understand what it meant for Anaximenes to say the cosmos whirls around like one. Couprie begins with the doxographical testimony by Aëtius [*Placita* 2.2] that "And some (say that) (the cosmos?) whirls around like a millstone, others (say) that it (whirls around) in the manner of a wheel," καὶ οἱ μὲν μυλοειδῶς, οἱ δὲ τροχοῦ δίκην περιδινεῖσθαι ⟨τὸν κόσμον⟩. He then turns to the familiar imagery of the μυλοειδῶς, a millstone, as we still know them today, referring to horizontally placed millstones, the lower one stationary and the upper one rotating, where the flat earth can be compared to the lower, immobile millstone, while the sun moves like the upper, rotating millstone above the earth. Couprie argues that this image is seriously misleading: such horizontally turning millstones did not yet exist in Anaximenes' time and region. Instead, he suggests, Anaximenes should be interpreted as referring to a vertically rotating millstone running in a circle. And if so, this entails a quite different cosmological interpretation of the image. This new interpretation is tested by confronting text A with other texts on the movements of the heavenly bodies that have been associated with Anaximenes. By attending to the material context to which Anaximenes points, Couprie gives new insights into Anaximenes' cosmic picture.

The conceptual leap behind the acceptance of coinage is the subject of Richard Seaford's posthumous essay "The Metaphysics of the Coin-Image." Seaford first concentrates on the emergence of the ideas of *imitation* and of the *image*, ideas that are barely to be found in Homer. Subsequently, both Xenophanes and Aeschylus combine a new, abstract conception of god (in terms of the power of ubiquitous thought) with a rejection of divine images, which are aligned with Seeming as opposed to Being, that a divine image can create no harm, that it is a *mere image*. It is left to Plato (in the *Sophist*) to formulate a definition of the (mere) image that explicitly excludes embodiment of its model. It is here that the material context becomes crucial. An important factor in the philosophically important idea of the mere image was the mass-produced coin-image. It performed its crucial and ubiquitous monetary

function by (a) being exactly like other coin-images and (b) excluding embodiment of its model: the presence or power of a deity or of anything else embodied in the coin would impede its monetary function. The coin-image *must* be a mere image. Thus, the coin prefigured within itself the antithetical interconnection between *material mere image* and *unchanging abstract Being* that is central to Platonic metaphysics.

For scholars of ancient philosophy, Plato's *Meno* is the classic locus for the problem of the construction of a square double the area of a given square. The only apparent material dimension of the geometry lesson Socrates administers to Meno's slave is the drawing of the square in the dirt at their feet. In "Weaving the double square: an (im-)material contribution to early Greek mathematics," Ellen Harlizius-Klück and Giovanni Fanfani take a fresh look at a classic problem for Greek mathematics along with the discovery of incommensurability by showing how weaving, unexpectedly, contributes to understanding of the problem. The geometrical figure of the double square can be found in Mediterranean fabrics as early as the 9th century BCE. In weaving, numbers of threads are manipulated to generate patterns and shapes. However, doubled squares cannot be generated as in geometrical construction. In weaving, lines are the result of proportions of natural numbers of thread counts. As a technical mode to generate patterns and geometric shapes, ancient weaving technology implements a logic, deeply anchored in the material, that engages arithmetic and its relation to geometry. Their chapter traces the nature of such engagement, and what challenges weaving a double square presents, particularly how it accommodates incommensurability. They conclude by considering what their conclusions can contribute to a material understanding of early Greek philosophy.

3 Philosophical Media and Their Messages

How should historians of ancient philosophy incorporate realities involving the material transmission of knowledge in the form of manuscripts alongside sustained and lived communicative practices? How can such practices be illuminated through comparisons to those in other cultures? Three chapters consider such questions.

In "On the Limited Relevance of Writing to early Greek Philosophy," Harold Tarrant questions the importance of written texts for the history of early Greek philosophy before Aristotle and even Plato. Tarrant argues that the absence of writings by Socrates was not accidental. Given the material difficulties confronting early writers and their readers, texts were seen as a poor substitute

for face-to-face studies with the thinker himself. Rather than full statements of doctrines, the writings of early philosophers were meant to arouse interest and solicit paying students. As a result, they explained little in detail. At the same time, philosophers were cautious about allowing their writings to circulate, aware of the hostile reaction that they were bound to receive in some quarters. Hence Plato's preference for oral teaching over written should not be viewed as an aberration, and his preference would have been shared by most teachers and pupils of philosophy alike. Even in the Hellenistic period a philosopher's reputation depended upon his public face as he interacted with others. Many famous individuals did not write, others acquired their reputation without their writings having been much noticed. Even though Plotinus was conscious that he too had a corpus to leave behind, it seems that its wider circulation, beyond a few privileged friends, was intended to be posthumous.

In "Metadiscourse: The Material Dimension of Early Greek Philosophical Prose" Gastòn Javier Basile examines how material conditions of writing in late archaic and early classical times transformed philosophical ideas and their transmission. The emergence of Greek science and philosophy through the sixth and fifth century BCE entailed not just a novel form of inquiry into nature but also a new mode of discourse, continuous technical prose writing. While considerable attention has been accorded to the disciplinary implications of Pre-Socratic thought, Basile argues that the material conditions leading to the development of continuous prose as the medium to communicate the new philosophical inquiries have not yet been fully charted. In particular, the inception of technical prose must be judged against the abandonment of poetic composition and the situated ritual performances associated with the Homeric and Hesiodic traditions. One major consequence is what Basile terms the meta-discursive dimension of early prose texts. The bulk of his chapter examines the meta-discursive function of language in early technical prose by focusing on two extant fragments of the pre-Socratic philosophers Anaxagoras of Clazomenae (B4a) and Melissus of Samos (B8).

The section concludes by asking, how does materiality work differently in different cultures? Though anything like a comprehensive answer would require several chapters or even a second volume, Geoffrey Lloyd gives an indication of such research by comparing Greek materiality with that of ancient China's. In "Materiality and Philosophy: the Ancient Greek and Chinese experiences compared," Lloyd compares the Greco-Roman and the ancient Chinese experience of the materiality of philosophy. Lloyd asks, what were the aims and goals of those whom we can identify as engaging in philosophical inquiry? What were the media and means of communication they used and with whom did they hope to communicate? How do answers to those questions impact

on our understanding of their activities? Many aspects of ancient Chinese culture are contrasted with those in ancient Greece – a learned literary culture focused on the emperor and often on obtaining patronage; the absence of marble sculpture in contrast to what is found in Ionia; the absence in China of the concept of nature as distinct from the supernatural; how civic planning was informed by the ideology of the imperial court rather than the much less hierarchical Greek polis; the Chinese were not a sea people. Even if the material circumstances of philosophizing cannot be said to have *determined* its content, a cross-cultural analysis on those conditions serves to bring to light influences that we might otherwise be liable to miss, notably with regard to the position of the individual in society and to the limits of human aspiration.

4 Philosophy and the Ancient Body

The final three papers turn to the question of embodiment and how it affected the development of philosophical ideas and their communication.

In Plato and Aristotle, *sophia* came to connote an exalted cognitive achievement – or at least a recognition of the *sophia tis* Socrates claims for his too-human knowledge in comparison to the knowledge of the gods. As such, "wisdom" was far removed not just from what the gods knew but also from the everyday craftsman. In "Thales and the Measures of *Sophia*," Philip Thibodeau takes a fresh look at Thales' celebrated *sophia* by examining the material contexts in which *sophia* appears in archaic literature. Several of the oldest sources that apply the term *sophos* to Thales of Miletus imply that he had acquired a reputation for *sophia* during his own lifetime. But in literature contemporaneous with Thales, the term does not mean 'wisdom' or even 'cleverness', the sense that prevails in later texts. Rather, *sophia* denotes forms of embodied knowledge, specifically a mastery of various manual skills – sailing, equestrianship, instrumental music, and carpentry in particular – each of which places a premium on precision and "measure" in lived situations. After reviewing the language used to describe these crafts, Thibodeau proposes a new etymology for *soph-*, linking it to a root, *hep-*, 'to handle' or 'to manipulate'. Thibodeau then argues that Thales earned his epithet not by an abstracted investigation into first principles, but by conducting tour-de-force demonstrations of *sophia* involving concrete cases of sailing and measurement, each firmly grounded in the material realities his mastery helped to manipulate.

In "New Insights into Pythagorean Women's Material Philosophy," Bella Vivante aims to resituate ancient Greek female Pythagorean philosophers

within the field of philosophy by demonstrating how their women's materially oriented concerns fully fit within the field. The chapter first briefly reviews the principal female Pythagoreans, their possible dates, and nature of their writings. It then focuses on how the material nature of many of their writings fit within the discipline of "philosophy." In this material focus, by addressing issues that primarily concerned women, the women contributed to the philosophic dialogue of their respective topics. Not only were the female philosophers' discussions fully parallel to what the men were doing: as was culturally appropriate, each gender focused on the matters that were of primary concern to them. But in contrast to the male philosophers' discussions, the women used this material focus as a stepping-stone to explore the personal impact of these matters on their actual lives. Their writings thus expand the perception, approach to and meanings of these material aspects within the philosophic dialogue.

In the final essay in the volume, "Xenophanes the Sophist?" William Wians firmly anchors Xenophanes in the embodied realities of his life and world. Wians begins by emphasizing that Xenophanes was an itinerant poet who left Ionia and its intellectual milieu in his mid-twenties and traveled widely across the Greek world – particularly in southern Italy and Sicily – for the remaining decades of his long life. He wrote on many non-philosophical topics – symposia, conventional moral exhortations, satirical verses – and did so using both epic and non-epic meters instead of adopting the Ionian innovation of prose writing. Who, Wians asks, was Xenophanes' intended audience? By drawing attention to the material realities of the itinerant poet, Wians argues that Xenophanes went from city to city in search of aristocratic patrons and an educated elite appreciative of his new ideas about nature and the gods. By re-situating Xenophanes in the context of a search for paying patrons on the one hand and a resistance to written texts on the other, Wians argues that Xenophanes cannot be fully understood simply as a poetically inclined Ionian natural philosopher, but rather as a forerunner of a quite different but equally important intellectual tradition, that of the traveling polymath Greek Sophist.

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Materia Philosophiae is not the first work to take seriously the situatedness of early philosophers and to challenge the exclusion of material elements from the study of their ideas. Indeed, several contributors to the collection have been in the vanguard of such work, and the bibliographies of individual chapters acknowledge others. What the editors hope this new volume will achieve

is to anchor some of the remarkable innovations of ancient Greek philosophers to aspects of their world that have been routinely neglected, and which amplify, elucidate, and deepen our understanding about the origins and development of philosophy in Greece.

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PART 1

Philosophers and Technologies



CHAPTER 1

Material Modular Thinking, Substance Monism, and the Origins of Greek Philosophy

Architecture, Gnomon, Coinage, and the Felting of Wool

Robert Hahn

While many studies try to account for the origins of philosophy in Greece, none have made an appeal to ancient technologies that include architecture, the gnomon, coinage, and even the production of industrial textiles, as contributing factors. The argument here is that these new technologies not only surrounded the Ionian Greeks in the sixth century BCE, but interpenetrated the thoughts of the early Greek philosophers as the surviving doxographical reports prove. The common feature of these very different technologies is "modular thinking," that is, each of these material techniques rely upon identifying an underlying unity that is capable of altering without changing; this is the relevant meaning of "module" here. In architecture, the Ionic temple architects chose "column diameter" as their module, in using the gnomon its height remained the same while the shadows it cast varied, for coinage the *statêr* was the basic unit in terms of which all other denominations were submultiples or multiples of it, and for the felter, given a material such as wool (as module), the transformation in appearance from a lofty pile to the final product is explained by compression. When Anaximander identified the size and shape of the earth with a 3 × 1 column-drum and measured out the cosmic distances to the fiery wheels of stars, moon, and sun in earthly-diameters, that is, column-drum diameters, he was making use of an architectural technique. When Thales measured the height of a pyramid and Anaximander made a seasonal sundial, both used gnomons whose shadows varied while retaining the same gnomon-height; the gnomon-height in each case was the module. When coinage was introduced in Ionia, the underlying module was called a *statêr* and all other denominations were reckoned as submultiples or multiples of it; Heraclitus explains that the underlying module (= substance monism) was fire and it exchanges for all things just like goods for gold and gold for goods. When Anaximenes tries to explain diversity and multiplicity in the cosmos, he begins by claiming that "air" is the underlying module (= substance monism), and all seemingly different appearances are only *felted* versions – more or less compressed – of the same stuff. The technologies to which the early philosophers

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refer are material conditions that reverberated in their thoughts, reflected new innovations around them, and offered a platform for natural explanations, rejecting mythical and supernatural ones. Appeals to these techniques, then, offer us fresh insights into how, by means of sensory and perceptual experience, not by rejecting them, philosophical speculation began.

The starting point for this study is Aristotle's account of the origins of philosophy and the theories of the early philosophers in his *Metaphysics A*. And while for generations of philosophers who took an historical interest, according to Aristotle, the earliest philosophers were positing what I am calling "source" and "substance" monism, studies in the last century have challenged Aristotle's report. The source monist holds that there is a single source from which all things come, and back into which they return at the end of the cycle. This has not been a controversial claim. But identifying these early philosophers as *substance monists* has been the point of contention. For the substance monist holds that while it seems we live in a world of multiplicity and different things, the underlying stuff – water, air, fire, or even *apeiron* – since it always persists and never perishes, always remains the same. Thus, the world we experience is ultimately illusory because despite the perceptual experience of multiplicity and diversity, there really is only one underlying reality that merely alters or modifies without changing substantially. Aristotle's critics challenge this report for various reasons, some contending that he is placing them anachronistically within the context of his own projects – not theirs – to show how he, Aristotle, succeeded where the earlier philosophers fell short.[1] And some have argued that attributing "substance monism" to the early philosophers is historically inappropriate.[2] This study argues, against Aristotle's recent critics, that Aristotle's report *in this case* is plausibly accurate. To do so, the argument defending Aristotle's report is to show that all around the early philosophers of the 6th century BCE, and interpenetrating their thoughts, are appeals to modular thinking by their technical analogies. Since their thoughts already show that they embraced modular thinking, Aristotle's report attributing to them modular thinking/substance monism is entirely plausible. Thus, it is by appeal to *material conditions* we get fresh insights into the reliability of Aristotle's account, and consequently, the origins of philosophy in Greece.

1 Cherniss 1936, 195.

2 Graham 2006; see also Hahn's review of Graham (Hahn 2008).

1 Did Aristotle Get the Origins of Philosophy Wrong?

At *Metaphysics* 983bff, Aristotle claims that the first philosophers were source and substance monists; Thales is identified as the ἀρχηγός, or founder, of this type of thinking. They claimed that there was an underlying nature – variously named ὕδωρ ["water"] by Thales, ἀήρ ["mist-air"] by Anaximenes, πῦρ ["fire"] by Heraclitus and Hippasus – that is the single source from which everything comes [= source monism]. Moreover, all the different things we sense – the fire at the forge, the liquid in my cup, the invisible air we breathe, the hard stone marble – are all only modifications [μεταβάλλειν] of this underlying unity.[3] In the world of the earliest philosophers, according to Aristotle, there is no change only alterations of the basic stuff, believing there is nothing either generated or destroyed since this sort of underlying nature always persists [καὶ διὰ τοῦτο οὔτε γιγνεθαι οὐθὲν οἴονται οὔτε ἀπόλλυσθαι, ὡς τῆς τοιαύτης φύσεως ἀεὶ σωζαμένης, 983b13–15],[4] and at the end of the cycle all appearances return to their original source-state. Aristotle's account portrays the first philosophers as monistic metaphysicians:[5] the world of diverse appearances is only an illusion; things look different but in *reality* there is only one basic underlying stuff capable of altering in appearance but substantially unchanged [= substance monism]. I will also refer to this mentality as "Modular Thinking," because techniques that are structured out of modules suppose an underlying unity that alters without changing. Did Aristotle's report get the origins of philosophy wrong?

Aristotle's account has been the subject of much discussion and significant criticism. Almost a century ago, Harold Cherniss[6] produced a major study that suggested Aristotle's account of the earliest philosophers was wrong and wrong-headed, that he purposefully misinterpreted his predecessors to create the impression that they had all been working on the same set of problems as was he, but that he had solved them with a success that revealed his predecessors to have been a mere stumbling toward his enlightened metaphysics. While

3 Aristotle, *Metaphysics* 983b7ff.

4 I will translate φύσις as "nature" and other times as "unity" since the underlying nature is a "unity" that allegedly persists despite the appearance of it as multiplicity.

5 In this study, as in Hahn 2017a, 2–3, when I use the term "metaphysics" I mean "Source and Substance Monism." I emphasize this point for anyone who might object that applying the term "metaphysics" to Thales and the Milesians is anachronistic; while I accept such a point in general since its technical use is documented only later, if we identify it specifically with the doctrine of source and substance monism, which is precisely what I am arguing for, I regard the use of the term as both an appropriate and helpful shorthand for this discussion.

6 Cherniss 1935.

his predecessors identified only one or two of the fundamental causes of the being of things, Aristotle succeeded in revealing all four causes. Cherniss' book sparked a wave of new studies repudiating Aristotle as an historian of philosophy and as trustworthy doxographer, among which Farrington, Graham, Sassi, and most recently Rossetti,[7] followed in his footsteps, though with different emphases. These scholars tend to call Aristotle's account "material monism" and they deny that this label describes the projects and aspirations of the earliest philosophers. Most especially they reject the idea that these early thinkers imagined a unity that persists underlying all appearances of diversity. This was a central objection by Graham who contended that there was no evidence in the sixth century BCE or earlier for substance monism, that is, he declared that Aristotle's claim was "historically inappropriate."[8] It is my argument that if we miss the point that the earliest philosophers were "substance monists," we miss the *metaphysical* core of the origins of philosophy in Greece. Thus, this is not a small point.

The label of "material monism," first introduced by Cherniss and then taken up by Graham – as opposed to source and substance monism – is infelicitous because it obfuscates what is really at stake, namely, that while these critics repudiate Aristotle's claim that they were "substance monists," there is no objection to the claim that they were "source monists" – a central point of departure for many ancient cosmologies, Egyptian and Mesopotamian.[9] It is not that the critics are rejecting the attribution of "monism" to these earliest philosophers, but rather only that they were rejecting "*substance* monism" – Modular Thinking – that there was an underlying unity that altered without changing.

Let me be clear that I am not arguing that Aristotle's *interpretation* of the early philosophers is what is at stake, nor trying to defend him in general as a reliable doxographer; I am here arguing only that in *this case* Aristotle is likely *reporting* accurately. Snell and Claussen argued for the plausibility

7 Farrington 1944; Graham 2006; Sassi 2018. Rossetti shared this point of view with me in email exchanges. They arose after discussing his new manuscript *Thales the Measurer*. He wrote: "in my opinion … Aristotle is affected by an extreme one-sidedness and what he reports is of little help, when it is not misleading. At least in the case of Thales there is little doubt on that, since we can rely on a very rich offer of independent pieces of information. And he was neither monist nor dualist or trialist or otherwise pluralist, since he hardly had an idea of this question, nor an interest to answer it."

8 Graham 2006, 53ff. He calls "Material Monism" what I am calling "Substance Monism."

9 The Egyptian Heliopolis cosmology begins with Nun, the primeval ocean, the eldest of the gods from which all else comes. The Babylonian creation myth begins with Apsu and Tiamat, the sweet and bitter waters, from which all else comes.

that Aristotle had access to a book or summary by Hippias of Elis,[10] and that Hippias was likely his source. This view was recently championed again and elaborated upon in a convincing way by Panchenko.[11] Moreover, the fragment of Hippias quoted by Clement (DK 86B6) shows that he was the earliest systematic doxographer. In that capacity, Hippias could have supplied the details for Aristotle or an intermediary upon which Aristotle's report rested. Cherniss thought Aristotle's knowledge of Thales was exclusively a matter of received oral tradition;[12] what speaks against this is that at 983bff Aristotle is unambiguous about the ideas of the earliest philosophers, including Thales, whereas when he wonders just *why* Thales held his view, Aristotle is clearly unsure, and introduces the word "perhaps" (ἴσως)[13] as when he proposes that since the nutriment of everything is moist, perhaps this is why Thales posited ὕδωρ as the underlying ἀρχή. In addition to Hippias, Oenopides and Hippocrates of Chios, the famous geometers, are likely candidates from whose treatises Eudemus, Aristotle's student who prepared a *History of Mathematics*, learned Thales' geometrical achievements,[14] and may well have informed Aristotle directly through their treatises or by some intermediary who had access to them.

Two additional points need to be emphasized: the first clarifies the direction of influence between craftsmen and philosophers, and the second clarifies the relation between substance monism and modular thinking.

(i) The argument being advanced here is that the earliest philosophers were affected by practices all around them when they came to imagine an underlying nature or unity of the cosmos that altered without changing, rather than the other way around. I am not arguing that the architects and coin-makers, for examples, launched their innovative projects as part of a commitment to "substance monism." Rather, the temple architects had to imagine, perhaps by the aid of small models or drawn diagrams,[15] how to guarantee that the aesthetic effects would appear as planned when building on a gigantic scale. Working out of hard stone for the first time in the first half of the 6th century BCE in eastern Greece, they realized that they must begin with a module, a *One under Many*, in terms of which all the other architectural elements would be scaled-up or scaled-down, as multiples or submultiples of the module; the

10 Snell, 1944, 170–182; Classen, 1965, 175–181, esp. 175–178. Cf. also Kirk, Raven, and Schofield 1983, who seem persuaded by Snell's argument.

11 Panchenko 2005.

12 Cherniss 1935, 375.

13 *Metaphysics* 983b23, and that heat is derived from moisture, and so if the seeds of everything have a moist nature, water must be the first principle.

14 Zaicev 1993, 16 extrapolated their conclusions to the case of Eudemus.

15 Cf. Hahn 2001, Chapter 3.

theory of proportions was applied to the module.[16] We have no evidence that the architects were driven by metaphysical considerations to complete successfully their monumental temples, but rather by practical concerns. The invention of coinage in Lydia, then embraced by Milesians and other Ionian Greeks, and the craftsmen who made the dies and certified the quantity and quality of the electrum, gold, or silver by their punches on the reverse side of the coin, also were not likely driven by metaphysical theories but rather by the practical tasks of monetizing their culture by establishing a standard unit, or *statêr*,[17] and then producing submultiples of this standard as ½, 1/3, 1/12, 1/24, 1/48, even as small as 1/96 *statêr*, the *tetartemorion*. Since in Miletus, the *statêr* weighed approximately 14 grams, 1/96 stater at .15 grams, was a tiny piece of metal indeed. And finally, in the production of industrial textiles such as felted wool for garments to protect against rain and cold winds, the felter was not driven by metaphysical considerations but only the technique to compress the wool effectively; it was Anaximander and Anaximenes who watched the felters work and saw a cosmological analogy. Anaximander imagined that the reason we do not see the fiery wheels of sun, moon, and stars is because moist air is *felted* around the wheels,[18] concealing them; all we see is the "mouth"[19] or "breathing-hole,"[20] through which the fire blows forth. Anaximenes imagined that diversity of appearances was a result of different amounts of compression,[21] and so fire was the least compressed state of the module "misty-air," and with added compression, things appear invisible as air, flowing as liquids, or hard as stone.

(ii) The second point is to clarify and emphasize the relation of substance monism to modular thinking. Let me be clear that substance monism is a special case of modular thinking. Modular thinking displays an underlying material unity – the architect's column diameter; the gnomon whose modular length is compared to the varying shadows it casts to allow us to assess heights

16 Cf. Hahn 2003, 78, 80, 86, 90–98, 105–121, 144. Cf. also Coulton 1977, chapter 2.

17 Cf. LSJ 1634 for its various meanings identifying the fixing of weight and applying the coinage.

18 DK 12A18, Aetius II,13,7 [sc. τὰ ἄστρα εἶναι] πιλήματα ἀέρος τροχοειδῆ, πυρὸς ἔμπλεα.

19 DK 12A18 στόμιον ἄστρων, DK 12A21 στόμιον κύκλου ἡλίου, DK 12A22 στόμιον σελήνης.

20 DK 12A11 ἐκπνοὴ ἄστρων, DK 12A21 ἐκπνοὴ ἡλίου, DK 12A22 ἐκπνοὴ σελήνης. The use of ἐκπνοὴ and στόμιον suggests cosmic respiration, and since it is of "fire" it seems to have preceded Heraclitus' idea.

21 DK 13A6, πιλουμένου δὲ τοῦ ἀέρος, Plut. Strom 3. The analogy with "felting" is intended to make clear that cosmic diversity is a result of condensation and rarefaction [as Simplicius explains on the authority of Theophrastus *Phys*. 24, 26 μανότητι καὶ πυκνότητι – different levels of compression.

and seasonal markers; the coin-maker's *statêr*; the geometer's right triangle as in Plato's *Timaeus*, the fundamental geometrical figure out of which the rest of the cosmos is constructed – that is open to modifications while allowing that underlying unity to persist. Positing water, air, or fire as the underlying substrate by the earliest philosophers offers an argument by analogy, *and I am proposing that surrounded by all these exemplars in modular thinking, the earliest philosophers inferred an underlying module – a substrate – that is capable of modification without changing substantially*. Their original contribution to metaphysical speculation was analogous to the modular techniques employed by architects, sundial-makers, and coin-makers, and some promising new studies suggest also by weavers and shipbuilders.[22] A technique is always an application enveloped by a theory; these techniques are enveloped by a *modular theory*.

2 Four Case Studies: Architecture, Gnomon, Coinage, Felting of Wool

A study of Anaximander, who is credited with writing the first philosophical book in prose, offers a most compelling case for modular thinking. Although Aristotle does not identify him as a "*material* monist," if we accept the surviving fragment preserved by Simplicius, on the authority of Theophrastus, to mean that out from the *apeiron* all appearances emerge and back into the *apeiron* things return at the end of the cycle,[23] then Anaximander appears to be a *source* and *substance* monist. Following Kahn, here is the translation of the fragment preserved by Simplicius, on the authority of Theophrastus:

22 See in this volume Gregory, and Fanfani and Harlizius-Klück. See also Fanfani and Harlizius-Klück in Hahn and Herda (forthcoming).

23 Cf. DK 12B1 as translated by Krell and Capuzzi 1975, 13: "But where things have their origin, there too their passing away occurs according to necessity; for they pay recompense and penalty to one another for their recklessness, according to firmly established time." KRS 1983, 117, n. 112, translate "And the source of coming-to-be for existing things is that into which destruction, too, happens 'according to necessity; for they pay penalty and retribution to each other for their injustice according to the assessment of Time…." Before them, cf. Nietzsche (Krell and Capuzzi 1975): "Whence things have their origin, there they must also pass away according to necessity; for they must pay penalty and be judged for their injustice, according to the ordinance of time." Heidegger 1975, 57, reaches the conclusion that the only genuine part of the "Anaximander fragment" is "… along the lines of usage; for they let order and thereby also reck belong to one another (in the surmounting of disorder)."

> Anaximander declared the Boundless [τὸ ἄπειρον] to be the principle and element of existing things.... he says that it is neither water nor any other of the so-called elements, but some different, boundless nature [φύσιν ἄπειρον], from which all the heavens arise.... out of those things whence is the generation for existing things, into these again does their destruction take place, according to what must needs be; for they make amends and give reparation to one another for their offense, according to the ordinance of time, speaking of them thus in rather poetical terms. It is clear that having observed the change in the four elements into one another, he did not think it fit to make any one of these the material substratum, but something else besides these.[24]

Keeping in mind that Theophrastus claims Anaximander was a student or associate of Thales, who identified *water* as the originative and underlying material reality, the passage in Aristotle's *de Caelo* discussing the number of elements places the identity of the *apeiron* among the early Greek philosophers who held that water, air, or fire was the underlying nature or unity. Aristotle identifies *apeiron* as an intermediary, rarer than water but denser than air: "Because the (number of) elements must necessarily be finite, it remains for us to consider whether there are more than one. Some philosophers posit one alone, either water or air or fire or a substance rarer than water but denser than air and this they say is *apeiron* and encompasses all the world."[25] This same point of view is adopted by Aristotle in the *Physics* Γ where he says "... of the *apeiron* there is no beginning ... but this seems to be the beginning of the other things ... and this is divine; for it is immortal and indestructible, as Anaximander says."[26] Here the *apeiron* is placed alongside the other candidates for source and

24 Simplicius, *Physics*, 24,13ff; DK 12B1. *Phys. Opinions*, fr. 2, in Kahn 1960, 166–167. Ἀναξίμανδρος ... ἀρχήν τε καὶ στοιχεῖον εἴρηκε τῶν ὄντων τὸ ἄπειρον, πρῶτος τοῦτο τοὔνομα κομίσας τῆς ἀρχῆς. λέγει δ᾽αὐτὴν μήτε ὕδωρ μήτε ἄλλο τι τῶν καλουμένων εἶναι στοιχείων, ἀλλ᾽ἑτέραν τινὰ φύσιν ἄπειρον, ἐξ ἧς ἅπαντας γίνεσθαι τοὺς οὐρανοὺς καὶ τοὺς ἐν αὐτοῖς κόσμους. ἐξ ὧν δὲ ἡ γένεσίς ἐστι τοῖς οὖσι, καὶ τὴν φθορὰν εἰς ταῦτα γίνεσθαι κατὰ τὸ χρεών, διδόναι γὰρ αὐτὰ δίκην καὶ τίσιν ἀλλήλοις τῆς ἀδικίας κατὰ τὴν τοῦ χρόνου τάξιν, ποιητικωτέροις οὕτως ὀνόμασιν αὐτὰ λέγων. δῆλον δὲ ὅτι τὴν εἰς ἄλληλα μεταβολὴν τῶν τεττάρων στοιχείων οὕτος θεασάμενος οὐκ ἠξίωσεν ἕν τι τούτων ὑποκείμενον ποιῆσαι, ἀλλά τι ἄλλο παρὰ ταῦτα.

25 Aristotle, d*e Caelo*, Γ 303b9–13: ὃ περιέχειν φασὶ πάντας τοὺς οὐρανοὺς ἄπειρον ὄν. See also Mansfeld 2011, 4. Aristotle repeats just this claim at *Physics* Γ5, 303b10.

26 Aristotle, *Physics*, Γ4, 203b7, and emphasized again at Γ4 203b15: εἰσὶ γάρ τινες ὃι τοῦτο ποιοῦσι τὸ ἄπειρον, ἀλλ᾽οὐκ ἀέρα ἢ ὕδωρ, ὡς μὴ τἆλλα φθείρηται ὑπὸ τοῦ ἀπείρου αὐτῶν.

substance monism, that is, other modules; Anaximander should be re-viewed in this context.[27]

Now, according to Vitruvius, the Ionic architects selected a module – a *One under Many* – to determine column-height. This module might also have been applied to the other architectural elements but, while the architect-archaeologists seem to concur that the limited evidence presently available will not allow us to establish this with a reasonable degree of certainty about the Ionic archaic temples of eastern Greece,[28] my argument about Anaximander's cosmic numbers invites us to re-think this matter because those numbers reveal a modular approach to the distances to heavenly wheels in earthly, that is column-drum, diameters. The underlying question that remains unanswered decisively, given the exiguous nature of the surviving evidence, is *how* did the archaic Ionic architects figure out how to secure the proportional relations they imagined as the temple was built on gigantic scale? How did they determine the proportions of length-to-width-to-height, the height of the upper orders in comparison with the column-height, and so on? If they made models out of impermanent materials or even drawings/diagrams on large animal skins – since none survive that would be architecturally useful – how might they have scaled-up all their architectural elements to display the aesthetic sensibilities they wished the finished temple to display? What Vitruvius does tell us is that the diameter of an Ionic column was equal to one module, and column height is equal to 9.5 modules:

> III.3.7: [Discussing Ionic temple architecture] Whether the temple is to be tetrastyle, or hexastyle, or octastyle, one of these units should be adopted, and it will be the *module*. *This module is equal to the thickness of the column. … The height of the individual columns is nine and a half modules.*

27 Cf. Burnet 1930, 53: "Anaximander taught, then, that there was an eternal. The indestructible something out of which everything arises, and into which everything returns; a boundless stock from which the waste of existence is continually made good, "elements." That is only the natural development of the thought we have ascribed to Thales, and there can be no doubt that Anaximander at least formulated it distinctly. Indeed, we can still follow to some extent the reasoning which led him to do so. Thales had regarded water as the most likely thing to be that of which all others are forms; Anaximander appears to have asked how the primary substance could be one of these particular things. His argument seems to be preserved by Aristotle….".

28 See Hahn 2003, 105; also Hahn 2007, Hahn 2019a, and Hahn 2020.

If we can believe Vitruvius, this seems to mean that in order to insure that the columns[29] of the gigantic house of the god, the cosmic power, would display the planned aesthetic proportional size, there was a rule that guided the builders. The importance of this is underscored by Coulton, where in addition to discussing the importance of proportional scaling for design and construction, he emphasized the likelihood that the rules of proportions were set out along with technical problems to be addressed in the first Greek prose treatises by the archaic Ionic architects.[30] We learn from Vitruvius that the first architectural prose treatises, by Theodorus, the architect of the first limestone temple of Hera at Samos, begun circa 570 BCE, and by Chersiphron and Metagenes for the archaic marble temple of Artemis in Ephesus, circa 560 BCE, were produced contemporaneously with Anaximander's prose book.[31] According to Vitruvius, Ionic stone temple construction identified a module – *column diameter*; then column-height would be reckoned as multiples of the module. The key underlying point is this: in archaic culture, the column was *symbolically* regarded as separating or connecting the earth with the heavens. Homer and Hesiod regarded the column as separating heaven and earth,[32] while Pindar regarded the column as joining the two.[33] And so, when we review within the archaic context Anaximander's cosmic numbers for the distances to the heavenly stars, moon, and sun we can explore the plausibility of whether the archaic Ionic architects influenced Anaximander, whether Anaximander influenced the archaic architects, or even the possibility that both were influenced by some other cultural source, such as the archaic formula of numbers of 9 and 9+1?

The precise rule of proportion for the relation between column-diameter and column height has recently re-entered the debate, subsequent to my publication of *Anaximander and the Architects* [2001], in light of more recent studies by Wesenberg, Haselberger, Ohnesorg, Labrinoudakis, Korres, and others. According to Vitruvius, Ionic temple architecture had a column-height 9.5 times the (lower) column diameter,[34] while Pliny claimed the proportional rule was 9 times the lower diameter.[35] The continuing stumbling-block has

29 This rule must almost certainly address the front columns of the temple, and perhaps also down the flank, since these would be noticeable first, and a defining feature of the temple.

30 Coulton 1977, esp. 25, but also 64–67, and 74–96.

31 Vitruvius 7, 12. Cf. also Hahn 2001, Chapters 2 and 4.

32 Homer, *Odyssey*, 1.53; Hesiod, *Theogony* 517ff.

33 Pindar, *Pythian Odes*, 1.39ff.

34 Vitruvius IV.1,7. Cf. also esp. 29; Schaber 1982, esp. 83. Cf. also Wesenberg 1983 and his review of Ohnesorg's 2007 book (Wesenberg 2008).

35 Pliny, *Natural History* 36, 179.

been that not a single archaic Ionic column has survived intact from eastern Greece to assist in confirming or denying those claims, and the excavators themselves have confessed that all claims about this relation must remain speculative.[36] In addition, we have the complication of outer columns and inner columns that differ. We do have a surviving column from the Naxian stoa at Delos whose height is 9 times the lower diameter,[37] and Hendrich has been able to identify the outer columns of the temple of Hera at Samos – Dipteros I, circa 570 BCE and following – at 9.4 times the lower diameter.[38] But, recent archaeologists who made and published new studies of the archaic temple of Artemis at Ephesus (*c.*560), the archaic temple of Dionysus at Yria (*c.*570) and to Demeter at Sangri (*c.*530) at Naxos suggest more slender columns. Just to be clear that the matter is still being debated, Ohnesorg argued that the archaic Artemision columns were somewhere between 10–12.7 times the lower diameter,[39] while Wesenberg continues to argue that they were more likely only 8 times the lower diameter based upon what he regarded as the uncertainty of the surviving pieces and the strength of the ancient literature by Vitruvius and Pliny. Central to the debate is reconciling the ancient literature with the archaeologists' excavations which still largely remain speculative on this matter.

Now, here is where and why this architectural rule of proportion is relevant for this study here. Anaximander identified the size and shape of the earth with a column-drum, three times as broad as it was deep [3×1];[40] the distances to

36 Here are representative statements (my translations from the German): Gruben 1963, 15 (specifically speaking about the archaic Didymaion): "Column height cannot be determined from the information we have from lower and upper column diameters….". Ohnesorg 2007, 111: "With the help of the fragments of bases, columns and capitals, no precise evidence can be obtained for determining the height of the columns – one of the most controversial problems in the architectural history of Ionia, which was sparked by the archaic Artemision." Wesenberg 1983, 315 reviewing Ohnesorg 2007: "The lack of reliable statements about the lower column diameters is particularly unfortunate because the reconstruction of the column height can only be based on these dimensions."

37 Wesenberg 2008, 316.

38 Hendrich 2007, 64.

39 Ohnesorg 2007, 111 (discussing the archaic Artemision at Ephesus): "There are two camps that, each based on historical tradition and its interpretation, advocate a higher or lower column height, from 10.3 to 12 or from about 8 lower diameters. In addition, the proportions vary with the different column thicknesses that have been observed, because the height of all columns must be the same. … The taper is small compared to other buildings, which could be an indication of the taller columns. A column height of s10 to 12 lower diameters is favored here."

40 According the Ps-Plutarch [DK 12A10], Anaximander's earth was 3 times as broad as it was deep [ἔχειν δὲ τόσουτον βάθος ὅσον ἂν εἴη τρίτον πρὸς τὸ πλάτος]. And according to

the heavenly, fiery wheels of stars, moon, and sun were reckoned as multiples of earthly/column-drum diameters, and consequently by means of a modular technique. The distances were reckoned as 9/10 diameters to the stars, 18/19 to the moon, and 27/28 to the sun since each heavenly wheel is 1 earth-diameter, that is 1 column-diameter or 1 module thick.[41] Anaximander not only made use of a modular technique, he in fact used the architect's module. The reason we can surmise why he used the architect's module was plausibly because he came to envision the cosmos as cosmic architecture, an architecture, like the temple, built in stages. But did he embrace the architect's rule of proportion to identify the column height as 9, 9.5, or even 10 times the module? Or might both he, and the architects, have been affected by a modular formula with even greater cultural currency? Let us explore this last possibility further.

Anaximander lived in a world that already supplied other modular formulas. Let us not forget the prevalence of poetic formulas such as dactylic hexameter itself in the regular alterations of long and short syllables. We should also acknowledge that the archaic Greeks had certain techniques for pattern-making that were called upon to produce a variety of forms that find expression in poetry, architecture, sculpture, music, dance, weaving, shipbuilding and more. The archaic formula of the number '9' was another module or pattern; it was a shorthand for great quantities, great amounts of time, and great distances.[42] When the poet mentions '9 swirling streams,' he means countless many.[43] In the *Hymn to Demeter*, Demeter wanders the earth for nine days looking for her daughter Persephone, and in the *Hymn to Delian Apollo*, Leto labors for nine days and nights; 9 symbolizes great durations of time.[44] The topper was the formula '9+1', or even '10.' We meet Homer's *Iliad* in the 9th year of the war being told it would end in the 10th: 9+1.[45] It takes 9 years for Odysseus, already gone from home for 10 years, to make his way home to

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Hippolytus it was likened to a stone column [DK 12A11.3]; and since it is cylindrical in shape, and 3×1, its size is likened to a column-drum: τὸ δὲ σχῆμα αὐτῆς ⟨τῆς γῆς⟩ γυρὸν, στρογγύλον, κίονος λίθῳ παραπλήσιον.

41 The cosmic numbers have long been a subject of debate, and I am relying on my arguments in Hahn 2001, 2003, 82–87, and especially 2010, esp. 60–64 including the arguments by Tannery, Diels, Burnet, KRS, Heath, Kahn, and West. My conclusion is that the numbers were "radii" [= distances], not circumferences [=sizes], and the two different numbers identify distances to the inside and outside of each heavenly wheel, each being 1 module thick.

42 Cf. Gigon 1945, 91.

43 Hesiod, *Theogony*, 790.

44 *Hymn to Demeter*, 47–51. *Hymn to Delian Apollo*, 91.

45 Homer, *Iliad* 2, 327ff.

Ithaca, arriving in the 20th: 9+1, repeated.[46] When Hesiod offers to illuminate the great distance from the highest heaven to earth he invites us to imagine allowing a brazen anvil to fall from its heights; it would fall 9 days and nights landing finally on earth on the 10th. And if we were to open the gates of Hades and once again allow the bronze anvil to fall, it would again fall 9 days and nights bottoming out in Tartarus on the 10th.[47] Hesiod adopts the module of 9+1 in an archaic poetic formula. By means of it, he places the earth ἐπὶ τοῦ μέσου, in the middle, from what is above and below. But what of the distances laterally to the extremities of its sides? Hesiod supplies neither numbers nor poetic formulas. Anaximander also places the earth ἐπὶ τοῦ μέσου, but his adoption of the module expands the poetry into architectural *syngraphai*,[48] and thus makes it more readily amenable to graphic representation. In this bold step, Anaximander *geometrized the cosmos*.

While the evidence is not sufficiently clear to show that the height of the archaic column, that symbolically separates or joins earth and heavens, was a contributing, motivating force for his decision to mark out cosmic distances in 9/10 modules, it becomes more tempting to do so when we press the architectural analogy further. Were the architects themselves influenced by the modular formula of '9' and '9+1' (=10) to make column height reflect the well-known formula? In an important sense, the archaic Ionic architects decided on column height in an arbitrary fashion, for surely, they could have made the columns shorter as did the Doric architects, or of course taller, and yet the numbers, despite the uncertainty in the debate, are still very close to what Vitruvius, Pliny, and the module to which archaic literature gives voice. Anaximander's cosmic numbers are not the result of astronomical observations or instruments,[49] they have symbolic meaning, and so we come to see the plausibility that the underlying module 9 and 9+1 that pervaded archaic literature, and possibly the architect's modular formula of column-diameter to column-height, contributed or influenced Anaximander's selection. If we entertain the newest speculative guesses by Ohnesorg that the archaic Artemision proportions for column height could be as small as '10' times the lower diameter, and we accept Hendrich's claim that the outer peristyle of the archaic temple of Hera is 9.4 times the lower diameter, and the only surviving

46 Homer, *Odyssey* 14, 240ff; cf. also for other examples of the use of the number '9' in Homer – *Iliad* 1, 52ff; *Odyssey*, IX, 82ff, X, 27ff, XIV, 228ff, symbolizing great quantities and great amounts of duration.

47 Hesiod, *Theogony* 790, and 722–726; and also 775–805.

48 For discussion of the *syngraphai*, the architectural specifications, cf. Coulton 1977, 54ff.

49 Dicks 1970, 45.

archaic column from the Naxian stoa on Delos at 9 times the lower diameter, then the formula of 9 and 9+1 seems broadly on target for Anaximander. What I am now proposing, and what seems never to have been proposed before, is that *Anaximander's cosmic numbers are evidence for and support the Ionic rule of proportion of column diameter to column-height – 9 or 9+1 – expressed in the ancient literature*. The testimony of Anaximander is relevant to the debate among architect-excavators. Moreover, the distances from earth to the stars, stars to moon, and moon to sun are all the *same* modular distance, repeated.

Let us resituate this discussion. Anaximander's book starts from the very beginning of the cosmos when the *apeiron* gave rise to a seed (γόνιμον), and from it separated off (ἀποκρινομένων)[50] or separated out (ἐκκρίνεσθαι)[51] the opposites, and from these oppositions of hot and cold, wet and dry, diversity appeared, with an original fire surrounding like bark around a tree (ὡς τῷ δένδρῳ φλοιόν)[52] – note the tree/cylindrical model of the cosmos. Then, due to continuous motion, the surrounding fire broke off into three concentric fiery wheels, the stars, moon, and sun, in that order of closest to farthest. Anaximander's narrative continued and unfolded up to his present day. This vision required a *cosmological* narrative; the cosmos now was not as it had been in the beginning and so a series of stages must be supplied to explain how it came to be this way.[53] As the architects' imagined the symbolic forms for the house of the cosmic powers, Anaximander did them one better by imagining the house that *is* the cosmos. But the claim here is not that Anaximander merely copied the architects, any more than the architects merely copied one another, but rather Anaximander embraced techniques and methods on display in front of his community in order to imagine the design of the cosmos and the stages by which it came to assume its present form,[54] techniques and methods of which his audience was doubtlessly aware.

We have additional architectural evidence from the 6th century of the East building on the Sacred Way from Miletus to Didyma. We have the ground-plan that still survives, the projected elevation of the building, and the roof tiling patterns thanks to a reconstruction by Schneider that includes 6000 pieces from that roof, that show that the same design formula was used throughout, and that I have discussed at length elsewhere.[55] Since it is not unreasonable

50 According to Aristotle, *Physics* A4, 187a20.
51 According to Simplicius, *Physics* 24, 21.
52 DK 12A10, Ps-Plutarch, *Stromateis* 2.
53 Cf. Hahn 2010, Ch. 1 for the narrative told in stages.
54 Hahn 2003, 150.
55 Hahn 2003, 130–149. Cf. Schneider 1996, 33–37, and 52.

to suppose that the roof of a building on the Sacred Way suggests a symbolic reference to the heavens above – the roof may well have been imagined as the heaven in every sacred building – it is noteworthy that Anaximander's distances to the heavenly wheels bear analogy to the patterns of the roof tiles. Here, it is enough to point out that there was a roof-tiling formula – length to width – to which a module was added, and in Anaximander's case, by analogy, the module is the width of each fiery wheel, 1 earth-diameter. To see the analogy with the patterns of roof tiling for the distances to the heavenly wheels, consider the formulas, below: Anaximander's modular earth was 3×1, and the distances to the heavenly, fiery wheels were in proportions 1:2:3 – or following the patterns of roof tiling in 6th century Miletus, the distances to the stars were $3 \times 3 \times 1 + 1$ [9/10], to the moon $3 \times 3 \times 2 + 1$ [18/19], and to the sun $3 \times 3 \times 3 + 1$ [27/28].

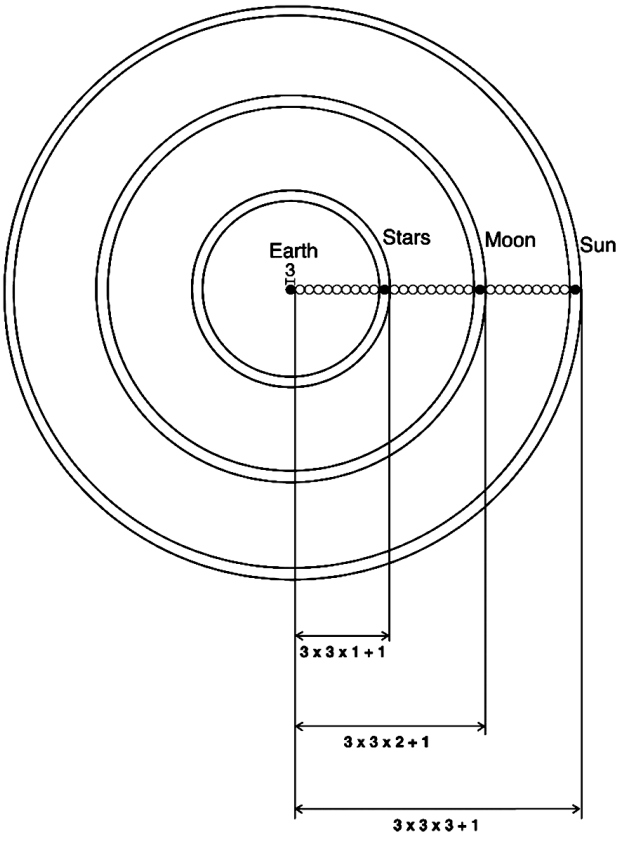


FIGURE 1.1
"Plan view" of Anaximander's cosmic picture, numbers mirroring the architectural roof tile pattern for the archaic East Building on the Sacred Way
IMAGE BY THE AUTHOR

The archaic Ionic temples – the houses of the gods – were rectangular, not circular or cylindrical in form as Anaximander imagined the cosmos, and their proportions of height to width to length was 1:2:4. The archaic temples – the Heraion in Samos, the Artemision in Ephesus, and the Didymaion just outside Miletus – were twice as wide as they were high, and twice as long as they were wide. Anaximander's cosmic picture is circular and cylindrical, with a 3×1 module and distances in proportions of 1:2:3. Thus, it is not that Anaximander simply copied the architects, but rather adapted and adopted the modular thinking of the architects, applying them to our cosmic house. And since the appeal to the archaeological evidence from the archaic temple sites in Ionia bypasses Aristotle by two centuries, it provides an independent window into archaic Ionia that allows us to confirm in their historical and technological context that the earliest philosophers embraced and were surrounded by modular thinking. Below, on the left, we have a reconstruction of the *grid for the ground-plan* for the archaic temple of Apollo at Didyma, after Von Gerkan,[56] and on the right a "plan view" of Anaximander's cosmos, showing the distances to the fiery wheels of stars, moon, and sun in earthly, that is, column-drum diameters. The limestone phase of the Didymaion began not much later than the Samian Heraion, and consequently has been thought to follow the Samian limestone plan.[57]

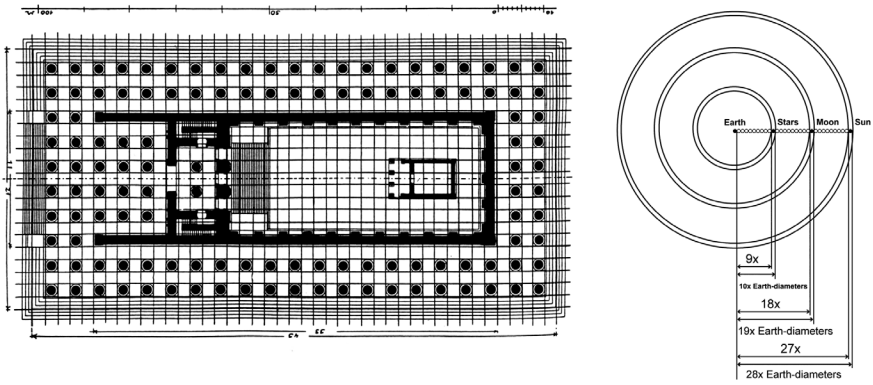


FIGURE 1.2 Left: Architect's grid-pattern for spacing between columns in column-drum diameters. Right: Anaximander's spacing between heavenly wheels of stars, moon, and sun, measured out in earthly, that is, column-drum proportions
IMAGE BY THE AUTHOR

56 Cf. Hahn 2003, 130ff.
57 Dirschedl 2013.

But how might Anaximander have represented it for those who read or listened to his book? It makes sense to see how he followed further the architects.

Unlike some other *technai*, the architects had to work from more than one point of view to successfully build their enormous temples. Since the case has already been argued that the eastern Greeks imported multi-columned temple designs and building techniques from Egypt in the 6th century BCE, the surviving evidence shows that the Egyptian architects envisioned their projects in plan-view sketches, in addition to elevation sketches and models.[58] The plan view – literally from 90° above and looking down – is not an experience any of us have for a gigantic building; it is an imaginative projection. In order to control the construction, the architect must imagine each course of stones, layer by layer, as the building goes up. And it has already been argued that Anaximander, following the architects, also relied on two views of the cosmos, one in "plan" [literally, a horizontal cross section through the plane of the earth, since there is no "above and below" in Anaximander's cosmos], and the other as an elevation.[59] For anyone who doubts that Anaximander could have imagined a "plan view" perspective, let us be reminded that Anaximander is credited with making the first Greek map [πίναξ] of the inhabited Earth [οἰκουμένη].[60] The drawing of the map on a tablet – like the picture of the cosmos on Achilles' shield,[61] had to be a plan view! What recommends further this multi-view interpretation is that Aristotle claims that Anaximander held the earth remains motionless in the center of the cosmos because it is ὁμοίως πρὸς τὰ ἔσχατα ἔχον – equidistant from all extremes[62] – but it is clearly not equidistant in "elevation" while it is indeed in plan.[63] Below is an illustration of the architect's plan vs elevation views of the archaic Temple of Artemis at Ephesus:

58 Cf. Hahn 2001, Ch.3; Hahn 2003, 78–98; Hahn 2010, Ch. 1.

59 Hahn 2001, 218.

60 Cf. Agathemerus 1,1 [DK 12A6] who reports that Anaximander first dared to draw the inhabited world on a tablet, and Strabo 1, 7, who reports that Anaximander was first to publish a geographical map. Cf. also Diogenes Laertius II, 1–2 [DK 12A1] who reports that Anaximander first drew an outline of earth and sea.

61 Homer, *Iliad*, XVIII, 478–608.

62 Aristotle, *de Caelo* 295b15. Cf. Bodnar 1992.

63 Concerning the comparative diagrams of plan and elevation of temple and Anaximander's cosmos, cf. Hahn 2019, 15 for a detailed analysis, and earlier Hahn 2001, 218.

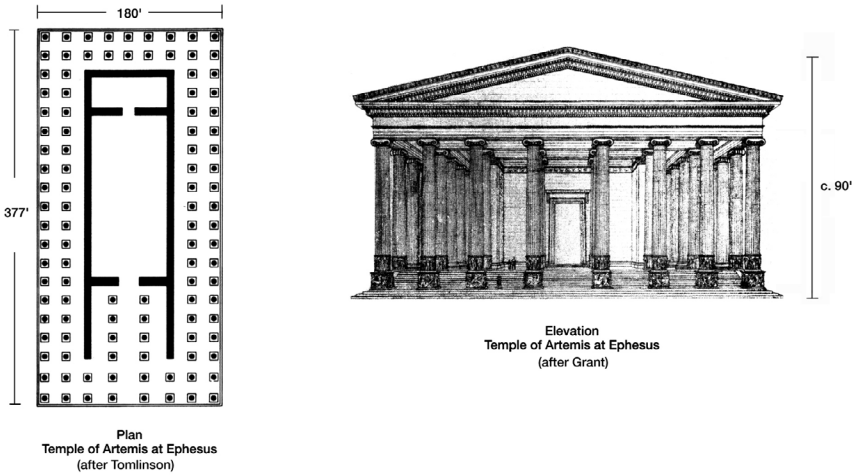


FIGURE 1.3 Temple plan vs. elevation. Left: Plan, Temple of Artemis at Ephesus (after Tomlinson). Right: Elevation, Temple of Artemis at Ephesus (after Grant)
IMAGE BY THE AUTHOR

And directly below, here is a proposal of Anaximander's cosmic picture in "plan" vs elevation:[64]

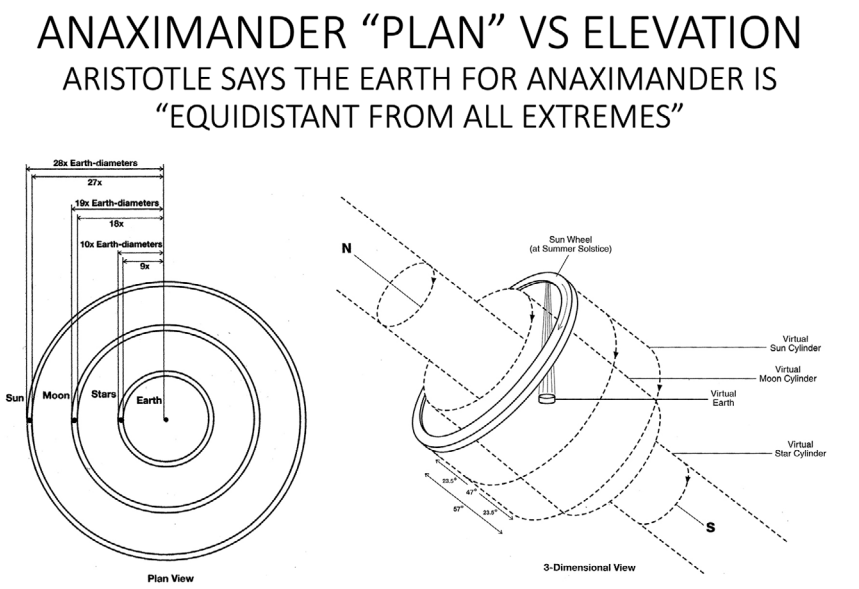


FIGURE 1.4 Left: Anaximander's Cosmic "plan" vs. right: elevation
IMAGE BY THE AUTHOR

64 Cf. Hahn 2001, 217–218.

Before the 6th century in Ionia, the archaic temples had roofs of thatch, held up by the available timbers. Through the 8th and 7th centuries when the temples were enlarged, they were lengthened, not widened, and so the available trees sufficed. But when the decision was made, first in Samos (*c.*580–570) and then in Didyma and Ephesus soon thereafter, to widen the temples, the available timbers could no longer carry the increased load; here was the transition to stone architecture by the end of the first quarter of the 6th century. The column drum was a technique likely inspired from Egypt to solve the problem of delivering more than 100 multi-toned monolithic columns from the quarry to the temple building sites, often many kilometers away. The idea was to bring drums, close to finished size, from the quarries to the building site, and then finish and install them. The labor-saving technique to prepare each drum face came to be called *anathyrôsis* and *empolion*. The circumference of each drum had to be uniformly distanced to the center, and a band nearest the circumference had to be carved to a plane; this process was controlled by one or two concentric circular marks on the drum face. Then, the portion of the drum between the center and the *anathyrôsis* band had to be counter-sunk so no part would protrude and so interfere with the drum's stability; each drum would rest on the carved lip around the circumference, like the jamb (or frame) of a door (= *thyra*). This is why Kirk, Raven, and Schofield seem to be mistaken when they regarded στρογγύλον as a gloss for γυρόν in the fragment preserved by Hippolytus.[65] Anaximander's earth is στρογγύλον (rounded) around the circumference, and γυρόν (concave) towards the middle of each drum. At the very center, a hole would be made – in Didyma they were circular (below, left), and in Samos they were rectangular (below, right) – and as the drum would be lowered into place, it would set precisely on the preceding drum or column base, resting only on the prepared band, and so eliminating the need for significantly more labor to dress the entire surface to a level plane.[66]

We know that even in archaic times, the Greeks had use of the pulley. In Figure 1.6 we can see a "boss" projecting from an archaic column-drum now being used in the later Artemisian.[67] On the left is an illustration of the installation of a column drum by means of the techniques of *anathyrôsis* and *empolion.*

Just as the circumference of the column drum must have its band *anathyrôsis equidistant* from the center so that each additional drum would

65 KRS 1983, 134. DK 12A11, Hippolytus *Ref.* 1,6,3: τὸ δὲ σχῆμα αὐτῆς (sc. τῆς γῆς) γυρὸν, στρογγύλον, κίονος λιθῳ παραπλήσιον.

66 Cf. Hahn 2010, 43.

67 Cf. Hahn 2010, 26.

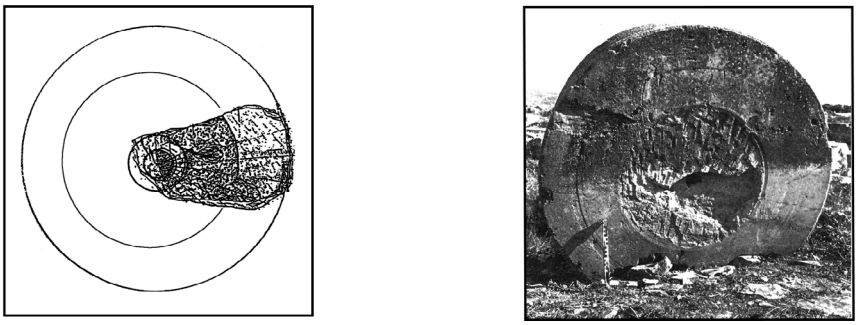


FIGURE 1.5 Left: Surviving piece of a column-drum from the archaic Didymaion displaying anathyrôsis and empolion. Right: An archaic column-drum from Dipteros II, Samian Heraion also displaying anathyrôsis and empolion
IMAGE BY THE AUTHOR

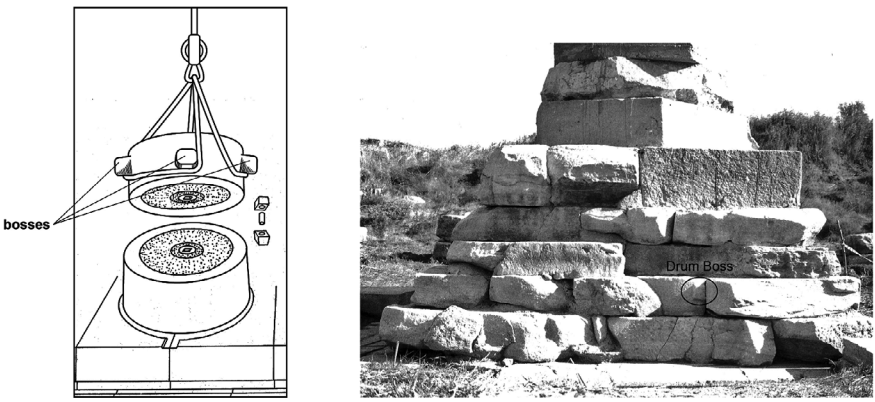


FIGURE 1.6 Left: Illustration of the technique of column-drum installation displaying bosses and using pulleys. Right: An archaic column-drum displaying original boss, built into the later Artemision in Ephesus
IMAGE BY THE AUTHOR

remain immobile, supported with stability by the preceding drum, so also Anaximander's column-drum shaped earth must be equidistant from all extremes to account for its perfect stability and immobility. The reason that it stays motionless at the center, says Aristotle, is that there is no reason for it to move left or right, up or down – an argument by sufficient reason. For Anaximander, and for countless of his compatriots, the earth seems to be at rest; consequently, there must be a reason for it. Indeed, a distinguishing mark of the early philosophers, transforming the background of mythological narratives, is that they regarded a need to discover and supply a natural, causal

reason for everything. The reason for the earth's immobility, then, is that since it remains aloft in the center of the cosmos held up by nothing, there is apparently *no reason* for it to move up or down, right or left. Being in uniformity or equidistance from all extremes is reason enough for the earth to remain there motionlessly, like the architect's technique for securing the column-drum motionless upon installation.[68]

Anaximander was part of a community that included the architects, a point rarely acknowledged and appreciated. While he is credited with writing the first philosophical book in prose, the only other source of prose treatises written contemporaneously and in the same location[69] of whom we know are the architects – Theodorus of the temple of Hera at Samos, and Cherisphron and Metagenes, the architects of the temple of Artemis at Ephesus. Both temples date to the first half of the 6th centuries BCE, contemporaneous with Anaximander.

Thus, Anaximander's cosmos imagined, and perhaps modeled in plan,[70] is analogous to the architect's stylobate. The architect's module is the *One under Many* in temple architecture – column-diameter – the house of the god, the cosmic power. Whether or not the architects consciously imagined column-diameter to be the module not only of column-height but also of all the architectural elements – length and width of the stylobate, column width, column height, intercolumniation, capital, and the entablature with its architrave, frieze, geison, and sima, the evidence will not allow us to argue for this securely. But it is worthy to consider that some decision was made about the relative proportions of the upper order – entablature – to the column height (i.e., 1/6 ?), and the width and length of the stylobate (i.e., 1:2) to column height, and if there was a general guiding rule of proportion for column-diameter to column-height, then all the architectural elements would stand in proportion to column-diameter, whether or not the architects were fully conscious of this. So, as a final point for this case study, let us take a look at a reconstruction of the archaic temple of Artemis at Ephesus. What do you see?

One might answer "steps, stylobate, plinth, column base, column shaft, column capital, architrave, and the upper orders," that is, you might answer "I see many diverse things." But Anaximander might well have come away seeing an

68 Aristotle, *de Caelo* B13, 295b10ff.

69 With the exception of Pherecydes of Syros who is also credited with a prose treatise; but he is a *theologos* not a *philosophos*. For the identification of the earliest architectural treatises, Cf. Vitruvius VII,12.

70 If Anaximander had made a *sphairos* as claimed in the report by Diogenes at DK 12A1.

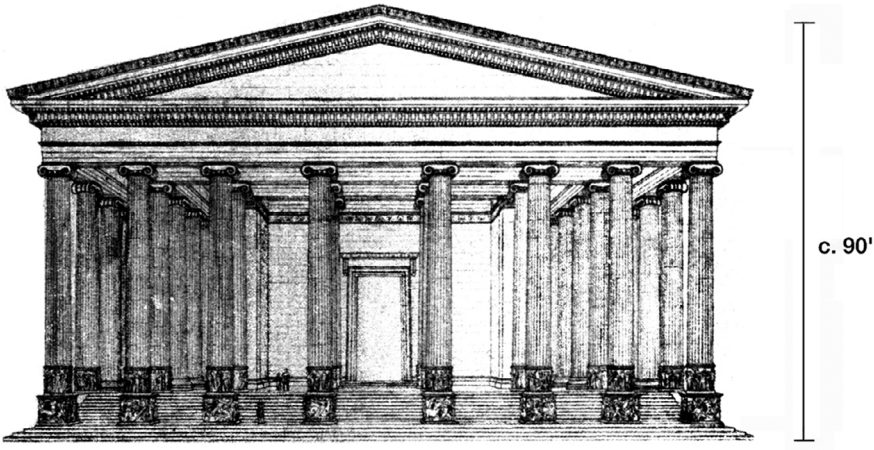


FIGURE 1.7 Possible reconstruction of the archaic Temple of Artemis at Ephesus, *after* the model in the Selçek Museum
IMAGE BY THE AUTHOR

underlying a module – column diameter – hidden inside all these elements – a basic underlying *One under Many* – and all the elements are multiples or submultiples of the module. The apparent diversity of appearances conceals that there is a single underlying unity altered without changing. This is what it means to speak, analogously, of substance monism, that concealed behind all differences in appearances, there is an underlying unity – a module – altered but unchanged – the *apeiron* – as Thales proposed water, Anaximenes, air, and Heraclitus fire. By imagining the house that is our cosmos, Anaximander seems to have adopted the modular technique of the architects; his thinking embraced the view that underlying all appearances is a module, capable of altering and yet itself remaining unchanged and the distance between stars, moon, and sun are all the *same* modular distances of 9 or 9+1.

The key point of contention in debates over interpretating Anaximander's conception is whether all appearances emerge from the ἄπειρον and return back into it, as an underlying unity that always persists – source and substance monism – or whether the ἄπειρον gives rise to a seed [γόνιμον], and from that seed the oppositions separate out or off – hot and cold, wet and dry – and all things return only into the elementary opposites. Does the fragment attest to the ἄπειρον as fulfilling the conditions for source and substance monism?

A recent supporter of the view denying the ἄπειρον that metaphysical role is Graham, who thinks there is no evidence for it in the 6th century.[71] He is joined by other scholars who, for different reasons, deny the central role to the ἄπειρον, that seems, then, to have no metaphysical purpose after giving rise to the seed.[72] But we have already considered that Aristotle identifies the *apeiron* as both the beginning of all things and intermediary between air and water, and placed alongside the other early philosophers who identify water, air, or fire as the underlying substrate.[73] Couprie recently joined the scholars arguing for the primacy of the ἄπειρον, the group to which my translation belongs.[74] But the reason we should see that the ἄπειρον is the originating source of all appearances, and back into the ἄπειρον things return upon destruction, as an underlying unity that always persists, is because re-situated in his technological context, Anaximander was a modular thinker.[75]

3 The Gnomon of Thales and Anaximander: More Evidence for Their Modular Thinking

Anaximander is credited with introducing the gnomon into Greece and set up one on the sundials in Sparta.[76] By means of a gnomon he marked out the

71 Graham 2006, 29–31; the rejection of "material monism" as historically inappropriate, 52–64.

72 For examples, Kahn 1960, Schwabl 1964, perhaps Heidel 1912.

73 Cf. notes 25, 26, and 27 above.

74 Cf. Couprie 1989, 159–199, who agrees with those like Nietzsche, Schmitz, and Gadamer, though in a 2017 study with Kočonderle, he suggested Anaximander's apeiron was really *apeira phusis*, unlimited nature. Stokes 1971, Hölscher 1970, and myself [Hahn 2017a, 192n16] opt for the ἄπειρον reading. But, cf. also, that in a more recent study, Couprie 2017 suggests that Anaximander more likely did not use the phrase τὸ ἄπειρον but rather used this term adjectively as φύσις ἄπειρος – unlimited nature, that is "nature" in some pregnant sense of the word (2017, 47).

75 I am not prepared here to argue that Anaximander was a modular thinker along the same lines as Thales and Anaximenes. Of course, Aristotle does not include him alongside them. But I am arguing here that Anaximander held that from the *apeiron* all appearances come forth, and back into it they return upon dissolution. And if from the *gonimon* the oppositions appear, and from their combinations, diversity manifests, the *apeiron* is still the underlying unity. Moreover, the modular thinking in Anaximander's cosmology may not parallel his metaphysical speculation, but it still seems to reflect modular thinking.

76 Diogenes Laertius II, 1–2 [DK 12A1] εὗρεν δὲ καὶ γνώμονα πρῶτος καὶ ἔστησεν ἐπὶ τῶν σκιοθήρων ἐν Λακεδαίμονι, and *Suda* s.v. γνώμονά τε εἰσήγαγε. For an effort to reconstruct Anaximander's sundial cf. Hahn 2010, Ch.6.

solstices and equinoxes – that is, he marked out the relevant shadow points identifying the beginning of each new season, each and all determined by the gnomon.[77] Thales is credited with using a gnomon to measure the height of a pyramid, both when the shadow was equal to its height and when the shadow was unequal but proportional.[78] These reports assure us that Thales and Anaximander spent time carefully watching shadows and made use of a gnomon and the varying lengths of its shadow to unfold their accounts.

Let us be clear that a gnomon is any vertical rod, whose size is arbitrarily selected, just like column diameter, or the weight of an electrum, gold, or silver *statêr*, and yet by means of and in comparison with it, the heights, dimensions, or values of other things are reckoned.[79] Thus, here again, modular thinking presents an ideal of substance monism: there is an underlying unity – the gnomon – that because it remains substantially unchanged offers insights into all the other things measured or evaluated against it. For both Anaximander and Thales, microcosmic-macrocosmic reasoning is at play; because the little world [i.e., gnomon and its shadow] and big world [vertical objects and their shadows] are imagined to share the same structure – they are *similar* – one can infer things about the big world having access only to the little world. The sundial takes solar events and reduces them to a model, that is, the big world scaled-down; the pyramid's shadow, evaluated against the one cast by the

77 Cf. Diogenes Laertius II, 1–2 [DK 12A1], and Suda s.v. [DK 12A2].

78 Diogenes Laertius I.27 and Pliny *Natural History* XXXVI, 12, 17; Ps-Plutarch, *Epit.* III.10. The passage in Diogenes: "Hieronymous says that he [sc. Thales] even succeeded in measuring the pyramids by observation of the length of their shadow at the moment when our shadows are equal to our own height." [Attributed to Hieronymous, 4th century BCE by Diogenes Laertius, 2nd century CE]. "The report in Pliny is that Thales discovered how to obtain the height of pyramids and all other similar objects, namely, by measuring the shadow of the object at the time when a body and its shadow are equal in length." But the precision of such a measurement could not rely on an approximation of one's own height being equal to the shadow cast; a gnomon would have been necessary along with very careful measurement. The report in Plutarch explicitly supplies the use of a gnomon, and this time is set when the shadow is un-equal but proportional to the height of the object that casts it: "Among other feats of yours, he [Pharaoh Amasis] was particularly pleased with your measurement of the pyramid when, without trouble or the assistance of any instrument, you merely set up a stick at the extremity of the shadow cast by the pyramid and, having thus made two triangles by the impact of the sun's rays, you showed that the pyramid has to the stick the same ratio which the shadow has to the shadow" [Plutarch, in his dialogue with Niloxenus speaking].

79 And we have other contemporaneous examples of modular thinking: the tunnel of Eupalinos on Samos, mid-6th century, is divided into fifty sections each identified by the Milesian letters of numeration painted along the western wall; the module was c. 2.04 meters that does not correspond to any foot or ell measurements we have elsewhere in Greece. Eupalinos invented his own tunnel measure, that is, his own module.

gnomon at the same time, reduces the gigantic pyramid to a *similar* model, a module, and while its height is inaccessible, Thales invents a scale, a type of ladder to mentally ascend to the top: as the shadow length is to the gnomon's height, so the pyramid's shadow length is to the pyramid's height. We should keep in mind that a technique is always an application that is enveloped by a theory.[80]

Since the earliest surviving Greek sundials date to Hellenistic times, the appearance of Anaximander's sundial must remain conjectural. The surviving sundials from the 3rd century BCE are conical or hemispherical in shape,[81] and while this makes sense given the prevailing suppositions that the earth, too, is spherical in shape, it does not make archaic sense for Anaximander who, along with Homer and Hesiod, believed the earth was a flat disk. We have testimony that Anaximander set up a gnomon on the sundials (i.e., σκιόθηρον or shadow catcher) in Sparta.[82] And it is tempting to think how he might have done this. Since both Miletus and Sparta are on almost the same line of latitude (i.e., 37 ° North), the measurements in both places should have been more or less identical. With this understanding, Anaximander plausibly took to Sparta, the gnomon he experimented with in Miletus, along with a few pieces of measured cord, knowing in advance where the shadows would be cast to identify the seasonal markers. And since Anaximander identified the shape and size of the earth with a 3 × 1 column-drum, and is credited with making the first Greek map of the inhabited earth, it is also tempting to imagine the gnomon set up in Sparta at the center of a column-drum, in place of the *empolion*. The shadows cast on the drum-face would be *similar* to the ones cast on the earth itself, the small-world microcosmically similar to the large world, and on this surface the map might also have been inscribed,[83] in addition to a portable *pinax*.[84] Below, left, is a re-drawing of a Neo-Babylonian map of the inhabited earth surrounded by ocean, dating to the Persian period of 600–400 BCE, and then the regions outside the known world indicated;[85] on the right is a possible reconstruction of Anaximander's map with gnomon set in place of the *empolion*:

80 Cf. Serres 1982, 86.

81 Gibbs 1976, 6–7; Cf. also Hahn 2001, 207–211.

82 DK 12A1, from Diogenes Laertius II, 1–2.

83 Cf. Hahn 2010, Ch. 6. Moreover, the report that Anaximander advised the Spartans to move into the fields when an earthquake seemed likely [Cicero, DK 12A5a], makes Anaximander's visit to Sparta all but certain. Cf. also Hahn, 2019b for a different take on the context of Anaximander's sundial.

84 DK 12A6, *apud* Agathemerus and Strabo.

85 Kahn 1960, 83–84.

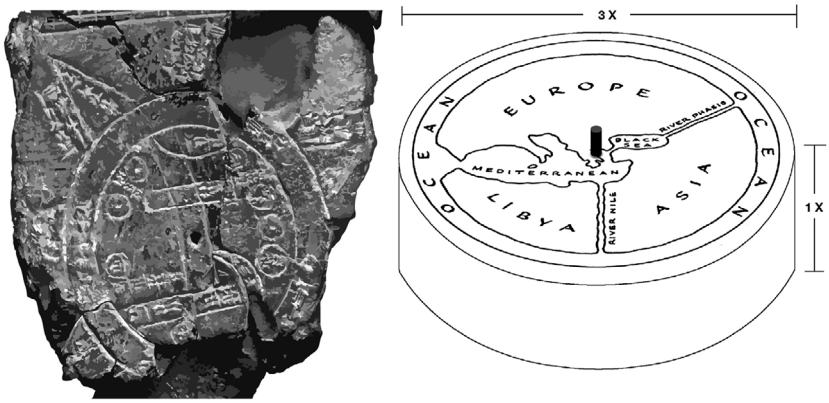


FIGURE 1.8 Left: Rendition of the Neo-Babylonian map of the world dating between the 7th and 6th centuries BCE, after the artifact in the British Museum. Right: Possible reconstruction of Anaximander's tripartite map. Both have "ocean" running around the circumference
IMAGE BY THE AUTHOR

While it must remain speculation whether the sundial, map, and model were all parts of one thing, what seems very clear is that the seasonal sundial reveals time-tested experience in observing and interpreting shadows. Such experience only strengthens the plausibility that Thales measured the height of a pyramid by its shadows.

Metaphysically speaking, the idea of "substance monism" defies commonsense. Our experience is of a world of multiplicity; the embrace of substance monism, however, affirms that there really is no multiplicity but only a single underlying unity capable of appearing diversely. The world of diverse appearances consists in modifications of an unchanging unity that underlies, hence the earliest philosophers searched for a *One under Many*. To think of it as modular thinking is also to think of "module" as "model." In measuring pyramid height, the shadow cast by the gnomon forms a model; the model reveals the shadow and the object that casts it, and invites us to think about the world as illusory, for while the shadow is not the object but a projection of the object, it holds a clue to the gnomon, the standard that casts it. Let us consider Thales' measurement of the pyramid to show that the gnomon and its shadow offers more evidence of the embrace of modular thinking; a thorough study of the gnomon and the sundial can be found elsewhere.[86]

We have the testimony that Thales measured the height of a pyramid when its shadow was equal to its height, and when un-equal but proportional. On

86 Cf. Hahn 2010, Ch. 6, and Hahn 2019b.

several occasions my students and I performed the measurement on the Giza plateau and discovered important things that Thales must have realized when he tried the same kind of measurement. The first photo made in May 2013, the second in May 2018, sun due east, and we are on the western side of the middle pyramid of Kha-ef-Re (i.e., Chefren).



FIGURE 1.9 Measuring the height of a Giza pyramid when shadow = pyramid height. Notice the gnomon's set up both at the end of the shadow, and to the side, May 2013
PHOTO BY THE AUTHOR



FIGURE 1.10 Measuring the height of a Giza pyramid when shadow = pyramid height, May 2018
PHOTO BY THE AUTHOR

More than one of my professors, many years ago, suggested that there was nothing particularly scientific about Thales' measurement when "shadow = height"; Thales simply observed that there was a time of day when everyone's shadow was equal to their own height and measured the pyramid's shadow then. The measurement almost certainly could not have happened this way. First of all, Thales had to imagine the measurement of an isosceles right triangle, by means of a gnomon that confirmed the time was right for "height = shadow length," and so the measurement had to be made through reasoning about similar triangles, specifically that the little world of gnomon and its shadow shared the very same structure as the inaccessible pyramid height and its shadow.

To be precise, he needed a gnomon with a very sharp point, and likely made a circle with the use of a piece of cord equal to the gnomon height, and using the gnomon height as radius of a circle, scratched out a circle in the surrounding sand, with the gnomon at the center, or on a platform of limestone or granite prepared in advance and set carefully near to the pyramid's shadow or even at the very end of the pyramid's shadow.[87] When the shadow cast by the tip

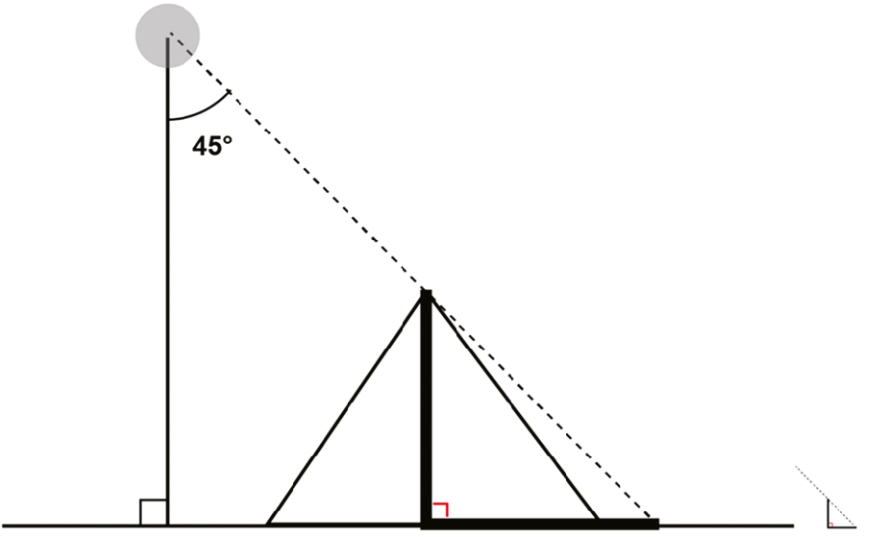


FIGURE 1.11 Pyramid measurement when shadow equals height
IMAGE BY THE AUTHOR

87 This technique was how Anaximander may well have made his sundial placing a gnomon in the center of a column drum, or mounted on a stone surface with its radius marking out a circle etched into the stone. Cf. Hahn 2010, chapter 6.

of the gnomon touched the circle then the time was right for the measurement (i.e., for then the shadow was equal to the gnomon's height). Thales was then in a position to realize that the sun had to be ½ right angle of inclination, or what we today call 45 °, because only when the sun is at half a right angle is the shadow equal to the height, and this means that the two legs of the isosceles triangle are equal in length, one of the geometrical propositions attributed to Thales.[88] But, since the pyramid conceals most of the shadow, which is the case when "vertical height = shadow length," how do we measure the shadow *under* the pyramid? Since the pyramid is aligned almost perfectly to cardinal directions, and the base is square, the only way to determine precisely the amount of shadow under the pyramid is to make the measurement when the shadow projects perpendicular to the edge of the pyramid. For then one can reason that the distance from the center of the pyramid to its edge [concealed under the pyramid] is ½ the length of any side since the base is square, and this distance can be added to the measurable, projected shadow to deliver an accurate measurement of the pyramid's shadow, and hence its height. If the shadow projects at an angle that is not perpendicular to the edge, trigonometry would be required to "correct" the angle, to precisely "straighten it out," which the Greeks at that time did not have. For the successful measurement, then, the sun must be "due" south, east, or west [it is never due north in the northern hemisphere] and also at ½ right angle. Surprisingly, this happens only 4 days a year,[89] and by "today's 2020 calendar,"[90] two days a year when the sun is due east and west on the same day, 23 May and 19 July, and

88 The preliminary key to this measurement was that Thales knew there were two right angles in every triangle, that the angles of every triangle summed to two right angles, and since the measurement of pyramid height created a vertical axis that was at right angles to its shadow, when the pyramid's shadow = pyramid height, the other two angles of the triangle were each equal to ½ right angle. And of course, the angles of the gnomon and its shadow at the same time were the same. This is what it means to say that the triangles were *similar*. We have the testimony of Geminus – preserved in *Eutocius' Commentary on Apollonius' Conica* (*Commentria Antiqua*, 170, ὥσπερ οὖω τῶν ἀρχαίων ἐπὶ ένος ἑκάστου εἴδους τριγώνου θηωρησάντων τὰς δύο ὀρθὰς πρότερον ἐν τῷ ἰσοπλεύρῳ καὶ πάλιν ἐν τῷ ἰσοκελεῖ καὶ ὕστερον ἐν τῷ σκαληνῷ) that while the Pythagoreans proved there that the angles of every triangle summed to two right angles, the ancient ones, who could only be Thales or a member of his generation, "theorized" how there were two right angles in every species of triangles, equilateral, isosceles, and scalene. For the details of how this plausibly took place, Cf. Hahn 2017a, 11, and also 169–170. But, regardless of how Thales and his contemporaries reached the conclusion that the angles of every species of triangles summed to two right angles, he knew that to be the case.

89 Cf. Hahn 2017a, 103.

90 By "today's calendar" I mean 2020. Due to precession of the equinoxes, these solar events would have taken place at different times.

two days a year when the sun is due south, 1 November and 9 February when due south. The measurements due east and west have a very short window of time, about five minutes, and the measurements due south only slightly longer, about twenty minutes.

Had Thales made the measurement when shadow length equals vertical height, he must have made a solar calendar, otherwise he would not have known when these circumstances would likely come together to make that measurement. To think that Thales just went to the Giza plateau any day, waited for the gnomon's shadow to be equal to its height – which cannot be done, in any case, from mid-October through early February since the altitude of the local noon sun does not even reach 45 ° – and made the measurement then, shows only that one does not understand the dynamics and complexity of this measurement – a technique is always an application enveloped by a theory. That Thales made a solar calendar fits seamlessly in the context of Anaximander's seasonal sundial. Thales is credited with a book called *On the Solstices and Equinoxes*,[91] and whether Thales wrote it or not, this measurement when "pyramid height = shadow length" suggests just the kind of knowledge that Thales would have needed – a solar calendar – in order to know when to come to the Giza plateau to make this measurement because on only four days in the entire year is the sun both at half a right angle and due east, west, or south. Only then could the shadow length, projecting perpendicular to the side of the face of the pyramid, be measured accurately by means of the royal cubit cord that the surveyors carried,[92] and added to it, the length of ½ side of the pyramid base.

Thales is also credited with measuring pyramid height when it was un-equal but proportional to a gnomon's height/shadow, and once again, if we allow ourselves to imagine the diagram that plausibly burgeoned in Thales' mind, it involves *right-angled similar triangles*. This measurement could be achieved most of the days of the year at "local noon," when the sun crosses the meridian, or stated differently, is "due south" at the moment when the sun is highest in the sky on any given day and casts the shortest shadow from a vertical gnomon. It could not have been done close to the summer solstice when the sun was highest in the sky in Giza, for then the shadow cast at local noon (= due south) did not escape the face of the pyramid, and so could not have been measured.

91 Cf. Hahn 2017a, 92–3; cf. also Burkert 1972, 416ff.

92 Cf. Hahn 2017a, 102–104.

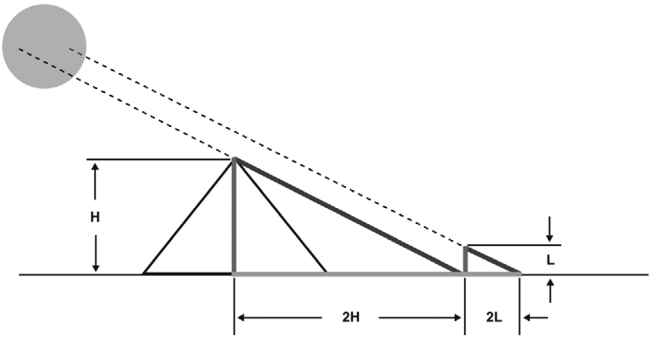


FIGURE 1.12 Pyramid measurement when shadow is not equal to height
IMAGE BY THE AUTHOR

In summary, by the use of the gnomon both Thales and Anaximander showed they made use of modular techniques, and *a fortiori*, were modular thinkers. The gnomon presents an underlying module, and together with its shadow, a model, by means of which all the other things – heights and seasons – can be measured.

4 Coinage and the Monetization of Miletus: a Further Argument for Substance Monism

In his important study, *Money and the Early Greek Mind*, Richard Seaford argues that the Milesian embrace of coinage played a pivotal role in accounting for the origins of Greek philosophy. Coinage, and more broadly the monetization of society in Miletus and the environs of Lydia, supplies yet another case of historically-appropriate evidence for modular thinking, and hence substance monism, contemporaneous with the origins of philosophy.[93] For Seaford, the invention of money introduces the counter-intuitive idea of a single substance underlying the plurality of things manifest to the senses. Since all empirical observations point to the multiplicity of phenomena, not monism [that he refers to as "neutral monism" that he attributes to the Milesians], we must look

93 Seaford 2004; see also Seaford's chapter elsewhere in this volume. Seaford proposes that the invention of coinage, and its embrace, provided a *sufficient* condition to account for the origins of Greek philosophy. I am not prepared to argue this strong case but at all events am persuaded by how the wide dissemination of coinage in Miletus plausibly contributed to Thales', Anaximander's, and Anaximenes' embrace of substance monism.

for the origins of monistic thinking elsewhere. Since money as a standard of measure provides an exchange value for all things, it can, in a metaphorical sense, become all things. Money has special features that lend themselves to thinking monistically: it is both abstract and concrete, homogenous, impersonal, displays universal aim and universal means, is unlimited, and unifies opposites; within a monetized society, money becomes the source and substance of everything. Thus, Seaford's conclusion is that the monetization of society in the widespread dissemination of coinage transforms the social mentality: all concrete objects now appear as manifestations of abstract, exchange value. Everything is at bottom the same homogenous substance, though they have various and different appearances; everything comes from that same source because everything is exchanged for that source (i.e., a vase is bought for money and later sold for money). We might consider it this way: monetary value can appear in the forms of chairs, lamps, boats, land, and so on.

Aristotle identifies Heraclitus among the earliest philosophers and claims he held "fire," not water or air, as the material substrate. As Heraclitus said: "All things are an interchange for fire, and fire for all things; just as goods for gold and gold for goods." [πυρός τε ἀνταμοιβὴ τὰ πάντα καὶ πῦρ ἁπάντων ὅκωσπερ χρυσοῦ χρήματα καὶ χρημάτων χρυσός].[94] Here Heraclitus brings together both the themes of substance monism and money, as exhibiting modular thinking. All things are "gold" but as multiples or submultiples of a basic unit, the *statêr* – electrum, gold, or silver. The part of Seaford's argument that I wish to emphasize is that his case for the monetization of society in 6th century Miletus (and following, in the Greek world) provided evidence for the mentality of modular thinking/substance monism, and consequently, contra Graham, is historically appropriate.

The invention of coinage, however, is not quite the same as the monetization of society for it might be argued that there were Greek traditions long before the 6th century where iron and bronze bars were traded, and other things for sale or trade were reckoned in terms of these metal bars. In Hilbert's new study, the picture that forms is that electrum coinage in Miletus was minted over a period of about 70 years, from around 600 to 530 BCE.[95] This dating is based on the number of dies for the three minting periods. By counting the *statêr's* obverse dies, we get an idea of the relative length of the three minting periods. For absolute dating, the end of high-volume coining "period 2" is equated with the demise of the Lydian Empire, *c.*564–546 BCE. From this fixed point we can calculate a date for the beginning and ending of the minting period.

94 DK 22B90.

95 Hilbert 2018, 151.

Apart from the dating based on die counts, an indirect linkage with the rare Lydian electrum coins suggests a start of the lion-type series around 600 BCE. The end of the Milesian electrum coinage probably was in the second half of the 530's. At this time, a rich silver coinage had been established already for at least twenty years[96] … and so datable to at least the mid-550's.

According to Hilbert, then, in Miletus, the first of the three minting periods began with electrum from 600–530, then mass production of silver coinage from 565–546, and then a third, much smaller minting after the fall of Kroisos in the Lydian defeat by the Persians. In the first period of minting, all denominations from the full *statêr* (approximately 14 grams) down to forty-eighth and ninety-sixth fraction of a *statêr* are present. The forty-eighth *statêr* weighed approximately .29 grams, and the ninety-sixth *statêr* (the smallest size is known as *tetartemorion*) weighed a mere .15 grams.

By Hilbert's rough estimate, the volume of electrum coinage from 600–530 could have amounted to a value between 900 and 1300 talents (roughly 30,000–40,000 kilos of silver). Since a *statêr* weighed approximately 14 grams, we can imagine how many hundreds of thousands of coins were produced from electrum alone (not including silver). Imagine how many of these coins could be produced from more than 30,000 kilos of metal! How many tiny pieces of metal jingled in the purses of the Milesian citizens, as they engaged in trade and commerce by means of coins, or how easy it might be to carry them in one's mouth as suggested (perhaps sarcastically?) by Aristophanes in the *Birds*?[97]



FIGURE 1.13 Left: An electrum *statêr* of Miletus ca. 600–550 BCE. Right: Electrum 1/12 *statêr* (0.52 g), about 600–550 BCE. Obverse: lion's head facing. Reverse: square incuse punch
PHOTO BY THE AUTHOR

96 Hilbert 2018, 151–152.

97 Aristophanes, *Birds* 503ff; cf also *Wasps*, 790–791. Philocleon puts fish scales into his mouth, thinking they are coins. When he goes home with his jury pay under his tongue, his daughter (lines 608–9) manages to get it away from him with a welcoming kiss! Euelpides (*The Birds*, 503) swallows an obol when he is startled.

How the mentality of the Milesians must have been transformed who lived in the first half of the 6th century in comparison to that of their grandfathers, and the generations before them? Hilbert claims that after a rather long and constant first minting period, the output expanded sharply in the second period, before dropping even below the initial level in the third period. The remarkable rise in coin emissions in the years between 565 and 546 BCE may be explained by high Milesian contributions to the military preparations of King Kroisos of Lydia for his war against Persia. Robust circulation of coins both before 565 and immediately after coincides exactly with the time-frame of the building of the first monumental stone temples in Samos, Miletus, and Ephesus; coinage could surely have facilitated the financial aspects of these extraordinary building projects, where the key to the success was also a modular technique.

If we accept Aristotle's report in the *Politics*[98] that Thales made a meteorological prediction of a bumper crop for the upcoming olive season, and bought out the olive presses in Miletus and Chios whose monopoly he now controlled, and rented them out making a neat profit, then surely along with barter and trade, Thales received in payments a hoard of *statêrs* issued from the Milesian and Ionian mints. Thales was surely aware of the transformative effect of coinage, and how a fortune could be evaluated in terms of the abstract

Lydo-Milesian
(before 494 BCE)

statêr	14.10 g
1/2 statêr	7.05 g
1/3 statêr (*trite*)	4.70 g
1/6 statêr (*hekte*)	2.35 g
1/12 statêr (*hemihekte*)	1.18 g
1/24 statêr	0.59 g
1/48 statêr	0.29 g
1/96 statêr	0.15 g

The Archaic Milesian Electrum Series, about 600 – 550 B.C.

Denomination	Weight	Obverse	Reverse
statêr	14.10 g	lion regardant	three punches (usually a square quincunx, an oblong running fox, and a square stag's head or four-dot geometric pattern)
1/3 statêr *trite* or "third"	4.70 g	lion regardant	two punches (usually a square quincunx and a square punch or four-dot geometric pattern)
1/6 statêr *hekte* or "sixth"	2.35 g	lion regardant	two punches (usually a square quincunx and a square punch)
1/12 statêr *hemihekte* or "half-sixth"	1.18 g	lion's head in profile	square quincunx or square geometric pattern
1/24 statêr	0.59 g	lion's head facing	square punch

FIGURE 1.14 Comparative lists of 6th century BCE *statêrs* and sub-multiples

98 Aristotle, *Politics*, 1259aff.

value of Milesian *statêrs*. Consider the tables above for an overview of coinage in archaic Miletus.[99]

To show the comparative sizes, below, on the far left we have a Lydian *statêr* or double-siglos (approx. 19mm across and approx. 14 grams), then second from left, a Lydian ½ *statêr* or siglos (approx. 7 grams), then a Milesian 1/12th *statêr* or obol (approx. 1.18 grams), and finally to the far right, a Milesian *tetartemorion* or 1/96th *statêr* or ¼ obol, 5.1mm across and .15 grams.[100]



FIGURE 1.15 For comparative sizes, Lydian *statêr* and half- *statêr*, and Milesian 1/12th *statêr* and Milesian 1/96th *statêr*
PHOTO BY THE AUTHOR

While the pieces of metal were material, they represented an abstract value in terms of which the value of other things were estimated. Moreover, coinage displayed the idea of a basic, underlying, standard unit – a *One under Many* – and other denominations were reckoned as submultiples of the standard unit; we could refer to them as modifications or alterations of the "*statêr*" since the basic standard permeates their value, and it is by means of a reference to the standard that the smaller coins acquire their value. This is a display of the ideal of substance monism. Just as the Ionic architects identified a module – column diameter – and perhaps reckoned all the other architectural elements as multiples or submultiples of the module, so also did the early coin-makers in Miletus (and elsewhere in Ionia), *ceteris paribus*.

99 While O'Hara is a generalist in comparison with those like Hilbert, he is able to provide a broad, general overview that addresses our inquiry in O'Hara 2022.

100 Photo by the author who owns the coins.

5 Substance Monism Without Substantial Change: Anaximenes' ἀήρ and the Felting of Wool

Aristotle and Theophrastus identify the earliest philosophers as positing one corporeal ἀρχή from which all existing things emerge [source monism] and into which they perish; since this ἀρχή is always preserved as a material substratum of the world, Aristotle declares that these monists think that nothing either comes into being or perishes [substance monism] – there is no substantial change, only alterations of the substrate. Graham, for example, argues that Anaximenes, like Anaximander before him, maintained what he called a "Generating Substance Theory;" that theory held that while there was a single source from which all existing things emerge – ἀήρ – when ἀήρ gives rise to a successor state, say wind or cloud or rain, the original perished, and there was no ultimate return to the original state. He insists upon this interpretation because he regards that "substance monism" [that he labels "material monism"] is historically inappropriate. But we have just seen in an investigation of Anaximander and the architects, and Anaximander, Thales, and the gnomon, and Heraclitus and coinage, how they adopted modular thinking, that is, the principle of substance monism, accepting an underlying substrate that always persists.

Moreover, Graham is mistaken when he denies evidence for Anaximenes as positing a single underlying substrate, as Zhmud emphasized in his critical review of Graham.[101] Theophrastus states explicitly that Anaximenes held that there was a single underlying substrate, and apparent differences are due to rarefaction and condensation: Ἀναξιμένες … μίαν μὲν καὶ αὐτὸς τὴν ὑποκειμένην φύσιν καὶ ἄπειρόν φησιν…. διαφέρειν δὲ μανότητι καὶ πυκνότητι κατὰ τὰς οὐσίας.[102] And Theophrastus is our principal source for the Presocratics. Moreover, Anaximenes claimed, according to Theophrastus (*ap*. Simplicius),[103] Aetius,[104]

101 Zhmud, 2007.

102 Theophrastus DK 13A5, preserved by Simplicius, *Physics* 24, 26.

103 Theophrastus (*ap*. Simplicius) *Physics* 24, 26, DK 13A5: Anaximenes held that when air becomes finer it transforms into fire; being condensed it transforms into wind, cloud, water, earth, stones. Moreover, on the authority of Theophrastus, and contra Graham who insists that there is no testimony that explicitly identifies Anaximenes ἀήρ with underlying substrate, Anaximenes held that μίαν μὲν καί αὐτὸς ὑποκειμένην φύσιν. Here is explicit testimony that identifies Anaximenes with "Substance Monism."

104 Aetius DK 13A17.

Hippolytus,[105] and Pseudo-Plutarch,[106] that cosmic transformations of appearances were affected by rarefaction [ἀραίωσις] and compression [πυκνώσις], processes that he illuminates by analogy with the felting of wool. For Anaximenes claimed that when ἀήρ becomes more rarefied, it becomes fire, but when it *felts* more and more it becomes wind, cloud, rain, rivers and streams, earth, and finally stone. If we could find craftsmen still producing felt in the traditional way, and watched (and photographed) the process, would we come away persuaded that Aristotle, or Graham, had it right? Let us be clear that what is being proposed is an argument by *ethnographic analogy*, a technique routinely engaged by archaeologists and anthropologists when techniques of old are still practiced today. This means, that as an exercise in experimental archaeology, we are witnessing the very same process *ceteris paribus* that Anaximenes and his compatriots witnessed. It would be as if you and I were standing next to Anaximenes – the Anaximenes whose belief system we know from the doxographical tradition – and since Anaximenes seemed to regard this appeal to πίλησις as clarifying his idea of cosmic transformations, would the process and product lend themselves to an interpretation of Substance Monism or rather the Generating Substance Theory? Let us, then, now turn to consider industrial textile production: how were felts made?

On the west coast of Turkey in the town of Tire, not far from the ancient towns of Miletus and Ephesus, Mr. Arif Coen and his father were still producing felt in the traditional way, and graciously allowed me to photograph the process. We have felts made in the same region preserved from the 5th century BCE in Pazyryk, and also ones from Gordion,[107] even earlier, dating to the 7th century BCE (see below Figure 1.16).[108]

All the surviving examples suggest they were made in the same way as the modern-day felters who I photographed. Here is what one can witness:

105 Hippolytus DK 13A7: When ἀήρ is most even, it is invisible, but it is revealed by the cold and the hot and the wet, and movement. It is always moving for everything that changes would not change unless it was moving. When it becomes finer, ἀήρ becomes fire, being condensed it transforms into wind. *Clouds and water result when* ἀήρ ***felts*** *more and more*: Κατὰ τὴν πίλησιν.

106 Ps-Plutarch DK 13B1.

107 Cf. Barber 1991, 218ff. For a discussion "felting" in the context of Heraclitus see Hahn 2017b.

108 The sequence of figures from Fig. 1.16 through Fig 1.26 were already published in Hahn 2017b.



FIGURE 1.16 Surviving examples of felts. Left: Pazyryk 5th century BCE. Right: Gordion 7th century BCE
PHOTO BY THE AUTHOR

The first step is to shear sheep and then clean the wool, removing dirt and other debris from the wool:



FIGURE 1.17 First the wool is cleaned by hand, and then washed
PHOTO BY THE AUTHOR

Next, by thin pieces of string or rope, reeds collected from the banks of the Meander River are tied together making a mat. The production of felt requires an *underlying* mat.



FIGURE 1.18
Then, a mat of reeds from the Meander River is rolled out – the Substrate
PHOTO BY THE AUTHOR

On this mat some dyed wool is placed creating a design. Of course, the felt could be made without a design.

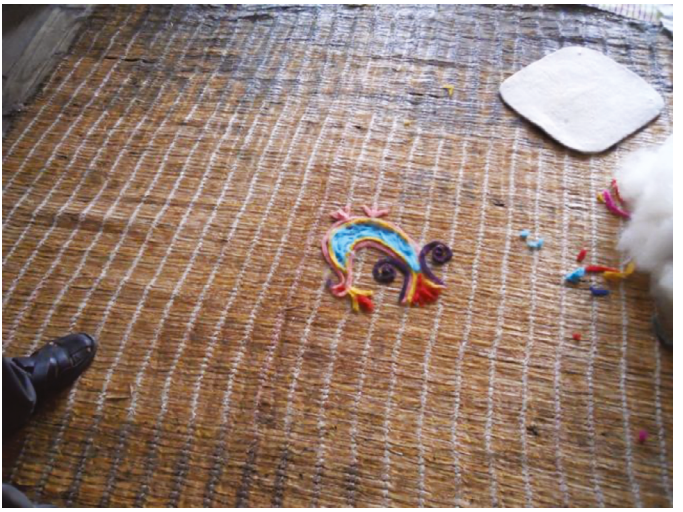


FIGURE 1.19
If a design is intended, the colored wool is arranged on the mat
PHOTO BY THE AUTHOR

Then, the white, cleaned sheep wool is heaped upon this design. Watching this part of the process, the imagery is immediately suggestive of a cloud.



FIGURE 1.20
Then, wool is heaped upon and over the design below
PHOTO BY THE AUTHOR

The next step is to moisten the wool, and here we watched Mr. Arik whisk water from a vessel. The image, too, was striking because here was the rain that Anaximenes' spoke of as the next stage of transformation, from cloud to rain.



FIGURE 1.21
Next, water is sprinkled on the wool, moistening it
PHOTO BY THE AUTHOR

The next step is to roll up the mat and tightly compress the wool.



FIGURE 1.22
Then, the mat is rolled up tightly
PHOTO BY THE AUTHOR

After this step, the felters work in tandem compressing the mat with their feet as they roll the mat from one side of the shop to the other. The imagery was at once suggestive of a festive dance!



FIGURE 1.23
The felters roll the mat from one side of the room to the other, compressing it as they go
PHOTO BY THE AUTHOR

Finally, the felt is produced after about 15 minutes of compressed rolling.



FIGURE 1.24
After about 15 minutes, the felt is complete
PHOTO BY THE AUTHOR

Notice, again, the cloud (below, left), and the water raining down on the wool (below, right). The analogy with the felting of wool picks up explicitly on stages of compression.



FIGURE 1.25
Focusing on two steps, piling on the wool creates an unmistakable image of a cloud
PHOTO BY THE AUTHOR



FIGURE 1.26
The felter sprinkles water on the wool introducing the imagery of rain
PHOTO BY THE AUTHOR

And now comes the pivotal question: when we finish watching this process, and see the resulting compressed felted wool, what did Anaximenes and his compatriots, who were surely his audience, plausibly believe they saw? Did they believe that the felt was something new, a genuine coming-to-be in which the original materials perished in the process? Or did they believe it was the same materials, cloud-like wool, rain-sprinkled water, rolled, transformed into a new appearance – altered *by compression* without changing substantially – in the process? After watching this exercise in experimental archaeology, an argument by ethnographic analogy, it seems clear that the key element in this analogy was "compression" [πίλησις] – rarefaction and condensation/compression. It is compression that permits a single underlying unity to appear divergently, modified, altered without changing substantially. Finally, we have a passage preserved by Simplicius that makes just this point: "And those who supposed that the principle is one and in motion, such as Thales [23.22–3] and Anaximenes [24.26] make creation happen by rarefaction and compression."[109] Thus, transformations of appearances are not simply "cloud to rain" but a richly complex combination of ingredients, each combination contributing to the other's complex appearance. The only thing that distinguishes one form from the other was *compression*. The doxographical evidence for Anaximenes reveals how qualitative change – alterations of appearances – result analogously from πίλησις, the felting of wool, a term that developed to mean "compression" in general.[110] Here, then, we have another illustration of what is historically appropriate, a point that escaped Graham's notice, that shows how modular thinking – Substance Monism – was the very technological context underlying Anaximenes' metaphysics. A technique is always an application enveloped by a theory.

6 Conclusions

These four case studies – architectural technologies, gnomon, the invention of coinage, and industrial textiles – each offer arguments, datable to the 6th century BCE Ionia, that display "Modular Thinking," that is, the mentality of

109 Simplicius, *Physics* 180.14. Cf. also *Physics* 149.34–150.3: "Theophrastus mentions rarefaction and condensation only in the case of Anaximenes, but it is clear that the others too … made use of rarity and density…."

110 Cf. D. Demetrakou 1953 and the chapters elsewhere in this volume by Fanfani and Harlizius-Klück, and Gregory.

"Substance Monism": there is a unity that persists, underlying multiplicity, capable of altering but remaining substantially unchanged. Taken separately, and even more persuasively take together, they help us to see that Aristotle's report about the earliest philosophers – Thales, Anaximander, Anaximenes, Heraclitus – is historically appropriate. At the same time, and in the same location, the architects and builders worked with a single unity – column diameter – underlying the divergent sizes of the other architectural elements, altered without changing. The gnomon offered an unchanging standard against which, by varying shadow lengths tied inextricably to the gnomon's underlying unity, heights and seasonal-markers could be measured. The monetization of Greek society, specifically in the embrace of coinage, provided the whole culture with an underlying unit of valuation – a *statêr* – against which all other valuations could be reckoned as multiples or submultiples of it. Monetization reveals that everything is at bottom the same homogenous substance, though they have various and different appearances; everything comes from that same source because everything is exchanged for that source. And finally, the analogy illuminating cosmic transformations in appearances by appeal to the felting of wool showed not the structure but rather the process of how this underlying unity – ἀήρ – could alter without changing. All appearances were the same underlying thing, distinguished principally by compression; nature provides a process of varying levels of compression.

According to Aristotle's report, the earliest philosophers posited an underlying unity – a module – that persisted despite the appearance of multiplicity and change. This was their original contribution to metaphysical speculation – it was an innovative *inference*. It is tempting to suppose that their inference sprang from their perceptions of modular techniques in architecture, the use of the gnomon, coinage, the felting of wool, and perhaps also, as other new studies suggest, in weaving and shipbuilding. All around Ionia in the 6th century BCE were exemplars of modular techniques. A technique is always an application that is enveloped by a theory.

Any doubts raised that the Greeks of the 6th century were not able to imagine the cosmos as having a single underlying unity capable of altering without changing – that Graham insisted was historically inappropriate – must come to terms with these examples, and doubtlessly others, that show a familiarity and commitment to the ideal of substance monism. By virtue of these arguments, it seems persuasive that Aristotle's report got the origins of philosophy right.

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CHAPTER 2

Placing the Ionian *Περὶ φύσεως ἱστορία* in Context

The Role of Sea Trade, Colonization, Navigation, and Analogies from Manufacturing Crafts (Τέχναι) *in the Birth of Greek Science*

Andrei Lebedev

1 Sea Trade, Colonization, and a New Technological Approach to Nature

Aristotle, in book *Alpha* of his *Metaphysics*, placed the doctrines of the first Ionian thinkers in a completely alien metaphysical context of the academic problems of 'first principles' (ἀρχαί) in Athens in the 4th century BCE. Aprioristic speculative metaphysics was created by the Pythagoreans and Eleatics in the late 6th and early 5th centuries BCE in the Greek West in Magna Graecia, perhaps as a rejection of Ionian naturalism and empiricism. Due to the enormous historical influence of the Aristotelian scheme on the historiography of ancient philosophy (all preceding Aristotle history of thought as a process of gradual discovery of his own four principles or causes of being) it is often repeated in secondary literature after Aristotle that most of the first philosophers recognized only 'material' principles, such as water of Thales, air Anaximenes, and the mysterious 'apeiron' Anaximander. In fact, the philosophical use of the ancient word 'beginning' (ἀρχή) in the metaphysical sense of 'first principle' was introduced into philosophy by the Pythagorean Philolaus in the context of Pythagorean mathematical metaphysics at the time of Socrates.[1]

For Anaximander, as for all the Milesians and all later philosophers of the Ionian tradition (Anaxagoras, Democritus, atomists, Epicurus), the fundamental and key scientific concept was 'nature' (φύσις), not 'arche'. It was this fundamental new concept that lies at the core of the scientific revolution in Miletus of the 6th century: a single word *physis* replaced dozens of names of

1 Philolaus DK B6, two 'unsimilar' ἀρχαί refers primarily to πέρας καὶ ἄπειρον of the Pythagorean Table of opposites, which Aristotle attributes to Pythagoras himself: see Lebedev 2017[3], 242–45. Even if Anaximander used once the term ἀρχή (DK 1,83,3), he used it in non-technical sense as a predicate of φύσις ἄπειρος.

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anthropomorphic gods and divine beings in the mythopoetic cosmogonies of Hesiod and other poets-theologians (as Aristotle called them).[2] The Milesians accomplished a scientific revolution, creating an evolutionary history of the cosmos and an empirical, observational science of nature, in which there was no place for anthropomorphic mythological gods. In this new Ionian science naturalism and evolutionism were combined with analogical method and inferential proofs (τεκμαίρεσθαι, τεκμήρια). Starting with Xenophanes of Colophon, who popularized the Milesian science of nature in his poems, the gods of popular faith were explained away as poetic fiction, as personifications of natural phenomena. Heraclitus (*c.*490 BCE) in the third chapter of his treatise 'On Nature' ('Discourse on gods') advanced a systematic allegorical interpretation of the Homeric gods (later adopted by the Stoics), based on etymology. In this chapter Zeus was identified with the cosmos and the cosmic 'ever-living fire', Apollo with the sun, Hades with the sublunary air, etc. At the same time, Heraclitus criticized the Milesian naturalism and undertook the deconstruction of polytheistic mythology only to propose a new doctrine of pantheistic monotheism.

The terms 'philosopher' and 'philosophy' as designations of a certain profession and a certain way of life arose later in the school of Pythagoras in the Greek West, and in Athens it became generally accepted only in the first half of the 4th century BCE thanks to Plato and the Academy. The words φιλόσοφος, φιλοσοφία as such were not unknown in the language of Athenians in the fifth century, but they denoted, like many other compounds with φιλο-, a type of character rather than a certain profession, something like intellectual curiosity and pursuit of knowledge.[3] The first Ionian thinkers called their occupation

2 For recent discussions of the topic of *physis* see Naddaf 2005; Hadot 2006; Macé 2013 and 2017; Heinemann 2021 and collective research project '*Physis kai phyta*', see note 10 below.

3 Contra Moore 2020. The hypercritical denial of the ancient tradition by Jaeger 1928 and Burkert 1960 has been persuasively criticized in recent decades, among others, by Gottschalk 1980, 23–36) and Riedweg 2012. However, *pace* Riedweg, we do not believe that Pythagoras 'coined' the words φιλόσοφος – φιλοσοφία as such. Like dozens of similar composita with the first element φιλο- , these words were 'coined' by the Greek language itself. Instances of the pre-philosophical, non-technical use in the sense of 'curiosity, love of knowledge' have been preserved, e.g., in Herodotus and Thucydides. Pythagoras was the first to invest them with a new meaning and to make them terms for profession and a way of life. The hypothesis of the original pejorative ironical meaning proposed by Moore 2020: 37 ff. is utterly implausible. Such usage was marginal. Pericles in his speech would have never used φιλοσοφοῦμεν in an ironical sense in his praise of Athenians. Heraclitus fr. 133Leb/B35 DK is alone sufficient to refute Moore's thesis. This fragment comes not from the epistemological proem in chapter 1 and has nothing to do with the criticism of *polymathia*. Most probably, it comes from the

not 'love of wisdom', but 'enquiry into nature' (ἡ περὶ φύσεως ἱστορία). The Greek word *historia* took on the special meaning of 'study of the past' only by the time of Aristotle in the 4th century. In the early Ionian use it was associated not with working in the library and studying written sources, but with traveling and collecting information for cognitive or practical purposes. Democritus, the direct scientific heir of the Milesians (and not of the Eleatics, contrary to the widespread misconception), in his autobiographical fragment XIV Luria (B299 DK) retained this early usage, saying that he surpassed all his contemporaries in the number of 'climates and lands', which he visited during his travels, 'conducting research' (ἱστορέων).[4] Thus, in contrast to the Western Italian 'love of wisdom', which was originally a life-building philosophy as a way of life, religiously and ethically based, the Eastern Ionian 'exploration of nature' was a dispassionate objective scientific study of the natural world. Aristotle, who looked at the Ionians through the eyes of a Platonist, misrepresented them in the Alpha of *Metaphysics* as primitive 'materialists' who had not yet discovered the moving cause (that is, God), the Platonic forms or the Socratic dialectical ethics. The Ionian natural history did not set itself such tasks. To reproach the Milesians for this – as Aristotle and some modern researchers who operate with a false category of 'Presocratics' do – is like reproaching a first-class geographer for not touching on the problems of happiness and the goal of human life in a geographical atlas. The genre of the Milesian treatise *On Nature* itself excluded anthropological or ethical issues. The first (and only) early Ionian thinker who connected cosmology with ethics, politics and theology, and also made 'nature' (understood theologically and teleologically) into a moral standard, was Heraclitus, but his poetic cosmology has nothing to do with natural science: essentially it is a theory of natural law, a political parable about the ideal monarchy of Apollo the Sun, which should become a 'paradigm' for the creation of a federal state of Ionian city-states to withstand the power of Achaemenid empire and to liberate the Ionian Greeks from slavery (we have argued for this reconstruction in Lebedev 2014). The Ionian (Milesian) concept of a self-developing 'nature' was 2000 years ahead of its time, whereas the

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second chapter of Heraclitus' book (Λόγος πολιτικός) and speaks about the role of philosophers in Heraclitus' ideal polis: 'the lovers of wisdom should be judges of the many', i.e., philosophical elite should rule over the masses (οἱ πολλοί) who lack 'mind and intelligence'. Both Heraclitus and Plato depend on the Pythagorean idea of philosophers-kings. See our commentary Lebedev 2014, 439–440.

4 The authenticity of this important autobiographical fragment has been defended by Luria 1970, who has refuted all objections of Diels. We propose additional arguments in support of its authenticity in Lebedev 2021[1].

'moving' and 'formal' causes of Plato and Aristotle were a regression into the mythopoetic past, a revival in a conceptualized form of a religious and mythological picture of the world, dismantled by the scientific revolution of the 6th century in Miletus.

No one reproaches physicists for not dealing with ethical or political issues in their scientific research. Aristotle's mistake is explained by the fact that in his excessively expanded concept of 'philosophy' he combined practical philosophy and natural science, Western φιλοσοφία and Ionian ἱστορία, which initially had nothing in common with each other, which arose in completely different socio-cultural contexts and posed completely different tasks: the former was concerned with human 'soul' (*psyche*), its moral education and its relation with the sphere of the divine and community, and the latter with detached study of the natural world within a pragmatic set of purposes posed by Milesian colonization and sea trade. Sea trade/colonization and manufacturing crafts (τέχναι) are two links of a single chain. The sea trade and colonization served as an economic trigger for the development of 'navigational' sciences, such as nautical astronomy, geography, meteorology. At the same time, it stimulated economic growth in the production of commodities for export.[5]

In this paper, I will first indicate the connecting links between the contents of Ionian works Περὶ φύσεως and 'navigational sciences', and will discuss biographical evidence on Milesians' direct involvement in the process of colonization. The recent discoveries of Bulgarian archeologists in Apollonia Pontica (Sozopol) shed new light on Anaximander's mission as *oikistes*. After this I will attempt to define with more precision the sociocultural status of the so-called 'Milesian school', its set goals and activities. In section 3 I will distinguish main types of analogies used by early *physikoi*, a *conditio sine qua non* for the precise understanding of their scientific/philosophical meaning. In sections 4–6 I will concentrate on analogies from metallurgy and metal work followed by analogies from felting and working wool (section 7), which provided empirical 'proofs' (*tekmeria*) for the reconstruction of the origin and evolution of the cosmos. Conclusion (section 8) will summarize the main results and draw some parallels with the scientific Revolution in 16th–17th centuries Europe.

5 Vanessa Gorman in chapter 2 'Trade and Colonisation' of her monograph on Miletus (Gorman 2001, 45–71) shows how the scarcity of arable land and the blocking of continental trade routes towards east by the barbarians of Hinterland 'pushed' the Milesian westwards into the sea, thus turning them into great commercial and colonizing power.

2 The Milesians and 'Navigational Sciences': Nautical Astronomy, Geography, and Meteorology. The 'Milesian School' and Apollo Didymeus, the God of Colonization

2.1 *Thales*

1. A didactic poem in hexameters titled 'Nautical astronomy' (Ναυτικὴ ἀστρολογία) was attributed to Thales[6] and, in some sources, to a certain Phokos of Samos, otherwise unknown (DK, ch. 5).[7] The divergence may be due to the rivalry of Milesians and Samians, both claiming priority in some scientific discoveries, therefore to dismiss *a limine* the possibility of Thales' authorship is precarious. The use of ἀστρολογία in the sense of astronomy points to archaic date of composition.[8] The attribution to Thales in any case implies that Thales was regarded as an established authority and a primary candidate in matters of navigational astronomy. Plutarch, who must have had this poem in his library, dubitates about its authorship, but still quotes Thales together with Hesiod as an archaic astronomer who wrote in verse (*De Pythiae Oracula* 18. 402E).

2. The discovery of the 'Phoenician Star' (α Polaris) as a more precise navigational orienting point than Ursa Major is attributed to Thales by Callimachus who had access to the treasures of Alexandrian library.[9]

3. Thales explained the flooding of the Nile by Etesian winds which were also relevant for the maritime meteorology and were of primary importance for the sea trade of Miletus (and all Aegean region) with Egypt. The Etesian winds, known in Modern Greece as *meltemia*, are strong dry northern winds that blow annually (every *etos*) in the Aegean from June to September and provided in ancient times easiest travel to Crete and Egypt. The importance of Etesian winds for Greek sea trade can be compared with the importance of 'trade winds' for the sea trade between Old and New world in modern times: the famous astronomer Edmund Haley published in 1686 a meteorological treatise

6 Diogenes Laertius 1,23; 11B1–2 DK.

7 On the two rival legends about the 'discovery' of Pythagoras theorem, the Samian (Pythagoras) and Milesian (Thales), favored by Callimachus, see Lebedev, 2022, 760–761.

8 Traces of this usage are probably also preserved in Diogenes' quotation from Heraclitus and Democritus: Diogenes Laertius 1, 23 δοκεῖ δὲ (scil. Θαλῆς) κατά τινας πρῶτος ἀστρολογῆσαι … μαρτυρεῖ δ' αὐτῶι καὶ Ἡράκλειτος καὶ Δημόκριτος. Heraclit. Fr. 24Leb/B28 DK. In the alleged fragment B105 DK ἀστρολόγος, on the contrary, means 'astrologist'. Therefore, it has nothing to do with Heraclitus of Ephesus (*contra* DK, Marcovich and others), but refers to grammarian of Roman times; see our objections in Lebedev 2015, 293.

9 Callimachus, *Iambi*, fr.94 = Thales A3a DK = T52 W (hereafter the form of citation for Wörhrle 2009); *Scholia in Iliadum* 18.487.4 (ed. Heyne) = Th 592 W.

on 'trade winds and monsoons, observable in the seas near and between the Tropics'.

4. One of the main items of Milesian export in archaic times was olive oil. Therefore, the story told by Aristotle in *Politics* about Thales' successful business with olive oil presses should not be dismissed *a limine* as an anecdote unrelated with Thales' activities: *se non e vero, e ben trovato*.[10] Aristotle admits that monopoly is a general and useful 'contrivance of the art of making money' (χρηματιστικὸν κατανόημα) attributed to Thales 'due to his wisdom' (διὰ τὴν σοφίαν). As in other early stories about Thales' his *sophia* is associated here with practical inventiveness, including spheres like hydrology and military engineering (*diabasis* of river Halys, Herodotus 1,75), not with impracticable speculations about 'first principles', attributed by Aristotle to the Ionian *physikoi*. In the scholia to Aristophanes' *Clouds*, 180 Thales is characterized as 'highly inventive' (πάνυ μηχανικός, Th 588 W.) or 'highest expert in the science of mechanics' or 'in constructing machines' (ἄκρος μηχανικός, Th 589 W.), a praise suitable for 'engineer' rather than philosopher in Platonic-Aristotelian sense. Μηχανοποιός was a standard Geek word for 'engineer', and its variant μηχανουργός could be applied to architect (*Anth.Gr.* 5.382).

5. According to Eudemus fr.8 W. (11A20 DK), the method of Thales' 'demonstration concerning the distance of the ships' presupposes the knowledge of the theorem that two triangles with one equal side and two equal angles are identical. Here again practical interest comes first and concerns navigational knowledge.

6. Aristotle in *De Caelo*, 294a28 briefly mentions Thales' view on the 'immobility' of Earth that it is floating on water 'like wood or something similar' (ὥσπερ ξύλον). In Seneca's *Naturales Quaestiones* Thales is credited with an elaborate analogy between the Earth and a gigantic ship afloat of primordial ocean of sweet waters. Both in the chapter 'Why don't the rivers dry up' (*NQ* III, 13 = Th 99 W.) and in the chapter on the causes of earthquakes (*NQ* VI,6 = Th 101), earthquakes are assimilated to ship roll. The same analogy also explains why rivers don't dry up. In III, 13 Seneca rebuffs the 'ancient and crude' view that 'water seeping through the cracks of the ship forms a bottom drain.' The *sentina* at the bottom of Earth's corpus on iconic level probably refers the sea, a dirty water which became salty 'seeping' (διηθεῖν in the Greek original) through the earth. Seneca's version looks more precise and authentic than that of Aristotle's. The analogy between earthquake and ship roll is not a metaphor or poetic simile: it is a genuine *tekmerion* which provides a general

10 Arisotle, *Politics* A11. 1259a8 ff. = Thales A10 DK.

explanation of the nature (*physis*) of earthquakes by citing evidential proof of how water can cause 'tremble' of floating objects. In the same vein Thales cited the examples of magnet and amber as *tekmeria* supporting his general thesis the whole Universe is full of vital forces. The analogy between earth and ship cannot be Seneca's invention because he rejects it as 'ancient and crude' nonsense. In this underestimated evidence, Thales' general picture of the Universe appears as a maritime cosmology with Earth as a lonely (?) ship in the boundless ocean of rippling water. This looks an anticipation of the 'eternal motion' of primordial *physis* in later Milesians. There is a recurrent structural pattern in most early Ionian cosmologies: *archê* (primordial *physis*) in cosmogony and τὸ περιέχον in cosmology (cosmography) coincide. Τὸ περιέχον is a peculiar early Ionian concept of 'encompassing' space conceived as a material mass. It is directly attested in Anaxagoras B2, who follows Anaximander's terminology,[11] and by its verbal equivalent in Aristotle's summary exposition of the view of 'Anaximander and most of physiologoi' that the infinite body (τὸ ἄπειρον) 'encompasses and governs all things' περιέχειν ἅπαντα καὶ πάντα κυβερνᾶν (*Physics* 203b6 ff.).[12] Aristotle attributes this view to 'all those who do not accept' a *causa movens* like Anaxagoras' *nous* or Empedocles' *philia*, including Thales with his 'single arche', water. The chances are that Aristotle got it right. Seneca's independent evidence on a boundless primordial ocean in Thales provides additional support. In the Greek original of Seneca's source the shape of Earth was probably assimilated to a boat or ship's hull (σκάφος), another anticipation of the standard Ionian (including Democritus) concept of the hollow earth with the sea as unclear 'drain' at the bottom: this model is attested in Heraclitus[13] and Hippocrates *De diaeta* 1,[14] and it is imitated in the extravagant cosmology of Plato's *Phaedo*.[15] It is often combined with the idea of a mountain at the North, 'behind which' sets the Sun, in a striking contrast with the Western Greek (Pythagoreans and Parmenides) spherical earth adopted by Aristotle and later standard astronomy.

The following passage from Seneca on Thales' 'water cosmology' is also based on a unique source, independent of Peripatetic doxography: *Naturales*

11 Τό γε περιέχον ἄπειρόν ἐστι τὸ πλῆθος 'the encompassing mass is infinite in multitude'.

12 Aristotle uses here his own term for infinite magnitude or infinite body (τὸ ἄπειρον) which is never attested in authentic early Ionian scientific prose, see Lebedev 2022, 716–722.

13 Parallelism of *micro-* and *macrocosmos* in Heraclitus: fr. 66–88 Lebedev, especially fr.69 (*anathymiasis* in man and Universe). Cf. also the 'bowls' (σκάφαι) of the celestial bodies, fr. 61 Lebedev = 61 Marcovich.

14 *De diaeta* 1.10 κοιλίην τὴν μεγίστην … θαλάσσης δύναμιν.

15 *Phaedo* 109a–110a. We live in the cavities of earth (κοῖλα) 'around the sea', which is an unclear bottom 'drain' (συρρεῖν) etc.

quaestiones 3.13.1 (ed. Hine) *Adiciam, ut Thales ait, 'ualentissimum elementum est.' hoc fuisse primum putat, ex hoc surrexisse omnia*. "I shall add that, water, as Thales says, is 'the most powerful' element. He holds that it was the first, and that everything arose (or 'emerged') from it." The language of this passage, with the exception of a single word *elementum*, significantly differs from the standard colorless Peripatetic arche-formula. It does not mention the 'principium omnium rerum' (ἀρχή τῶν πάντων), The word *valentissimum*, introduced as quotation from Thales ('ait'), almost certainly renders the Greek original κράτιστον (or ἰσχυρότατον) which echoes the common pre-Platonic characterization of primoradial *physis* as 'the most powerful' element that 'overpowers all other things': so in Diogenes of Apollonia B5 (ἀήρ) πάντων κρατεῖ; in ps. Hippocrates, *On diet* I, 10 τὸ θερμότατον καὶ ἰσχυρότατον πῦρ ὅπερ πάντων κρατεῖ (the fire of the sun); in Heraclitus the power of the 'divine law' is unlimited fr.131Leb/B114 κρατεῖ τοσοῦτον ὁκόσον ἐθέλει; so in Anaxagoras B12 πάντων νοῦς κρατεῖ. This authentic language goes in line with the common pre-Platonic conception of the four world masses as 'powers' (δυνάμεις) rather than 'elements' (στοιχεῖα), a term that did not exist before Plato, and as standard term before Aristotle (see Lebedev 2017[1]). The origin of the world in Seneca's passage is described in terms of 'geological' changes of the cosmic landscape: surrexisse renders Greek ἀναδύεσθαι, a Homeric word (*Iliad* I, 359) often used of something of 'rising from the sea' (ἁλός, θαλάσσης, πελάγους) and used by Strabo of 'new islands' that 'emerge from the sea', 'as it happens in many places now as well' (καθάπερ καὶ νῦν πολλαχοῦ συμβαίνει, 6.11). I have argued in a special study (Lebedev 1981) that one the main sources of Aristotle's knowledge of Thales' cosmology, besides Hippias (suggested by Snell), was the polemics of Xenophanes with Thales attested in Diogenes Laertius IX, 18 (ἀντιδοξάσαι λέγεται Θαλῆι). Given the poetic flavor of Seneca's report on Thales' primordial *physis*, I would venture to suppose that his ultimate Greek source was a poem of Xenophanes in hexameters, presumably mediated by Stoic doxography. The original verses paraphrased by Seneca in Latin may be reconstructed as follows:

> Πάντων κράτιστόν τε ὕδωρ πρῶτόν τε πέφυκεν,
> ἐξ οὗ δὴ … ἀνεδύσετο πάντα.
>
> (Thales says) that water is the most powerful and the first of all things, and it is from water that all other things have risen (or 'emerged').

The "Nautical astronomy" attributed to Thales or Phokos of Samos should be ruled out as a possible source since it was a highly specialized technical handbook of practical navigation that excluded cosmogonical speculations.

It is after expounding Thales' doctrine on 'floating earth' that Xenophanes launched a critical attack preserved in Xenophanes' verse B27 ἐκ γαίης γὰρ πάντα καὶ εἰς γῆν πάντα τελευτᾶι. When Aristotle in *De Caelo* 294a21ff. contrasts Thales' and Xenophanes' views on the 'immobility of earth' he actually reports a historical debate between them.

In the *S-Placita* on the 'location of ruling principle' of the cosmos we read: "τὸ δὲ ἡγεμονικὸν ἐν τῶι μεσαιτάτωι πυρὶ, ὅπερ τρόπεως δίκην προϋπεβάλετο τῆς τοῦ παντὸς ⟨ὁλκάδος⟩[16] ὁ δημιουργὸς θεός". "[According to Philolaus] the ruling principle is located in the central-most fire, which the craftsman god from the start laid down like a ship's keel as the foundation of the ship hull of the Universe". Doxographers do not invent picturesque similes, they usually omit them or replace with colorless paraphrases. The image of *demiourgos* as a ship-builder is unique, its authenticity cannot be doubted, as cannot be doubted the assimilation of the firmament to the ship hull (ὁλκάς) also attested in B12.[17] According to the incipit of Philolaus' work (B1) the whole 'nature' (*physis*) was 'constructed' (literally 'fit-together' ἁρμόσθη) from the unlimited and limiters'. ἁρμόσθη is a genuine passive 'was constructed', *scil*. by someone. Ἁρμόζω in Philolaus is a creationist geometrical metaphor for constructing regular solids of the elements, as in Plato' *Timaeus*.[18] It does not matter whether in the original text Philolaus called his cosmic god δημιουργὸς θεός or Harmonia; cf. the role of ἁρμονία as efficient cause that joins the opposites in B6. What really matters is the well-attested Pythagorean origin of Platonic *demiourgos* wrongly denied in modern scholarship by those who view early Greek philosophers through the lens of the misleading category of 'Presocratics' and seriously exaggerate the originality of Plato's metaphysics, epistemology and theory of the soul.

2.2 *Anaximander's Direct Involvement in Milesian Colonization*

Anaximander's place in the relation of the so-called Milesian school to colonization is exceptional. Aelian in his *Varia historia* has preserved a unique and precious piece of evidence on Anaximander's personal involvement and active participation in Milesian colonization. Chapter 17 of book 3 is a kind of *apologia pro philosophia*. Aelian aims to demonstrate that philosophers, "too, took part in political life, and not only excelled in intellect, spending

16 ὁλκάδος scripsi, σφαίρας DK.

17 Contra Huffman 1993, 96 ff.

18 For detailed refutation of modern naturalistic interpretations of Pythagorean first principles (Burkert, Huffman) see Lebedev 2019, 658–661.

their life in quietude."[19] To refute this prejudice he produces a long list of examples of social and political activity of philosophers beneficial for their poleis. Anaximander's political achievement beneficial for his polis is adduced right after Seven sages and before Xenophon: καὶ Ἀναξίμανδρος δὲ ἡγήσατο τῆς ἐς Ἀπολλωνίαν ἐκ Μιλήτου ἀποικίας "and Anaximander conducted as a leader the colonial expedition (*apoikia*) from Miletus to Apollonia". Aelian seems to believe that Anaximander was the actual founder of Apollonia Pontica, an *oikistes*/*archegetes*: this is the most natural meaning of the words ἡγήσατο τῆς ἀποκίας, and the great honor of being an *oikistes* in Greek eyes perfectly accords with Aelian's context, which lists glorious deeds of philosophers. Ps.-Scymnus puts the date of the foundation of Apollonia at 610 BCE. This is in general agreement with archeological data on earliest Greek settlement: pottery from the site dates back to the second half of the seventh century BCE. Therefore, archeologists and historians of Apollonia commonly accept late seventh late century as the date of the foundation of Apollonia Pontica. This does not square with Aelian's report (610 BCE is Anaximander's date of birth!), therefore some historians of Apollonia dismiss it as a mistake.[20] Avram (2012: 201–205) tried to solve the contradiction by admitting that Aelian refers to the second colonial expedition to Apollonia with 'additional settlers' (*epoikia*) mentioned in Aristotle's *Politics* 303a35 which he connected with hypothesized influx of refugees caused by the subjugation of Ionia by Harpagos in 547/546 BCE. Elaborating on this hypothesis, Herda (2019: 24–31) proposed an ingenious hypothesis according to which Anaximander not only led the colonial expedition, but also took part in the civil strife (*stasis*) in Apollonia between the demos and the old oligarchs as a leader of the democratic party. This hypothesis goes far beyond available evidence.

Avram's suggestion of *epoikia* as chronologically distinct from original *apoikia* is hard to sustain on linguistic grounds. *Epoikia* (in singular) is actually a modern term. The word ἐποικία is attested only once, as a synonym of ἀποικία.[21] Ancient sources speak only of ἔποικοι 'additional settlers' as a second wave of colonists in the same *apoikia*. I therefore propose to take Aelian's report at face value as accurate and precise, but to connect Anaximander's mission with *refoundation* of the city under a new name of Apollonia. The original name of the joint foundation of Milesians and Rhodians was probably

19 Ἐπολιτεύσαντο οὖν καὶ φιλόσοφοι, μηδ' αὐτὸ τοῦτο μόνον τὴν διάνοιαν ἀγαθοὶ γενόμενοι ἐφ' ἡσυχίας κατεβίωσαν.

20 Gorman 2020, 251 and note 29.

21 LSJ, s.v. TLG-only provides only two instances, neither one supports the modern use of this word.

Antheia. In the face of the invasion of Harpagos in 546 BCE, the Milesians decided to obtain exclusive rights to own strategically important copper mines in Meden Rid. They obtained a foundation oracle from the oracle of Apollo Didymeus and appointed Anaximander as an *oikistes/archegetes* of this important mission.

Starting from 2009 Bulgarian archeologists have made a series of remarkable discoveries in Apollonia Pontica (modern Sozopol in Bulgaria) which have dramatically changed the early history of the development of the polis, especially in archaic period. Excavations on the island of St. Kirik have brought to light an archaic temenos with a temple of Apollo Ietros with altar and remains of the earliest settlement. I quote what is important for us in present context, especially the distinction of two archaic periods, from the report of investigators Panayotova, Damyanov et al.: "Two archaic phases could be distinguished, marked by the appearance of a temple and altar in the late 6th–early 5th centuries BCE .... the settlement became urbanized in later 6th century BCE. ... The houses are small, mainly with one room of 20–25 m^2. Already from the early 6th c. BCE, there are ubiquitous traces of metallurgy: copper slag was discovered in all contexts and some houses had floors, leveled and insulated with pieces of slag. The ore was mined from the nearby hills of Meden Rid ("Copper Ridge"), hinting at peaceful relations with the Thracians."[22]

The two stages of the development of Apollonia, as documented by archeological research, are in perfect agreement with our interpretation of the literary evidence. For a helpful survey of the current state of research see Konova, 2020, who admits possible impact of the Ionian school on the colonization process, *op.cit.* 274. The original settlement was an *emporion*, the refoundation by Miletus resulted in the urbanization and construction of the temple of Apollo in late sixth century BCE: a foundation oracle, conceivably, contained both political (name of the city, constitution) and cult regulations. The construction of temple was followed by the erection of the colossal bronze statue of Apollo Ietros by Calamis in the early fifth. This points to an oligarchic regime.

Miletus had no copper mines in her *chora*. Meden Rid was one of the most important centers of copper metallurgy in the Circumpontic region, comprising both mines and pyrotechnical installations. It is here that Anaximander could see with his own eyes metallurgical processes that provided him with a clue to the reconstruction of the origins of the cosmos.

22 Panayotova et al., 2014.

2.3 *Anaximenes and the Discovery of 'Air'*

The word ἀήρ from Homer on meant 'mist'. It is only in late 5th century BCE that it became the standard term for the 'invisible' element of air (Democritus, Diogenes). Anaximander and Anaxagoras still used it in the sense of 'dark air' contrasted with αἰθήρ 'shining air'. Both Anaximander and Heraclitus may have called air πρηστήρ 'blower'. The first instance of the new use is attested in Anaximenes fr. B2, in a *hen dia dyoin* with πνεῦμα 'wind' added to avoid confusion. The 'discovery' of the 'essential' element of air underlying various familiar concrete forms was triggered by the fundamental importance of air in sailing and navigation, and by the observation of inflated 'bags', including smith's bellows. In Epicharmus' parody of a naturalistic theory of air as primordial *physis* 'air' is metonymically called ἀσκοὶ πεφυσιαμένοι: "What is the nature of men? Inflated bags!" (B10 DK).

A striking historical parallel and example of how the demands of seafaring and navigation trigger the rampant development of theoretical physical-mathematical sciences from scratch, is the case of 'Navigational school' (*Navigatskaia shkola*) opened by the order of Peter the Great in Moscow in 1701. It was in early years of 18th century that Russia was being transformed from a Byzantine style, dreamy, and technologically retarded country into a naval power with new a European-style capital in St. Petersburg, housing a new Russian fleet. A navigational school was the first technical educational institution in Russia, in which mathematics, nautical astronomy, geography etc. were taught. It was an elite college for gentry: its graduates would become naval officers, engineers, artillerists, geodesists, architects. It was a first step in the implementation of Peter's cultural and educational project of reforms followed by the foundation of the Academy of sciences in 1724 with world-class mathematicians and astronomers like D. Bernoulli and Leonard Euler, and of St. Petersburg University.

3 Main Types of Analogies and Conceptual Metaphors in Early Greek Natural Philosophy and Science

A preliminary note on terminology. Lakoff and Johnson's distinction of 'source' and 'target domains' may be useful for preliminary cataloguing purposes. This terminology is metaphorical itself, an elaboration on Aristotle's concept of transfer (μετα-φέρω) 'from' and 'to'. When it comes to the semantical analysis, I prefer to distinguish 'iconic' and 'referential' levels of meaning in the semantical structure of metaphor or analogy as two integral and interactive elements of a composite whole. This terminology is a variant of the familiar

distinction of signification and denotation in linguistics and semiotics, as well as of Frege's distinction between '*Sinn und Bedeutung*'. The iconic level is a kind of lens through which we see the referent; therefore, I also occasionally speak of 'framing' the iconic level, i.e., widening or narrowing it to include or exclude some associated images, e.g., the image of a craftsman in a technological analogy. Naturalistic monists (I mean those who recognize *physis* as the only type of reality, i.e., opponents of the substance dualism) in their analogies from manufacturing crafts usually focus on material change as such, leaving the image of craftsman behind the scenes. On the contrary, creationists, like Heraclitus (*sic*), Pythagoreans, and Plato always keep the craftsman in focus.

The classical triad of Greek analogical models of the cosmos, which may be termed biomorphic, technomorphic, and sociomorphic, has been described in the pioneering and unjustly underestimated work of G.E.R. Lloyd (Lloyd 1966 who does not use these particular terms). As a matter of fact, the technomorphic model – understanding techne in the Greek broad sense, including all the arts, crafts, specialized practices of any kind – are as many as there "arts" and crafts (τέχναι) of the Greeks.[23]

This typology, based on the thematic catalogue of 'iconic domains' of metaphors, is important, but not exhaustive. It is useful for practical purposes (like collecting instances), but it is rather formal and does not tell us much about the explanatory function and philosophical content of the simile. Another formal distinction (not always easy to make) is between isolated metaphors-analogies and extended (complex) analogies implying an elaborate model of the cosmos and a corresponding 'language game' or a metaphorical code. Philosophically more important is to distinguish (1) metaphorical vs. natural analogies; and (2) creationist (teleological) vs. naturalistic (deterministic) analogies. In metaphorical analogy the iconic and referential level of meaning as a rule come from different domains, one from culture another from nature. In natural analogy both the iconic and the referential level derive from the domain of nature, one natural phenomenon serves as a model of another. Metaphorical analogies are more poetic, natural analogies have scientific value and explanatory function. Metaphorical analogies may derive from mythopoetic traditions, natural analogies are the product of scientific revolution in Miletus in the 6th century BCE. Sometimes they come close to what we call 'experiments.' Let

23 Lloyd did not, however, take into account the agonal model of the cosmos of Heraclitus (described in Lebedev 1985), as well as the economic ("lend-and- borrow") model of cosmic change in Anaximander and Heraclitus, which serves to formulate the law of conservation of matter (Anaximander B1 DK, Heraclitus 45Leb/B31, 31Leb/B80, 42Leb/B90).

me give a couple examples. A typical example of metaphorical analogy in philosophy of nature is the agonal model of the cosmos in Heraclitus (Lebedev 1985). The cosmos is assimilated to a stadium; the Day and Night (Dawn and Sunset) are like competing runners, constantly running the 'path up and down' from start to finish and back again; Vernal and Autumnal Equinoxes are like 'turning posts' (τέρματα) 'opposite each other'; the Sun is an umpire' (βραβεύς, σκοπός) who oversees the agon, sets the rules, awards the winners and regulates the unchangeable μέτρα of diurnal and annual cycles; the athletes are bound by 'great oath' which stands for the universal 'divine law' (θεῖος νόμος) of the harmony of opposites. Violators will be punished by Erinyes. This is a brilliant poetic picture, an ingenious variation on the theme of Cosmopolis as a paradigm of the ideal state, with a transparent political message and hymn to enlightened monarchy of the king the Sun (as well as an invective against the rule of ignorant 'mob', ἀξύνετοι πολλοί), but it has no scientific value. One natural analogy is based the system-building theory of cosmogonic vortex: the hypothesized cosmic vortex is modelled on vortices observed 'in the water and in the air', as Aristotle puts it (DC 295a10). An example of a natural analogy in biology is provided by Alcmaeon of Croton (Lebedev 2017[3]). Man reaching puberty "blooms" like flowering plants before seeding, the gray hair of old age is like withering grass, the four stages of human life are analogous to the four seasons of the year. Man dies because he cannot 'join the beginning with the end' (B2), i.e., the winter of his life (old age) is not followed by a new spring (youth), as it happens in the immortal nature. Here the biological cycle of human organism (natural phenomenon) is modelled on the vegetable cycle of plants, another natural phenomenon. This empirical observation has scientific value, Alcmaeon probably strives to establish the universal formula of the life-cycle of all living beings, i.e., to formulate a law of nature. As a rule, metaphorical analogies more often occur in the texts of teleologically, as well as ethically, politically, and theologically minded thinkers, and natural analogies in the fragments of Ionian dedicated *physikoi* or those influenced by them in the West, like Alcmaeon. Technomorphic analogies present a complex and heterogeneous group. One should distinguish in it a demiurgical, creationist type, implying a cosmic craftsman-*demiourgos* (Pythagoreans, Heraclitus, Empedocles) on the one hand, and a non-demiurgical type focused on the process or mechanism of material change caused by impersonal necessity, ἀνάγκη, τὸ χρεών (Anaximander, Anaximenes and other Ionian *physikoi*, Atomists). Both for Pythagoreans and Heraclitus the cosmic *harmonia* (originally metaphor from τέχνη μουσική) is a part of an intelligent design theory: if cosmos is a work of art, there must be a craftsman who made it and sustains its operation, i.e., the divine mind (νοῦς, γνώμη, φρήν, λόγος, τὸ σοφόν). When the Ionian *physikoi* use analogies from metallurgy or agricultural works like winnowing

etc., they leave aside ('bracket') the figure of specialist/craftsman (human, not divine!) as irrelevant and focus only on the material change and familiar from everyday life technological operations which explain the 'works' (ἔργα) of nature. Both the teleologists (creationists) and the determinists (naturalists) employ analogies from *tekhnai* as empirical proofs (*tekmeria*, *martyria*) in support of two incompatible metaphysical and cosmological paradigms (on this theoretical conflict see Lebedev 2024), depending on whether they include into the iconic frame the anthropomorphic figure of *technites* or bracket it and focus on the behavior of matter (materials) itself under strained conditions. This means that, e.g., analogies from gold-washing, winnowing, or smelting in Ionian *physikoi* (Anaximander, Archelaus, Anaxagoras) discussed below, although they derive from *technai*, are essentially natural analogies (bracketing craftsmen), whereas very similar analogies from metal-work in Heraclitus, Empedocles, or Plato are metaphorical and creationist (including craftsmen in the iconic frame).

4 A Neglected Analogy with Gold-Washing and the Theory of Vortex (Δίνη) in Anaximander's Cosmogony

Histories of early Greek philosophy of nature and physical science sometimes confuse or identify the notions of corpuscular and atomistic theories of matter. As a result of this confusion the very existence of corpuscular theories of matter in Greek thought before the atomists is wrongly denied. In fact, every atomistic theory of matter is a corpuscular theory, but not every corpuscular theory of matter is atomistic. The truth was seen by Alexander Heidel as early as 1911 in his "Antecedents of Greek corpuscular theories", but unfortunately his observations have been commonly neglected due to the false derivation of Democritus' atomism from the Eleatic 'ontology', a kind of theological metaphysics that has nothing to do with physical science, as Parmenides himself explicitly states. Corpuscular intuitions are found long before classical atomism in Greek theories of evaporation (ἀναθυμίασις), medical theories of nutrition, Anaxagoras' concepts of 'seeds' (σπέρματα) and 'portions'(μοῖραι) of various simple stuffs, Empedocles theory of effluences (ἀπόρροιαι) and microscopic molecules of odor by which a dog recognizes her kennel on a roof (31A20a, originally not an 'apophthegm'). To these we should add Anaximander's conception of primordial substance (φύσις) as *panspermia* (mixture of various seeds), attested both by the consensus of Aristotle and Theophrastus, as well as by Anaximander's own gold-washing analogy in his theory of the cosmogonic vortex (on which see below). Democritus' theory of matter was strongly influenced by Anaximander's and Anaxagoras' theories of invisible 'seeds of all things' combined

with the vortex cosmogony and Infinite Universe, but it has nothing to do with the immutable divine *Sphairos* of the Western philosophical theology (Pythagoreans, Xenophanes, and Eleatics) conceived as incorporeal light which is both intelligible (*noeton*) and intelligent (*noeron*). Democritus' originality consists primarily in the two modifications of the original Ionian panspermia theory of matter: he made the 'seeds of all things' indivisible and lacking secondary qualities, distinguished only by size and shape. Both in Anaximander and Anaxagoras the 'seeds of all things' were divisible and qualitatively distinct, and yet it was a corpuscular theory of matter of non-atomistic type, i.e., a theory of primordial substance (*physis*) with molecular structure, conceived as mechanical mixture (*migma*) of various stuffs. Anaximander's and Anaxagoras' theory of matter was far ahead of the naïve popular doctrine of 'four elements', still cherished by Plato and Aristotle, since in their view the primordial *panspermia* comprised, among other 'seeds', all metals, i.e., a considerable part of Mendeleev's periodical table of elements.[24]

Having in mind these preliminary considerations, we should approach the crucial early evidence on the mechanistic (*panspermia* or *migma* type) theory of primordial substance and material change in Anaximander: *diakrisis* of particles as opposed to *alloiosis* of single substrate.

> Ἀναξαγόρας .... πρῶτος μετέστησε τὰς περὶ τῶν ἀρχῶν δόξας καὶ τὴν ἐλλείπουσαν αἰτίαν ἀνεπλήρωσε, τὰς μὲν σωματικὰς ἀπείρους ποιήσας· πάντα γὰρ τὰ ὁμοιομερῆ, οἷον ὕδωρ ἢ πῦρ ἢ χρυσόν, ἀγένητα μὲν εἶναι καὶ ἄφθαρτα, φαίνεσθαι δὲ γινόμενα καὶ ἀπολλύμενα συγκρίσει καὶ διακρίσει μόνον, πάντων μὲν ἐν πᾶσιν ὄντων, ἑκάστου δὲ κατὰ τὸ ἐπικρατοῦν ἐν αὐτῷ χαρακτηριζομένου. χρυσὸς γὰρ φαίνεται ἐκεῖνο, ἐν ᾧ πολὺ χρυσίον ἐστὶ καίτοι πάντων ἐνόντων. λέγει γοῦν Ἀναξαγόρας ὅτι "ἐν παντὶ παντὸς μοῖρα ἔνεστι" καὶ "ὅτῳ πλεῖστα ἔνι, ταῦτα ἐνδηλότατα ἓν ἕκαστόν ἐστι καὶ ἦν". καὶ ταῦτά φησιν ὁ Θεόφραστος παραπλησίως τῷ Ἀναξιμάνδρῳ λέγειν τὸν Ἀναξαγόραν· ἐκεῖνος γάρ φησιν ἐν τῇ διακρίσει τοῦ ἀπείρου τὰ συγγενῆ φέρεσθαι πρὸς ἄλληλα, καὶ ὅτι μὲν ἐν τῷ παντὶ χρυσὸς ἦν, γίνεσθαι χρυσόν, ὅτι δὲ γῆ, γῆν· ὁμοίως δὲ καὶ τῶν ἄλλων ἕκαστον, ὡς οὐ γινομένων ἀλλ' ἐνυπαρχόντων πρότερον. τῆς δὲ κινήσεως καὶ τῆς

24 To avoid misunderstanding, it should be noted that we do not attribute to Anaximander a 'strong' version of the theory of universal mixture, according to which every single 'portion' of matter, including seemingly homogeneous stuffs, contains 'trace elements' of all other stuffs. The gold-washing experiment quoted by Theophrastus clearly distinguishes the 'seeds' of 'gold' and the seeds of 'earth', but neither in this analogy nor in any other extant source on Anaximander' theory of matter there is a clear indication that he, like Anaxagoras, regarded every single 'seed' of gold as *predominantly gold* with admixtures of all other metals.

γενέσεως αἴτιον ἐπέστησε τὸν νοῦν ὁ Ἀναξαγόρας, ὑφ᾽ οὗ διακρινόμενα τούς τε κόσμους καὶ τὴν τῶν ἄλλων φύσιν ἐγέννησαν. "καὶ οὕτω μέν, φησί, λαμβανόντων δόξειεν ἂν ὁ Ἀναξαγόρας τὰς μὲν ὑλικὰς ἀρχὰς ἀπείρους ποιεῖν, τὴν δὲ τῆς κινήσεως καὶ τῆς γενέσεως αἰτίαν μίαν τὸν νοῦν· εἰ δέ τις τὴν μῖξιν τῶν ἁπάντων ὑπολάβοι μίαν εἶναι φύσιν ἀόριστον καὶ κατ᾽ εἶδος καὶ κατὰ μέγεθος, συμβαίνει δύο τὰς ἀρχὰς αὐτὸν λέγειν τήν τε τοῦ ἀπείρου φύσιν καὶ τὸν νοῦν· ὥστε φαίνεται τὰ σωματικὰ στοιχεῖα παραπλησίως ποιῶν Ἀναξιμάνδρῳ."

SIMPLICIUS, *In Phys.* 27, 2 = Theophrastus fr.228A = Anaximander Ar.164 W. = Anaxag. A41 DK

Anaxagoras ... was the first to change the opinions about the first principles, firstly, by making the corporeal principles infinite, for he admitted that all homogeneous stuffs like water, fire, or gold are unborn and indestructible, but only seem to be generated and destructed due to conjunction and disjunction, since all stuffs are present in all other stuffs, but each is characterized by the prevailing stuff: a stuff, in which there is a lot of gold, appears to be gold, although it contains all other stuffs as well. Indeed, Anaxagoras says "in everything there is a portion of everything" and "which thing contains most parts of a certain kind, with those parts it was and it is identical". And these tenets of Anaxagoras, according to Theophrastus, are similar to what Anaximander states. For he [=Anaximander] says that in the separation of the infinite homogeneous particles agglomerate together, and what was gold in the Universe, becomes gold, while what was earth in the Universe, becomes earth, and in the same way all other things as well, on the assumption that they are not generated [in this process], but preexist before. However (δέ!), Anaxagoras [*scil.* "unlike ἐκεῖνος", i.e. unlike Anaximander] posited above [the material principle] as a cause of motion and generation the Mind. "And if we take it in this way, it seems that Anaxagoras admits infinite number of material causes and only one cause of motion and generation, the Mind, under whose action [the material causes] produced the worlds and the nature of all other things. But if we conceive the universal mixture as a single nature indefinite both by its form and by magnitude, it follows that Anaxagoras admits two causes, the nature of the infinite and the Mind, and so it appears that he treats the corporeal elements similarly to Anaximander."

Since the 19th century, scholarly opinion has been divided between those who took the word ἐκεῖνος with reference to the preceding name of Anaxagoras, and those who understood it as "the former", i.e., with refence to Anaximander.

Although the first opinion seems to be still prevailing (partly due to the 'magic of great names' like Diels and the authority of DK as "standard edition" in the last century) it is certainly wrong and should be discarded in favor of the second, primarily because it destroys the clear logical nexus of Simplicius' text and results in at least two incongruities of which neither Theophrastus nor Simplicius can be held guilty. Theophrastus compares the theories of the "first principles" (in Aristotelian sense) of Anaxagoras and Anaximander, and finds a striking similarity (παραπλησίως λέγειν) in their conception of material cause as a universal mixture of innumerable preexistent homogeneous stuffs (ὁμοιομερῆ in Aristotles's own terminology, σπέρματα in Anaxagoras), which in the process of mechanical "separation" produces all seemingly homogeneous stuffs as agglomerates of particles according to the *simila similibus* principle. It is both natural and logical that after quoting in paraphrase the theory of Anaxagoras, Theophrastus (and Simplicius) quotes for comparison the "similar" *diakrisis* doctrine of Anaximander. Now, according to Zeller's and Diels's view, Theophrastus 'compares' Anaxagoras with Anaxagoras, which is absurd. After pointing to "similarity" of Anaxagoras and Anaximander's "treatment" of "material causes" Theophrastus also points to an important difference in their general theory of first principle, which is introduced by a contrasting particle δέ 'however'. Their theory of matter is similar, 'however' Anaxagoras, unlike Anaximander, 'posited above' matter a *causa movens*, the cosmic Mind. There is a clear contrast in Theophrastus/Simplicius text between the preceding words "he says that in the separation of the infinite etc." that stress the "similarity", and the following reservation "however Anaxagoras etc." which contrasts the views of Anaximander and Anaxagoras on the cause of motion. This contrast is clear only on the assumption that ἐκεῖνος refers to Anaximander. The equation of ἐκεῖνος with Anaxagoras again results in logical incongruity, because in this case the doctrine of Anaxagoras is contrasted with Anaxagoras himself which is absurd.

It is important to note that Theophrastus ascribes to Anaximander as textually attested in his work only the doctrine of universal mixture and 'excretion' or 'separation'. He makes it clear that the interpretation of the universal mixture as "one single nature indefinite both in form and magnitude" (μία φύσις ἀόριστος) is his own interpretation (οὕτω λαμβανόντων "if we take it in this way"), which is not found in Anaximander's original text. This interpretation is apparently influenced by the Platonic/Pythagorean use of τὸ ἄπειρον as indefinite material principle contrasted with πέρας as formal cause. Such usage is alien to Ionian scientific prose. It is therefore remarkable that some scholars (e.g., Cornford and Kirk) have rejected the authentic ancient Ionian doctrine quoted by Theophrastus from Anaximander's book, and instead ascribed to

him the Platonizing/Peripatetic interpretation of this doctrine taking τὸ ἄπειρον in the sense of ἀόριστον as 'without internal distinctions or "indefinite".'[25] If we turn to the best extant examples of early Ionian cosmological prose, the fragments of Anaxagoras, we can make sure that in Ionian tradition ἄπειρος is used only in quantitative sense of either "infinite" in extension or "infinite" by number. Both Anaximander and Anaxagoras spoke about the 'Infinite surrounding body' (τὸ ἄπειρον περιέχον) and 'innumerable worlds.'

Theophrastus's exposition of both Anaximander's and Anaxagoras' theories of original universal mixture and of the process of "separation" in cosmogony is a paraphrase that preserves some original wording and contains one concrete example of separation of "gold from earth". It is conceivable that when Theophrastus marks the 'similarity' of two doctrines he especially points to the verbal coincidences and especially the use of the same example. The value and meaning of this example have been commonly misunderstood and underestimated. The choice of 'gold and earth' is not accidental, the two stuffs are not adduced 'exempli gratia', but rather form a fixed pair. The reference is to the real 'separation of gold from earth' in the technological operation which was known under the technical term of διάκρισις, the same as used by Anaximander and Anaxagoras.[26] There are at least two other instances of the use of metallurgical analogies in Anaximander's cosmology and meteorology: he compared the 'exhaust' of fire from the circular hole on sun's 'wheel' with the 'blow-tube' (πρηστῆρος αὐλός A21, B4 DK) for the nozzle of smiths' bellows, and he explained the nature of wind as a 'flow of air when the most thin and wet particles of it are set in motion or *melted by the sun*' (τηκομένων A24 DK). The 'smith's bellows' of the sun and the 'melting' of air caused by it, are likely to be parts of the same extended metallurgical analogy assimilating the cosmos to a smelting furnace, on which see section 5 below.[27]

Gold was either mined from mountains (μεταλλευτός) or collected from gold sand of rivers (συρόμενος). Gold from mines had to be separated from earth (γῆ, πηλός). The initial stage of this process is described by Heraclitus in fr.

25 This mistake is also committed by Dührsen 2013, 274. Gregory's 'unlimited, but finite' (2016, 91) is a plain absurdity based on the hypercritical denial of the theory of innumerable worlds and Infinite Universe which is attested with the same degree of certainty as Anaximander's Milesian origin.

26 Pollux, *Onomasticon* 7.97 describes the stages as follows: χρυσουργοί … χρυσὸν ὀρύττοντες, τὴν χρυσῖτιν γῆν μεταλλεύοντες, διασήθοντες, διηθοῦντες, **διακρίνοντες,** ἕψοντες, καθαίροντες, πυρὶ βασανίζοντες. Demetr. Cydon. *Apol.* line 235 ὥσπερ ἂν εἴ τις τὴν χρυσῖτιν (scil. γῆν) σκάπτων τὸν μὲν πόνον ὑφίσταιτο, τὰ **ψήγματα δὲ τοῦ πηλοῦ διακρίνειν** οὐδ' ὅλως ἐπίσταιτο.

27 This analogy should be distinguished from the image of *pnigeus* in Aristophanes *Clouds* 96 = Hippon A2 DK, on which see Excursus below.

26Leb/B22 χρυσίον οἱ διζήμενοι γῆν πολλὴν ὀρύσσουσι καὶ εὑρίσκουσι ὀλίγον "those who seek for gold dig out a lot of earth and find very little". In the 'technological' section of the second chapter of his work (*Logos politikos*) in which Heraclitus enumerated various τέχναι in order to demonstrate that all of them 'imitate nature' and the 'divine law' of the cosmos by joining the opposites into harmonious whole, he also compared the cosmogonical process with 'melting gold' and producing various figures from the same recycled amorphous stuff by the cosmic god (fr. 116 Lebedev = Aristotle, *De Caelo* 304a9). The chances are that Heraclitus, as in many other cases, borrowed some technological analogies of the Milesians and – by means of the polemical device of *peritrope* – gave them a new teleological meaning, thus 'turning them around' against Milesian naturalistic determinism.

The most difficult and laborious was the subsequent process of gold washing in χρυσοπλύσια.[28] According to Pollux (see note 26 above) the 'separation of gold from earth' (διακρίνω) is a process preceded by διασήθω (= διασείω) 'shake violently', by διηθέω "strain through, filter" (cf. διήθημα 'riddled earth') and followed by ἕψω 'smelting, refining'. 'Shaking' was performed, according to some sources, on a wooden tray (σανίς) or washing pan.[29] This 'shaking' may have included rotary motion, as in modern artisanal gold-washing using 'turbo pan'.[30] It is reasonable to conclude that Theophrastus paraphrases Anaximander's analogy between the cosmogonical vortex and the separation of gold from earth in *chrysoplysia*. This is more than analogy. It is a striking example of a kind of scientific experiment intended to prove that rotary motion can 'separate' similar constituents of a mixture, the mechanical law of motion of *simila similibus* type. In our study of the conceptual metaphor in Heraclitus (Lebedev 2020[2]) we proposed to distinguish this type of analogies from metaphorical analogies and to term it 'natural analogy', since it is based on the comparison of one natural phenomenon with another. Unlike metaphorical analogies which are poetic rather than scientific, natural analogies were the product of the scientific revolution on 6th century Miletus. They are inextricably linked with the new empirical method of τεκμαίρεσθαι, τεκμήρια also known as ὄψις ἀδήλων τὰ φαινόμενα ascribed to Anaxagoras (B21a). Democritus in his acoustic theory used two similar analogies explaining that

28 Agatharchides, *De mare Erythraeo* 27; Strabo 3.2.8; 4.6.7.

29 Diodorus Siculus 3.14.2 ἐπὶ γὰρ πλατείας σανίδος μικρὸν ἐγκεκλιμένης τρίβουσι τὴν κατειργασμένην μάρμαρον ὕδωρ ἐπιχέοντες· εἶτα τὸ μὲν γεῶδες αὐτῆς ἐκτηκόμενον διὰ τῶν ὑγρῶν καταρρεῖ κατὰ τὴν τῆς σανίδος ἔγκλισιν, τὸ δὲ χρυσίον ἔχον ἐπὶ τοῦ ξύλου παραμένει διὰ τὸ βάρος.

30 See e.g., https://www.youtube.com/watch?v=Y5–l2SiR7D0 or search *YouTube* for similar videos labelled 'turbo pan, gold-washing'. Unfortunately, extant ancient evidence is scanty.

in the production of sound air is broken into groups of atoms of similar size: the violent motion of waves on the sea shore brings together pebbles of similar size and form; the rotational motion of the sieve (δίνη) separates and brings together barley grains, lentils, and wheat grains.[31] Plato's 'winnowing sieve' in the *Timaeus* (52e6), which separates the heavy bodies from the light, depends on these analogies of Democritus,[32] who in turn continues the ancient Ionian tradition that goes back to Anaxagoras and Anaximander.

Alexander Heidel saw the truth in his 1906 paper in which he argued that the 'eternal motion' of the primordial matter ascribed by Aristotle to the Milesians must have been conceived by Anaximander and Anaximenes as vortex (δίνη). Heidel's hypothesis was accepted by John Burnet (1920: 62), but rejected by Cornford and Kirk in *KRS* 128–129 on insufficient grounds and omitted without notice in Kahn's influential monograph (1960), presumably because it did not fit his Platonizing reconstruction of Anaximander's cosmology (denial of innumerable worlds etc., wrong interpretation of fr. B1). In the more recent scholarship it was persuasively defended by Perilli (1992; 1996, 21–34). Heidel and Perilli did not take into consideration the decisive evidence of Theophrastus discussed above, but they made some interesting points: e.g., plausibly explaining the circular shape of the 'drum' of earth as produced by the original vortex in which heavy bodies tend to agglomerate at the center. The origin of other celestial 'wheels' of the sun and the moon in Anaximander's model can be also adequately explained by the action of cosmogonical vortex. That Anaximander held the doctrine of original vortex cannot be doubted since it is attested by three reliable and independent sources: 1) virtually by Anaximander's own words precisely paraphrased by Theophrastus – genuine Theophrastus, quoted by name, and not the hypothetical 'Theophrastus' of Diels; 2) by Aristotle in *De Caelo*, 295a9 ff. with Simplicius' commentary, *In de Caelo*, 511, 12; 3) by Epicurus in book XI of Περὶ φύσεως. In Lebedev 2022, 729–735, I argue that the 'divine man' quoted by Epicurus is Anaximander who explained the 'immobility' of earth mechanically, by equilibrium of opposite forces produced by vortex, not logically, by the misapplied principle of sufficient reason, as Plato.

31 *Verbatim* quotation in Sextus VII.117 = Democritus Fr.316 Luria = B164 DK.:
καθάπερ ὁρᾶν πάρεστιν ἐπί τε τῶν κοσκινευομένων σπερμάτων καὶ ἐπὶ τῶν παρὰ ταῖς κυματωγαῖς ψηφίδων· ὅπου μὲν γὰρ **κατὰ τὸν τοῦ κοσκίνου δῖνον διακριτικῶς φακοὶ μετὰ φακῶν** τάσσονται καὶ κριθαὶ μετὰ κριθῶν **καὶ πυροὶ μετὰ πυρῶν**, ὅπου δὲ κατὰ τὴν τοῦ κύματος κίνησιν αἱ μὲν ἐπιμήκεις ψηφῖδες εἰς τὸν αὐτὸν τόπον ταῖς ἐπιμήκεσιν ὠθοῦνται, αἱ δὲ περιφερεῖς ταῖς περιφερέσιν. Paraphrase in: *Placit.* IV.19.3 = Democritus 491 Luria, cf. Democritus A128 DK.

32 On the relation of Plato's *Timaeus* to Democritus see, e.g., Nikolau 1998; Gorey 2018.

5 Metallurgical Analogies: the Model of the 'Smelting Furnace' in Ionian Cosmogonies

Anaximander's doxa 'on the nature of the sun' has been preserved in the Plutarch's version (P) of the SP-Placita (omitted in Stobaeus):

> Ps.Plut., *De placitis* II, 20 (889F, p.115–116 Lachenaud)[33] Ἀναξίμανδρος κύκλον εἶναι ὀκτωκαιεικοσαπλασίονα τῆς γῆς, ἁρματείῳ τροχῷ παραπλήσιον, τὴν ἀψῖδα ἔχοντα κοίλην, πλήρη πυρός, κατά τι μέρος ἐκφαίνουσαν διὰ στομίου τὸ πῦρ ὥσπερ διὰ πρηστῆρος αὐλοῦ, καὶ τοῦτ' εἶναι τὸν ἥλιον.
>
> According to Anaximander, ⟨the sun⟩ is a circle 28 times larger than Earth, similar to a chariot wheel, which has a hollow rim, filled with fire, at a certain point showing-out fire through a nozzle as if through a blaster-tube, and that is the sun.

The meaning of the simile ὥσπερ διὰ πρηστῆρος αὐλοῦ has been disputed since 19th century. In 1879 Hermann Diels in his *Doxographi Graeci*, 25 proposed a new at that time interpretation 'as if through a mouthpiece of a pair of bellows' (follis fabrorum). This interpretation has been commonly accepted until 1966 when Lloyd put it to doubt in *Polarity and Analogy*, 313–314, pointing out that πρηστήρ 'bellows' is ill-attested.

Confusion among interpreters of Anaximander has its roots partly in Greek lexica. There is no clear evidence for the supposed *lexical* meaning of πρηστήρ 'smith's bellows.' In the 1996 Supplement to LSJ the mistake in the ninth edition (1940) has been corrected: the section II is to be deleted and transferred to section I, inserting 'transf., of the hot blast produced by bellows' and citing Apollonius Rhodius IV.777. 'Blast' is a correct word for the precise understanding of the semantics of πρήθω, πρηστήρ, but the phrasing of the meaning of πρηστήρ in LSJ, s.v., section I 'hurricane or waterspout attended with lightning' is imprecise and the mention of 'lightning' *as essential feature* is misleading. This imprecision has been corrected in Montanari which gives as *essential* general meaning 'stormwind, whirlwind', and after this quotes various *contextual associations* 'with βροντή,' 'with τυφώς', 'with κεραυνός'. Montanari is also right eliminating the separate meaning 'jet' in LSJ, s.v. πρηστήρ I.2 and translating πρ.

33 12 A 21 DK = Ar 57 W. = V.1, p.970 Mansfeld-Runia hereafter MR.

in the verse of Euripides as 'whirlwinds'; a bit more precise would be 'bursts' (of tears from eyes with drops of blood).[34]

Πρηστήρ is never used in classical Greek as a direct designation of lightning. It is only in Byzantine lexica like Suda (Π 2268) or Pseudo-Zonaras (Π 1572) that πρηστήρ is glossed as κεραυνός ἀστραπή on the basis of the wrong explanation ἐκ τοῦ πρήθω τὸ καίω. The original meaning of πίμπρημι and its derivative πρήθω is 'to blow, to blast', not 'to burn';[35] the association with burning is secondary and derives from 'blowing at the fire', 'inflaming' etc. Πρηστήρ *sensu proprio* means 'blower' or 'blaster', hence 'stormwind' and 'whirlwind'. In Heraclitus it is metonymically used for the cosmic air, one of the four cosmic powers engaged in the great battle of *Megas Eniautos*. The Πυρὸς τροπαί in fr. B31 does not mean 'transformations' of fire (impossible meaning in archaic Ionian prose), but 'reversals', a military metaphor 'turning back' for 'defeat' with allusion to τροπαί in astronomical sense, used for solstices and equinoxes, which mark the advances and retreats of battling cosmic *dynameis* both within astronomical years (change of seasons) and in the Great cycle of 'abundance' and 'scarcity' (*koros* and *chresmosyne, ekpyrosis* and *diakosmesis* on later language). Heraclitus could not use the word ἀήρ, which became a standard term for 'air' only in late fifth century. For Heraclitus, as for Anaximander and still for Anaxagoras ἀήρ sill retained its Homeric and early Ionian meaning of 'mist'. His other words for cosmic air were ψυχή and ἀναθυμίασις. Later ancient readers of Heraclitus, the Stoics and Platonists, in their paraphrases of Heraclitus (fr. 46 Lebedev = B36 DK. = 76 Marcovich) correctly rendered the archaic word πρηστήρ with standard ἀήρ.

Another source of confusion and erroneous interpretations was the Achilles version, as well as the Arabic translation of Qusta. There can be no doubt that the version of Achilles depends on the SP-Placita and is not even a paraphrase, but a fanciful interpretation based on several misunderstandings of the text of the SP and one anachronism. Unlike Arius Didymus (second half of the 1st century BCE), whose fundamental textbook of physics underlies the tradition of SP-Placita,[36] a professional philosopher of colossal erudition, Achilles was a grammarian of the 3rd century, who taught "Phaenomena"; his scholia are a doxography of second rate, full of didactic trivializing, incomparable in quality and accuracy with the SP-Placita. First, he (or the student who copied the

34 Montanari 2015, 739. Surprisingly, despite correcting these imprecisions in LSJ, the Brill dictionary retains 'bellows' as a separate meaning.

35 Chantraine 1968, 902–903.

36 See our refutation of Diels's "Aetius" hypothesis and evidence for the authorship of Arius Didymus in Lebedev 2016.

lecture notes) mistakenly attributed two similes to two different philosophers: this fact alone is sufficient to dismiss his version as corrupted. Secondly, he confused the "cavity" inside the rim of the sun wheel with the "hollow" wheel hub, which is not mentioned at all in the original text, and which could not exist at all in Anaximander's system, since the place of a hub in Anaximander's 'wheel' is occupied by the earth. Thirdly, continuing to fantasize further, he imagined that, in comparison with the wheel, the outburst rays of the sun are compared with spokes radiating from the hub, although neither spokes nor rays are mentioned in the original. Fourthly, the comparison with πρ. αυλ., erroneously attributed to another philosopher, mistook αὐλός for a musical instrument and turned it into a "trumpet" (σάλπιγξ). Fifthly, he made an awkward attempt to reconcile the image of "trumpet" with the "spokes" (although he attributes it to another philosopher!): the rays of the sun supposedly radiating from one point are similar not only to the spokes of a wheel, but also to gusts of air (plural πρηστῆρας!), emitted out of a narrow tube through an expanding funnel. The sixth fundamental mistake of Achilles is that he replaced the astrophysical and astronomical problems of Anaximander's theory with an optical one (how the light of the sun is dispersed), which Anaximander does not touch at all. Explaining the nature of the wheel of the sun, Anaximander says that in one place it "reveals fire" (ἐκφαίνει τὸ πῦρ), Achilles rewrites this archaic text as ἐκπέμπει τὸ φῶς "radiates light". This phrase (teste TLG) first occurs in the 1st century BCE. in the texts of Posidonius and Cleomedes, and it sounds like Modern Greek when compared with the archaic ἐκφαίνει τὸ πῦρ. Seventhly, this amazing tangle of errors is based on anachronism: until Roman times, the standard Greek wheel was a cross-bar one, without radial spokes of the Oriental and Roman wheel,[37] therefore such a simile could not even occur to Anaximander. The Arabic translator made only one mistake: he translated πρηστήρ as 'lightning'. This error was common in the Byzantine era (see above); in addition, he could be misled by passages from Aristotle's *Meteorology* and SP-Placita, in which πρηστήρ is discussed together with ἀστραπή, κεραυνός because Aristotle attributed to all of them similar 'pneumatic' etiology. Couprie took at face value all seven mistakes of Achilles, added to them the mistranslation of Qusta and attributed to Anaximander a phantasmagoric image of a "stream of lightning" emitted by mysterious trumpet in the shape of a Roman wheel with radial spokes,[38] which did not exist in archaic and classical Greece. All analogies of the Milesians have explanatory purpose: they explain something perplexing on the basis of everyday experience, of phenomena and processes familiar to

37 Raepsaet in Oleson 2008, 597.

38 Couprie 2011, 145–152.

everybody and accessible to direct observation. The mysterious image of "continuous stream of lightning" explains nothing, it could occur in an apocalyptic vision, but certainly not in an Ionian treatise Περὶ φύσεως.

Diels and Kranz were absolutely right in considering the words πρηστῆρος αὐλός as a literal quotation. But the preceding part of the same placitum contains other authentic words as well. There is no doubt that the sun doxa preserves the authentic simile ὥσπερ διά (in the Ionian original text it was ὅκωσπερ διά). In this case, the first part of the comparison ἐκφαίνουσαν διὰ στομίου τὸ πῦρ should be either a literal quote or a precise paraphrase very close to the original text. The same must be said about the simile ἁρματείωι τροχῶι παραπλήσιος, since doxographers do not invent colorful similes, but, on the contrary, often replace them with colorless paraphrases. Anaximander's *doxa* about the sun once again demonstrates how conventional and misleading can be Diels's division of texts into "doxography" and "fragments". In terms of the number of authentic elements, this allegedly "doxographic" text is not inferior to the so-called "fragment" B1.

The nominative from the genitive διὰ πρηστῆρος αὐλοῦ is usually restored as πρηστῆρος αὐλός. But this makes the syntax difficult. It takes effort when reading to distinguish between the genitive dependent on the preposition διά (αὐλοῦ) and the *genitivus possessivus* πρηστῆρος. The text immediately becomes smooth if the nominative is restored as an appositive construction πρηστὴρ αὐλός 'blow-pipe' or 'air-pumping tube', in which πρηστήρ has the meaning of an adjective, as in Hesiod Th.846 πρηστήρων ἀνέμων "hurricane winds."

The exact formal parallel to the appositive construction is Anaximander's κίων λίθος (another verbatim quotation 12B5 DK., also in a simile), which, as Classen rightly pointed out, should not be corrected to κίονος λίθος.[39] With this understanding, the connection of the analogy with metallurgy and the bellows is not lost, but it becomes possible to overcome the objection repeatedly expressed against Diels that the comparison does not work, since air, and not fire, comes out of the nozzle of the bellows.

Another striking parallel is αὐλὸς καμινευτήρ, the name of one of the goldsmith's tools in the Greek anthology (*Anth. Gr.* VI, 92). According to Blümner, it is a blow-torch (Löthrohr), the only mention of such an instrument in written sources.[40] Καμινευτήρ is derived from the verb καμινεύω "to heat in a furnace", which was applied to various operations requiring the use of furnace (κάμινος), both metallurgical and related to the production of metal products,

39 Classen 1966, 275. For in-depth study of the impact of architecture on early Greek cosmology see the works of Robert Hahn 2001; 2010; 2020; 2021.

40 Blümner 1912, IV.302.

glass, firing of ceramic vessels and baking bread. LSJ interprets καμινευτήρ as "the pipe of a smiths' bellows", Stephanus – Dindorf thesaurus as "fistula follis quae in caminum inserta flammam excitat". The standard term for the bellows nozzle appears to have been ἀκροφύσιον or, less commonly, ἀκροστόμιον.[41] Cf. in the simile of *prester aulos* in *Placita* II, 20, 1 ἐκφαίνουσαν διὰ στομίου τὸ πῦρ. Pollux (*Onomasticon* 10.147) gives the following list of blacksmith's tools: χαλκέως σκεύη ἄκμων ἀκμοθέτης, ῥαιστήρ, πυράγρα, φῦσαι φυσητήρ ἀκροφύσιον, χοάναι, ἀκόναι, θηγάναι, ἐσχαρίδες, κροταφίδες. "Blacksmith's tools: anvil, anvil post, hammer, tongs, bellows, blowpipe, bellows nozzle, melting crucibles (or melting-pots), whetstones, braziers, pointed hammers."[42] In this list a third implement between the bellows and the nozzle, there is probably an elongated tube connecting the nozzle to the bellows.[43] Hippocrates probably adapted such a 'pipe from a forge' (αὐλὸς ἐξ χαλκείου) for medical purpose, the treatment of joints (*On Joints.* 47).

All these data confirm that Diels was on the whole on the right track in linking Anaximander's analogy with blacksmithing. Opponents of the technological interpretation raised two main objections: 1) the standard word for bellows in Greek is φῦσα, not πρηστήρ, 2) bellows are filled with air, not fire (like the "wheel" of the sun), etc. The first statement is generally true, but it should not be absolutized. The verbs πρήθω and φυσάω both mean 'to blow', therefore the *nomina agentis* in -τηρ, πρηστὴρ and φυσητήρ formed from them are close in meaning. The connection of πρηστῆρες with the forge of Hephaestus in Apollonius remains obvious. Φυσητήριον (properly 'blower'), like αὐλός, also combined two meanings: 'wind-instrument, pipe' (Aristophanes, *Lysisirata*, 1242) and 'furnace with bellows' (LSJ, s.v. III). As regards the second objection, some difficulties indeed remain. The direct identification of πρηστήρ(ος) αὐλός with ἀκροφύσιον of the bellows is also difficult because the hole in the wheel is described as a hollow funnel which "reveals" the fire hidden inside. Therefore, on the basis of what has been said above, I propose to modify Diels' interpretation and to connect πρηστὴρ αὐλός not with the bellows nozzle itself, but with the hole in the furnace into which it was inserted. A typical smelting furnace in Greece was a cylindrical shaft of clay and stone with small dimensions (about 30 to 60 cm internal diameter, and 1–2 m tall.).[44] It had two openings, a lower

41 Photos of bellows nozzles of archaic period, e.g., in Hahn 2010, 106–17, fig.4.11–12.

42 7.106 τὰ δὲ ἐργαλεῖα τούτων φῦσαι ἀκροφύσια, χοάναι, πυράγραι, ἄκμονες, ῥαιστῆρες σφῦραι, ἐσχαρίδες, ἀκόναι θηγάναι, κροταφίδες.

43 Cf. Suda A4447 αὐλός, ὁ επιμήκης φυσητήρ 'aulos: an elongated blow-pipe.'

44 Craddock in Oleson 2008, 102–104; Craddock 1995, 169–74. For ancient images in vase-painting see Craddock, 2008, 103, fig. 4.4 (Greek oinochoe, 525 BCE).

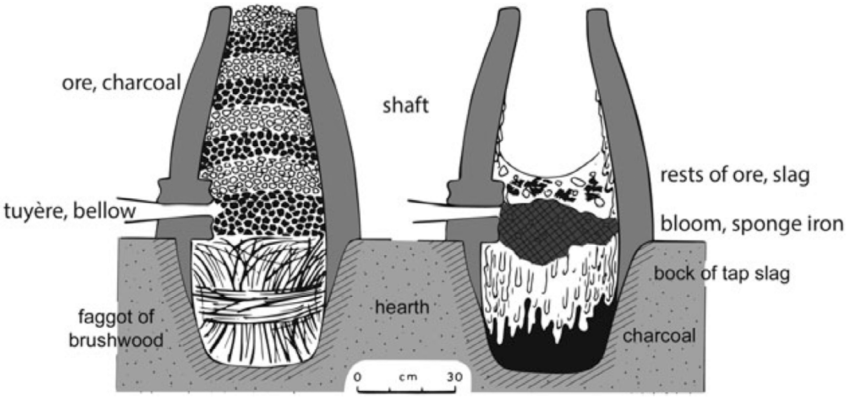


FIGURE 2.1 Furnace with Tuyere. After Hauptmann, 2020. *Archaeometallurgy – Materials Science Aspects*. Cham, Switzerland: Springer

one for removing slag, and a higher one, known by the modern term 'tuyere', in which the nozzle of the bellow was inserted and the air was blown into the upper level to burn charcoal.

In archaic Greek smelting furnace only these two openings could be called ἐκπνοαί 'vents' or στόμια 'mouths', 'apertures'. The iron ore was placed under the charcoal and the droplets of metal smelted out of the ore collected at the bottom and formed a lump that the Greeks called μύδρος. Here we see the processes of *diakrisis* and *synkrisis* of *semina rerum* caused by the action of heat. When the hole is open, it 'reveals' fire (ἐκφαίνει πῦρ) raging inside the furnace. When it is closed by the nozzle of the bellows, it makes the fire invisible, and in the same way the disk of the sun becomes invisible when it is covered by the dark *aer*. Modern recreations of the ancient iron smelting technique visualize Anaximander's 'blow-tube' or 'tuyere' (πρηστὴρ αὐλός) in the upper part of the furnace, Anaxagoras' 'hot red' lump of iron (μύδρος πεπυρακτωμένος) and the 'slag' (τρύξ) removed from the lower 'exhaust' (ἐκπνοή) of smelting κάμινος (aka βαῦνος).[45] Was this comparison isolated in Anaximander's text, or was it part of an extended metallurgical analogy that modeled the entire cosmogonic process? There are several indications of the latter in the texts. At the same time, one should not try to find an exact correspondence of all elements,

45 See, e.g., the following videos and photos on You Tube. (1) by UCL Quatar research group in Sudan: https://www.youtube.com/watch?v=SPU8Uwa-jBQ&t=320s. (2) spectacular video with archaic pair of bellows by Polish enthusiast Maciej Tomaszczyk: https://www.youtube.com/watch?v=uO6HXn18x8A; (3) by Anita Chawdry: https://anitachowdry.blog/2014/07/30/the-ancient-art-of-smelting-iron-in-a-bloomery/.

Anaximander chose and used what best served the explicative tasks of presenting his theories.

It is significant that Anaximander already described the initial stage of the cosmogonic process in terms of the preliminary processing of the ore, which precedes the actual metallurgical stage: see section (IV) above. It doesn't matter that it was about washing gold. The iron ore is also milled and washed before smelting, but gold-washing probably provided a better analogy with separation by vortex (panning). The observations themselves over the technological processes of transformation of ore, as well as over the processes of nutrition (Anaxagoras speaks directly about this in A45), suggested that the primordial substance from which the world originated is a 'mixture' of various seeds (*panspermia*), and that the process of material change is a mechanical "excretion – separation – coalescence etc." of particles. We have seen how important was the role of the "vortex" theory in Anaximander's cosmogony. In his cosmology and celestial mechanics, vortex motion continues to play an equally important role. The very rotation of the celestial wheels of the luminaries is a continuation of the original whirlwind. It was the vortex motion that determined the cylindrical shape of the earth and of the "wheels", which in a certain sense are '*aeric*' streams, relics of the primordial great vortex.[46] Attention should be paid to the fact that the base of many ancient iron-making furnaces was a marble circle, similar to a cut of a stone column (often, this is all that remains of them). These hard and heavy bases are at the bottom of the furnace, while the blazing fire of coals is above, like the sun above the earth. The third explicitly attested metallurgical analogy in Anaximander's meteorology in his theory of the nature of the winds also suggests a general explanatory model of 'the cosmos as a melting furnace': SP-Placita III 7, 1 (12A24 DK; III, 1245 MR) Ἀ. ἄνεμον εἶναι ῥύσιν ἀέρος τῶν λεπτοτάτων ἐν αὐτῶι καὶ ὑγροτάτων ὑπὸ τοῦ ἡλίου κινουμένων ἢ τηκομένων. "Anaximander [holds that] wind is a flux of air [produced] when the thinnest and wettest [particles] in it are set in motion or *melted* by the Sun". Τήκειν was a common metallurgical term both for melting (liquefying) metals in crucibles and for smelting (extracting) metals from ore in a smelting furnace (Blümner 1912, IV.109).

Anaximander's metallurgical analogies in cosmology have been adopted and elaborated on by several *physikoi*. In Archelaus heaven and earth, including the four *maxima membra mundi* (earth, sea, air and celestial fire), after preliminary stage of mechanical *diakrisis* of the hot and the cold (presumably by

46 In the Greek language the word τροχοί itself was semantically associated in certain contexts with δίνη, cf. Achilles, *Isagoga*, 28 (On the axis of cosmos) δινεῖται ὁ οὐρανὸς, ὥσπερ περὶ ἁρμάτειον ἄξονα δινοῦνται οἱ τροχοί.

vortex as in Anaximander), is modelled on three consecutive stages of smelting and further refining (like metals): first is produced by melting (τηκόμενον) the sea, which, like an alloy, is split into earth and air by 'roasting', and finally from the air by further 'extraction by roasting' is produced the finest and purest substance the Sun, the Moon and the stars:

> Hippolytus, *Refutatio omnium haeresium* 1.9,2–3 (p. 15, 5–13 Wendland = 60A4 DK). Εἶναι ἀρχὴν κινήσεως ⟨τὸ⟩ ἀποκρίνεσθαι ἀπ' ἀλλήλων τὸ θερμὸν καὶ τὸ ψυχρόν, καὶ τὸ μὲν θερμὸν κινεῖσθαι, τὸ δὲ ψυχρὸν ἠρεμεῖν. **τηκόμενον** δὲ τὸ ὕδωρ εἰς μέσον ῥεῖν, ἐν ᾧ [καὶ] **κατακαιόμενον** ἀέρα γίνεσθαι καὶ γῆν· (3) ὧν τὸ μὲν ἄνω φέρεσθαι, τὸ δὲ ὑφίστασθαι κάτω. τὴν μὲν οὖν γῆν ἠρεμεῖν καὶ γενέσθαι διὰ ταῦτα· κεῖσθαι δὲ ἐν μέσῳ, οὐδὲν μέρος οὖσαν, ὡς εἰπεῖν, τοῦ παντός· ⟨τὸν δ' ἀέρα τῇι γῆι περιρρυῆναι⟩[47] **ἐκδεδομένον**[48] **ἐκ τῆς πυρώσεως.**[49] ἀφ' οὗ πρῶτον **ἀποκαιομένου**[50] τὴν τῶν ἀστέρων εἶναι φύσιν, ὧν μέγιστον μὲν ἥλιον, δεύτερον δὲ σελήνην, τῶν δὲ ἄλλων τὰ (5) μὲν ἐλάττω, τὰ δὲ μείζω.
>
> The beginning of motion is the separation from each other of the hot and the cold. And the hot is in motion, whereas the cold is at rest. Water, *being melted*, flows towards the center, in which, *after being submitted to firing*, it turns into air and earth. The former moves up, the latter settles down. And so, the earth remains at rest and it was formed in this way. She rests in the center, being, so to speak, a negligible part of the Universe. And the air, resulting from the *roasting*, encircles the earth from all sides. It is from the air, which has been first *submitted to firing*, that derives the substance (*physis*) of the stars, the largest of which is the sun, the second in size the moon, and the rest are some smaller and some bigger.

We can now better understand the origin of the theory of Metrodorus of Chios that 'the earth is a sediment and 'slag' of water, and the sun of the air': τὴν μὲν γῆν ὑπόστασιν εἶναι καὶ τρύγα τοῦ ὕδατος, τὸν δὲ ἥλιον τοῦ ἀέρος.[51] Metrodorus reproduces Archelaus' theory of the splitting of the water (a kind of alloy)

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47 ⟨τὸν δὲ ἀέρα τῇι γῆι περιρρυῆναι⟩ supplevi; ⟨τὸν δ'ἀέρα κρατεῖν τοῦ παντός⟩ Roeper & Diels, acc. Wendland, DK.

48 Ἐκδιδόναι μέταλλα κτλ. (γῆν); LSJ, s.v. I.9: 'return, yield, produce' Strabo, 5.2.5.

49 πυρόω can mean 'melt', e.g., silver plates; it is also used of gold, LSJ, II,3: πεπυρωμένος χρυσός 'tested, proved by fire'. Σίδηρος πεπυρωμένος is a set phrase for red-hot iron in forge etc. (Plut. *Moralia* 1116A, many more instances in TLG online).

50 'To burn off', to reduce to ashes, used for 'calcine' in Dioscorides 5.125. Here probably implies 'eliminating all admixtures' in refining.

51 SP-Placita III,9,5 = DK 70A20.

into earth and air by heating', and subsequent 'smelting' of the Sun out of the air. Τρύξ, gen. τρυγός is a metallurgical *terminus technicus* for 'slag'[52] produced in smelting. Archelaus is credited in doxography with a conception of stars (probably in broad sense, including the Sun and the Moon) as 'ignited lumps' of metal: SP-Placita II 13, 6 = 60 A15 DK Ἀρχέλαος μύδρους ἔφησεν εἶναι τοὺς ἀστέρας, διαπύρους δέ. It is natural to compare the earth with 'slag' and the sun with a blazing *mydros*, but the comparison of the sun with 'slag' in the doxa Metrodorus must be a result of doxographer's confusion.

Theories of matter and cosmogonies of Anaximander, Anaxagoras, and Archelaus are closely related and based on the same principles of mechanistic determinism (with a slight deviation in Anaxagoras' theory of Mind), Infinite Universe with innumerable worlds, cosmogonic vortex etc. continued by Democritus and Epicurus. However, Anaxagoras' astrophysics significantly differs from that of the Milesians in that it broke with the archaic 6th century 'meteorological' view of stars as 'fire' or 'clouds' and introduced the new concept of celestial solid 'bodies' and of moon as a 'heavenly earth'. We have seen that Anaxagoras adopted Anaximander's theory of *diakrisis* of panspermia modelled on gold-washing. The early Ionian model of 'cosmic furnace' reconstructed above was also well known to Anaxagoras and his disciple Archelaus, and this provides a new context for Anaxagoras' famous doctrine of the Sun as μύδρος πεπυρωμένος (a red-hot lump of metal) which was raptured from the earth by the cosmogonic vortex and thrown into its orbit. Μύδρος is a technical term from the 'crafts' of metallurgy and metal-work (smithery), referring to an unshaped 'lump' or block of iron, often a hot-red lump of iron, although in cold state it could also be used as anvil in smith's shop. This was most probably an authentic word used in Anaxagoras' book.[53] It is worth noting that, strictly speaking, Anaxagoras' theory of the iron sun was not based on analogy: he believed that the sun is indeed was made of iron, and he most probably arrived at this conclusion 'concluding on the ground of the evidence' (τεκμαιρόμενος) of the meteorite of Aegospotami which he took as a *tekmerion*, a specimen coming from the region of the sun: presumably, it had a porous iron texture. Something very similar to Anaxagoras' and Archealus' μύδροι seems to be Diogenes' of Apollonia conception of stars and the sun as 'pumice like' (κισηροειδῆ), i.e., with porous texture; the stars are also said to be 'vents of the cosmos' (διαπνοαὶ τοῦ κόσμου), terms reminiscent of Anaximander's ἐκπνοαί of

52 Blümner 1912, IV.110 and note 7.

53 In later doxography and biographical sources it was often supplanted by less technical and familiar words like βῶλος or πέτρος 'rock'.

the τροχοί.[54] The fixed stars are holes in the firmament which, as in Anaximander, 'reveals' the fire hidden behind them. Galen uses the words ἐκπνοή 'vent', διαπνεῖσθαι in his analogy between the work of furnace and respiration.[55]

The crafts of metallurgy and metal-works supplied analogies not only for the 'separation' of material mixture into compounds (*diakrisis*), but also for the reverse process of 'blending' simple stuffs and making 'alloys.' In Empedocles, Harmonia-Philotes combines in 'spacious crucibles' three elements in certain proportion to produce 'white bones' (B96). The analogy is probably suggested by the production of 'hard metal' (bronze or brass) from softer metal (copper) by alloying it with tin or zinc, although the proportions used by Philotes for bones seem to be symbolical: two parts of earth, two parts of fire, four parts of water. Analogies from other manufacturing crafts employing furnace and heating technologies, like ceramic works and glass-making, were also used. Irini Viltanioti (2014) has suggested that a passage in Plato's *Timaeus* (60d2 on τὸ μέλαν χρῶμα ἔχων λίθος) describes the production of Attic black gloss pottery, but the common alternative Greek word for κέραμος for the material of potters was πηλός, never λίθος (Blümner 1912, 11.7). And besides, κέραμος cannot be "melted" and liquefied (χυτή). It is therefore more likely that the liquefied and solidified 'stone with black color' refers to basalt as was suggested by Lindau (quoted by Taylor, Commentary on *Timaeus*, 424) or rather, I would guess, to rock-crystal.

6 Analogies between Material Change and Melting (Casting, Shaping, Reusing) Metals

Analogies with smelting (metal extraction from ore) should be distinguished from analogies with melting (liquification) of already produced metal. Strictly speaking, only the former are 'metallurgical', whereas the latter pertain to the sphere of 'metalworking'. The Greeks distinguished χαλκωρυχεῖα (or simply μέταλλα) for mining works, χαλκουργεῖα (σιδηρουργεῖα) for processing ore and metal production, and χαλκεῖα, ordinary smitheries, for all kind of working

54 64 A12–13 DK.

55 Galen, *De utilitate respirationes* 4,491 K. ἐγὼ δέ ποτε καὶ κάμινον ἰδὼν σβεννυμένην ὑπὸ τοῦ μὴ διαπνεῖσθαι, κἄπειτ' αὐτὴν παρανοιχθεῖσαν ⟨καὶ⟩ πολὺ μὲν αἰθαλῶδες ἐκπνεύσασαν, πολὺν δ' ἔξωθεν εἰσπνεύσασαν τὸν ἀέρα καθαρὸν ἐπ' ἀμφοτέροις ἀναλάμψασαν, οὐ μικρὰν οὐδὲ τῆς ἐκπνοῆς | ἐλογισάμην εἶναι τὴν χρείαν κτλ. However, Hahn 2010: 212–214 goes too far overstating the alleged 'hylozoistic' connotations of these technical terms. A glance at Greek lexica will show that πνέω, πνοή, πνεῦμα originally (in Homer and archaic poetry) are used of 'blowing' and wind, and only centuries later start to be used of human breath.

metals and production of utensils and metal artefacts (Blümner IV, 163. 323). Only the latter were a part of everyday life in Greek polis, metallurgical installations were usually located outside the city close to mines.

Pure metals of certain kind (copper, bronze, gold etc.) were melted in crucibles (χόανοι from χέω) for casting and molding in molds of various shapes. Ancient furnaces could not achieve the high temperature of melting iron (1539°, technologically impossible before 19th century), iron could only be made soft by heating and shaped by hammering. Greek words for melting were τήκειν and χέειν, hence χόανος 'crucible' and its derivative χοανεύω (contracted form χωνεύω), as well as καμινεύειν, ἕψειν, ὀπτᾶν etc. (Blümner IV, 109; 278). Χόανος was used both for crucibles and melting furnace as a whole, syn. κάμινος.

In modelling cosmogonical processes, analogies with smelting were suitable for the mixture-type theories of primordial matter: the various simple stuffs were 'separated' or excreted (ἀποκρίνεσθαι) from panspermia just as iron or copper are extracted from ore. But they were not suitable for single-element theories of matter conceived as homogeneous stuff like those of Anaximenes or Diogenes. It was more natural to compare the transformations of the single original *physis* into various bodies with the process of melting and casting, taking different forms and shapes. The description of Anaximenes cosmogony in Hippolytus (A7 DK) is of high quality and possibly preserves traces of original wording in *Refutatio* 1.7.3 ὅταν εἰς τὸ ἀραιότερον **διαχυθῇ**, πῦρ γίνεσθαι … "when [the original homogeneous air] is melted [dissolved or liquefied] into more rarefied state, it becomes fire …". Διαχεῖσθαι, δίαχυσις (like the simple verb χεῖσθαι) is used in the sense of 'melting' in a number of contexts relating to metalwork.[56]

In his treatise *De Caelo* Aristotle, inter alia, speaks of those who identify the material principle with fire and subdivides them into two groups: those who attribute to the particles of fire a geometrical form (pyramid) and those who just make fire an *arche*:

> Οἱ δὲ περὶ μὲν σχήματος οὐδὲν ἀποφαίνονται, λεπτομερέστατον δὲ μόνον ποιοῦσιν, ἔπειτ' ἐκ τούτου συντιθεμένου φασὶ γίγνεσθαι τἆλλα **καθάπερ ἂν εἰ συμφυσωμένου ψήγματος** (*De Caelo* 304a 9).
>
> Others say nothing about the figure of fire, but only accept that it consists if the smallest parts, and then, as they say, from the fire – in the process

56 Strabo 3.2.8 Discussing the smelting of pure gold from electrum: ἀχύρωι τήκεται μᾶλλον χρυσός, ὅτι ἡ φλὸξ μαλακὴ οὖσα συμμέτρως ἔχει πρὸς τὸ **διαχεόμενον** κτλ. Pausanias 9.41.2 Σαμίους εἶναι τοὺς **διαχέαντας χαλκὸν** πρώτους. "Samians were the first to melt bronze."

> of its composition – other things are generated *as if from the melting of gold sand*.

The first view is that of Pythagoreans (Hippasus) with allusion to Plato in *Timaeus*, the second can only be the view of Heraclitus. I have attributed the neglected fragment to Heraclitus (Lebedev 1979) and included it in my edition of Heraclitus fragments (2014: 202–203) with number 116. Ψῆγμα ('scrapings') in Ionian usage means gold sand, συμφυσάω is a word from the lexicon of smiths, it could mean 'weld together' and 'melt', like Latin *conflare*. Heraclitus probably adduced this 'case at point' in the series of other *tekmeria* from various crafts. Gold-smiths imitate nature by producing from the same gold (ταὐτόν) new figures (ἕτερον).

Aristotle in another passage of *De Caelo* gives an interpretive paraphrase of this quotation, connecting it with *ex nihilo* principle: the eternal *arche* is preserved in all changes of shape: *De Caelo* 298b32: Οἱ δὲ τὰ μὲν ἄλλα πάντα γίνεσθαί φασι καὶ ῥεῖν, εἶναι δὲ παγίως οὐθέν, ἓν δέ τι μόνον ὑπομένειν, ἐξ οὗ ταῦτα πάντα μετασχηματίζεσθαι πέφυκεν· ὅπερ ἐοίκασι βούλεσθαι λέγειν ἄλλοι τε πολλοὶ καὶ Ἡράκλειτος ὁ Ἐφέσιος. "Others say that all things are becoming and flow, and nothing is stable, but there is something one only that remains /the same/, from which all these things are produced by reshaping. This seems to be the meaning of the teaching of Heraclitus from Ephesus and many others."[57]

Analogies between transformations of original *physis* in cosmogony and melting, casting, and creation from reused materials of new 'figures' may have been not only a didactic image (illustration), but an observation that served as empirical ἐπαγωγή (inductive argument) and contributed to the formulation of general law of preservation of matter starting with Anaximander B1.

7 Analogies from Felting/Working Wool in Anaximenes and Heraclitus

In Anaximenes the cosmogonical process was conceived not as a separation of panspermia, but as "compression" and "rarefaction" of a single homogeneous stuff, *aer*. Anaximander's analogy of gold-washing as *diakrisis* was unsuitable for this theory, which is why Anaximenes ingeniously substituted for it another

57 Imitation in *De diaeta* 1,20 and Plato, *Timaeus*, 50a. Plato, *Timaeus* 50a. εἰ γὰρ πάντα τις σχήματα πλάσας ἐκ χρυσοῦ μηδὲν μεταπλάττων παύοιτο ἕκαστα εἰς ἅπαντα … The compiler of *Placita* 1,13,2 misunderstood ψήγματα as 'minima' (ἐλάχιστα) and made Heraclitus an atomist.

analogy, that of *spinning* and felting wool (πίλησις A7.§3). Elaborating on this imagery, he compared the 'revolving' of heavenly vault around earth with that of a felted hat around head (πιλίον ibid. §6). The analogy with felting substitutes image of a single homogenous stuff (wool) for Anaximander's 'mixture' of various 'seeds' and at the same time preserves the explanatory function of rotational motion as a mechanism of transformation of matter (compression). At the same time, he retained the importance of the vortex-like motion (δίνη) by comparing it with spinning wool: felting is impossible without preliminary spinning.

Miletus was an important center of textile industry, the Milesian chitons made of wool cloth were famous throughout the Greek world. Anaximenes had good opportunity to observe with his own eyes the work of γναφεῖς whose specialty was not only to clean and repair, but also to make clothes.

Hippolytus has preserved the unique description of the work of Ephesian fullers as observed by Heraclitus: Heraclitus fr. 113 Lebedev (B59) = Hippolytus, *Ref.* IX,10,4, the text as restored in my edition (2014: 198–199):

> **Γναφέων ⟨ἵπου⟩ ὁδὸς εὐθεῖα καὶ σκολιὴ** {ἡ τοῦ ὀργάνου τοῦ καλουμένου κοχλίου ἐν τῶι γναφείωι περιστροφὴ εὐθεῖα καὶ σκολιή· ἄνω γὰρ ὁμοῦ καὶ κύκλωι περιέρχεται}, **μία ἐστί, φησί, καὶ ἡ αὐτή.**[58]
>
> *The way of ⟨the press of⟩ fullers is straight and curved* {the rotation of the instrument in the fuller's shop is straight and curved, since it moves up and by circles at the same time}, *one and the same*.

I take at face value Hippolytus' explanatory remark and restore the name of the implement lost in the transmission of MSS, the fullers' screw press depicted in a fresco from Pompeii.

Excursus. *"Heaven Is an Oven, Men Are Embers": the Sources of Aristophanes' Parody of Ionian Cosmology in the* Clouds*, 96*

In the opening scene of Aristophanes' *Clouds* Strepsiades introduces to his son the "Thinkery" of Socrates with these caustic remarks: *Clouds* 94–96 ψυχῶν σοφῶν τοῦτ' ἐστὶ φροντιστήριον. / ἐνταῦθ' ἐνοικοῦσ' ἄνδρες, οἳ τὸν οὐρανὸν / λέγοντες ἀναπείθουσιν ὡς ἔστιν πνιγεὺς / κἄστιν περὶ ἡμᾶς οὗτος, ἡμεῖς δ' ἄνθρακες. "This is

58 γναφέων Dunker, Bywater, Zeller: γραφέων P, acc. Kirk 97, Guthrie: γνάφων Marcovich, acc. Kahn: γναφείωι Bernays, Diels-Kranz, Conche alii || ἵπου supplevi || γραφείωι P: γναφείωι Bernays fere omnium consensu || περιέρχεται Roeper: περιέχεται P.

a thinkery of wise souls. Here live the men who try to convince us, saying that heaven is a stove cover that surrounds us, and we are embers."

According to the scholiast, this parody was used before Aristophanes by Cratinus in *Panoptai*, who mocked the philosopher Hippon.[59] The purpose of Cratinus' parody was to expose the 'impiety' (*asebeia*) of Hippon, his denial of divinity of heaven and of Olympian gods. Aristophanes' purpose is the same: the first thing Socrates tells Strepsiades after he enters the school, is "gods are not an accepted currency for us", with intentional ambiguity of the word νόμισμα (v. 242). Other scholia on this passage take the image of 'stove cover' with a reference to the all-surrounding 'air' enclosed in a hemispherical *pnigeus* of *ouranos*.[60] In other scholia the rare classical word πνιγεύς is often rendered by more familiar words for 'stove' or 'oven' κάμινος, φοῦρνος, κλίβανος. This is a common feature of resemblance with the 'cosmic furnace' analogy in the early Ionian cosmogony (Anaximander, Archelaus, Diogenes of Apollonia, Metrodorus etc.) reconstructed above.

The differences, however, are essential. In the first case we have a strictly physical-cosmological analogy between 'separation' of the original material 'mixture' and the metallurgical process of smelting metal from the ore by heating. In a smelting furnace 'embers' are placed in the upper region (and correspond to the sun), whereas in a *pnigeus* they are placed at the very bottom under a ceramic cover. The image of *pnigeus* in the parody of Aristophanes and in Hippon (Cratinus) is rather 'anthropological' and biological: it explains the survival of living beings in the atmosphere with, so to speak, regulated temperature. The regular 'raising and lowering' the cover of a barbecue oven supports the 'life' of the gleaming embers and retains the necessary heat. The same beneficial effect for living organisms is produced by the regular alternation of day (heat) and night (cold) in the cosmos.

Analogy between the humans and 'embers' is explicitly attested for Heraclitus by Sextus Empiricus *Adversus Mathematicos*, VII.130 ὅνπερ οὖν τρόπον οἱ ἄνθρακες πλησιάσαντες τῶι πυρὶ … διάπυροι γίνονται, χωρισθέντες δὲ σβέννυνται, οὕτω καί κτλ. "Just as embers coming close to fire become ignited, and separated from it extinguish," so the human soul becomes intelligent in after wake up etc. The attribution of the simile to Heraclitus is made certain by an independent reflex in the imitation of Heraclitus in ps. Hippocrates, *De Diaeta* I.29. I therefore include the passage from Sextus and parallels in my edition of Heraclitus

59 *Schol. Nub.* 96d Holwerda ταῦτα πρότερος Κρατῖνος ἐν Πανόπταις δράματι περὶ Ἵππωνος τοῦ φιλοσόφου κωμῳδῶν αὐτὸν λέγει.

60 See images of 'baking covers' from Athenian agora in Sparks 1962, Plate IV,2; also reproduced in Picot 2013, 113.

as independent fragment 75A from the same original context as fragment 75L/B26 which I restore on the basis of Clement's paraphrase as follows: ἄνθρωπος εὐφρόνη φάος· ἅπτεται ἑῶιος ἀποσβεσθεὶς ὀψίας. ζῶν δὲ ἅπτεται, τεθνεῶτος, εὗτε ἐγρηγορὼς ἅπτεται, εὕδοντος "man is night and light: he kindles up in the morning after going out in the evening. And he kindles up alive after he has died, just as he kindles up awaken after sleep." In Heraclitus the main point of the analogy is the parallelism of micro- and macro-cosmos: man, like all other living beings "follows" (ἕπεται or μιμεῖται) the same law of cyclical alternation of opposite states (ἅπτεσθαι and ἀποσβέννυσθαι) of the divine 'ever-living fire.'

The anecdote of Heraclitus 'warming himself at the stove' (θερόμενος πρὸς τῶι ἰπνῶι) quoted by Aristotle in *On the Parts of Animals*,[61] contains a pantheistic message 'all is full of gods' (πάντα πλήρη θεῶν); like some other 'episodes' in his biography it may well be based on the text of his book. The word ἰπνός, like πνιγεύς, is closely associated with the kitchen and could be metonymically used for 'kitchen' (μαγειρεῖον). However, ἰπνός is regularly glossed by grammarians as φοῦρνος, i.e., a solid closed construction, not a charcoal grill with a cover.

It would therefore be a mistake to attribute to Hippon Heraclitus' natural theology. Hippon had a reputation of an 'atheist', he did not believe in a cosmic mind like Heraclitus or Anaxagoras. Aristotle dismisses him with contempt for his 'cheap thought' (εὐτέλεια τῆς διανοίας; *Metaphysics* 984a30), having in mind his radical sensualism and materialist identification of the soul with the liquid sperm. The doxography on Hippon's first causes is divided: one group (based on Aristotle) attributes to him water as *arche*, another, represented by the best doxographical source Hippolytus and by Sextus, probably derives from Arius Didymus and is based on the fresh reading of Hippon's original text.[62] In these reports Hippon's cosmogony is described as an interaction of two elements: fire as active force, and water as passive and 'nourishing' element. This two-elements cosmogony is strikingly similar to the first book of ps.-Hippocrates '*On Diet*', which is based on Heraclitus. It seems therefore very likely that both Hippon and the author of '*On Diet I*' depend on Heraclitus as a common source: all psychology of Heraclitus is based on the juxtaposition of 'dry' and 'wet' elements, the first intelligent and wise, the second irrational and connected with sensuality and passions. Hippon borrowed from Heraclitus the analogy between 'embers' and humans, but gave it a physiological rather than theological meaning.

61 *De part. anim*. 645a 20 ff. = Heraclit. Fr. 117 Lebedev.

62 Hippon 38 A3, A5 DK.

We conclude that Heraclitus was the original source of the 'stove and embers' analogy in Greek philosophy just as Anaximander was the original source of the 'smelting furnace' cosmogonical model. Both versions of 'cosmic furnace' analogy originated in Ionia. According to the most reliable evidence of Aristoxenus, Hippon was a native of Samos, i.e., an Ionian.[63] The 'meteorological' doctrines put by Aristophanes into the mouth of Socrates in the *Clouds*, like those of the surrounding cosmic Air, the cosmogonic vortex etc., are those of the Ionian sophist Prodicus of Ceos; they are paralleled in the Derveni papyrus, which is most probably a remaining part of Prodicus' *Epochs*.

One should not expect from Aristophanes' comedy a precise exposition and differentiation of these two versions, as his main purpose was a comic effect. A kitchen charcoal grill with a top was a familiar part of everyday life in every Athenian house. Metallurgical furnaces were placed far away from the city in the close proximity with the mines, as smelting was a technical equipment known to specialists. The 'cosmic furnace' model plays a pivotal role in the cosmogony of Archelaus. The viewers of the *Clouds* in the theater of Dionysus were familiar with the Athenian gossip about intimate relations between Socrates and his 'teacher' Archelaus (60 A 3 DK). It is conceivable therefore that to achieve a comic effect and to allude to Socrates' relations with Archelaus, Aristophanes either confused two images or substituted the familiar kitchen stove for a smelting furnace, putting into Socrates' mouth the extravagant doctrine of his teacher and *erastes*. Both the kitchen stove and the smelting furnace are occasionally referred to by the same Greek word κάμινος 'oven', and both imply the use of charcoal. Archelaus, like Hippon and Anaxagoras, must have been a refugee from Ionia: this explains Ἀθηναῖος ἢ Μιλήσιος in Diogenes, and just Μιλήσιος in Suda. His cosmogony, like that of Hippon and Hippocratic *De diaeta* 1, as well as that of the Derveni papyrus (Prodicus), is also based on the interaction of two elements: active θερμόν and passive ψυχρόν (60 a 1, §17; A4, §2). This explanatory model, alongside with the infinite Universe and vortex theory, goes back to Anaximander. Therefore, Archelaus was 'Milesian' both by birth and by his philosophical affiliation.

63 *Ap.* Censorinus, *De die natali* 5,2 = Hippon A1 DK. 'Metapontinus' derives from confusion with Hippasus the Pythagorean, Metapontinus and Ῥηγῖνος just continue the confusion. Diels wrongly placed in *vs* the chapter 'Hippon' in the group of Pythagoreans. The Pythagorean philosophy was religious philosophy *par excellence*, no Pythagorean was ever accused of atheism or included in the ancient lists of 'those who deny the existence of gods'.

In a special study of *Clouds*, 96, Jean-Pierre Picot (2013) tries to trace the image of *pnigeus* back to Empedocles through a chain of arguments all of which are invalid. The first mistake is his premise that the 'first' who invented this image was not Hippon, but Cratinus (p. 119). But could Cratinus parody his own image invented ad hoc? This premise is based on the misreading of Greek: πρότερος in the scholia does not mean 'first' in absolute sense, but someone *before* or *preceding* Aristophanes. The scholiast is concerned not with history of this image in Greek philosophy, but only with its use in comedy: Aristophanes's parody of Socrates was preceded by similar parody of Cratinus targeting Hippon. The second mistake is to dismiss without a single objection the explicit evidence of Sextus on the analogy between men (*anthropoi*) and charcoals (*anthrakes*) in Heraclitus (p. 114–115). As said before, doxographers do not invent picturesque analogies and metaphors, they usually eliminate them in their summaries, and there is a striking parallel in the story of Heraclitus 'warming himself' at kitchen oven (ἰπνός). The third mistake is the far-fetched and unconvincing attempt to find non-existing traces of this image in Empedocles (p. 123 ff.). The eschatological Orphic-Pythagorean image of 'cave' (ἄντρον), the prison of immortal souls, has nothing whatsoever to do with the Ionian naturalistic analogy between oven and the cosmos, let alone with Hippon's materialist concept of human soul as sperm. The fourth mistake (p. 126 ff.) is the wrong identification of 'life-giving Hera' in Empedocles list of four elements with air rather than with earth. I disagree with P. Kinsgley on many other points, but in this particular case he is on the right side of the debate, and Picot is on the wrong. This dispute is baseless and should never have started because in all cases of the divergence between the two versions of *Placita philosophorum*, ps. Plutarch and Stobaeus, the latter always preserves the original, more complete text of the common source, whereas ps. Plutarch gives the abridged, distorted, and interpolated version. In other words, Stobaeus' version with Hera = Earth and Aidoneus = Air, is the only authentic and correct one.

8 Conclusion

As stated in the introduction, a single chain of material activities connects Ionian sea trade and colonization on the one hand with manufacturing crafts (τέχναι) on the other. The manufacturing crafts provided a new *technological epistemic paradigm* and analogical method of explanation. Fundamental legal terms and concepts, regulating trade, exchange and borrowing, reparation of inflicted damage etc. (such as ἀδικία 'damage', δίκη καὶ τίσις 'just compensation', χρόνου τάξις 'appointment of time', i.e., 'debt maturity') provided a conceptual

frame and terminology for the formulation of universal laws of nature, such as the law of preservation of matter (known later as ἐκ μηδενὸς μηδὲν γίνεσθαι …) in all material change conceived as exchange: Anaximander B1 DK.[64]

The interconnection of colonization and trade is paralleled by the interconnection of trade and industry, i.e., manufacturing crafts which the Greeks called τέχναι. We have seen that technological analogies from metallurgy and textile industry played important role in the cosmology and theories of material change of the Ionian *physikoi*. The mathematical and natural sciences founded and pursued by them, such as geometry, astronomy, geography and cartography, meteorology, geology, mineralogy served the practical needs of the Milesian colonization and seafaring. They have extended the exploration and mapping of the geographical world that was of vital importance for the economy of Miletus into exploration and 'mapping' of the physical world as a whole.

The appropriation of artisanal knowledge by scholars and natural scientists has been widely discussed in the historiography of modern science and the Scientific Revolution in the 16–17th centuries, especially in connection with the program of 'history of trades' (i.e., τέχναι) adopted in 1660 by the Royal Society of London, following the project and recommendations of Francis Bacon.[65] It is worth noting that the use of term "history" in Bacon's project in the sense of empirical research with a collection of all pertinent facts about subject, goes back to the early Ionian meaning of the word in ἡ περὶ φύσεως ἱστορία, which survives in the titles of Aristotle's zoological (Περὶ ζώων ἱστορίαι) and Theophtrastus' botanical works (Περὶ φυτῶν ἱστορίαι). We have seen that in 6th century Ionia such a process of appropriation indeed took place. Greek cosmologists learnt more from a smelting furnace than they could learn from Hesiod and all traditional Greek lore. As Craddock put it, "the familiar adage of the Industrial Revolution, 'Science owes more to the steam engine than the steam engine owes to science,' could well be expressed in the classical world as 'Science owes more to mining than mining owes to science'."[66]

64 For detailed refutation of Burnet's 'meteorological' interpretation (no mention of 'opposites' in the quotation!) and Jaegers fanciful 'ordering of Time' (TLG whole corpus proximity searches fail to provide a single instance of τάξις 'verdict of judge') see Lebedev 2022. All ancient readers understood the text with reference to ἀναστοιχείωσις, inevitable resolution of all composite bodies into constituent elements, and χρόνου τάξις as 'in a set time', i.e., according to προθεσμία.

65 On which see Applebaum 2000, 464 ff.; Ochs 1985.

66 Craddock 2008, 94.

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CHAPTER 3

Greek Ships, Seamanship, and Cosmology

Andrew Gregory

Ships were an important feature of Greek commerce and warfare, and were also interesting and sophisticated pieces of technology. Were the early Greek investigators of nature influenced by this technology? Indeed they were, sometimes in clear and evident ways and sometimes in more surprising, subtle, and interesting ways. Certainly we can find the use of many seafaring metaphors and examples in Greek science, from Anaximenes' comparison of the bright colours made by oars striking the dark water to lightning and clouds, through to Plato having the cosmos bound together by *hupozōmata*, the ropes tied around ships to make them stronger when faced with a storm. It is also significant that many early Greek thinkers (Anaximander, Heraclitus, some Hippocratics, Parmenides, Diogenes, Plato) believed that the cosmos was steered or that it steered itself, the same words being used as for steering or captaining a ship. Here it is interesting to look at Greek seafaring practice and the hierarchy of roles on board a ship to give us some traction on what steering might mean in relation to the cosmos. In particular I argue that the person in charge of steering a ship had a critical responsibility for the overall safety of the ship. In this context it is also interesting to look at comparisons between ship's captains and doctors which are to be found in the literature and also to look at Homer's Phaeacian ships, which could steer themselves and always came home safely whatever the weather.

1 Influences on Greek Thinking?

There are strong realist positions (which I support) which assert that at least some of the contents of philosophy, maths, or science are true, atemporal, free from context, and ahistorical.[1] Our knowledge of these subjects, though, and how we have arrived at it, is an entirely different issue. That surely has a history and has been the subject of interesting influences, inspirations, and contexts.

1 Barnes 1982, xii is the classical statement in relation to early Greek thought; cf. Frankfort et al. 1960.

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Unguru's seminal paper on the history of Greek mathematics argued that Greek mathematics was not modern algebra dressed as geometry, but was fundamentally geometrical in nature and that something important is lost with a simple translation into algebra.[2] Similarly I have argued that we should pay close attention to the analogies the Greeks used for natural processes, as these too are not modern ideas in different garb.[3] As I argue in the case of Anaximander, it is not merely language or imagery that show the influence of maritime technology, but the substance of this thought on some key cosmological issues as well. There has also been interesting recent work on analogies in the ancient world, showing that they often had heuristic and explanatory value making them essential parts of the account rather than being merely ornamental or disposable extras.[4]

Strong realist positions do not justify Whiggish or anachronistic approaches to the history of their subject. Solely seeking what we believe at the moment to be the correct answers among the Greeks generates a highly misleading picture of Greek thought. If we do wrongly attribute modern ideas to the Greeks, this may make them look more sophisticated and modern, but widens the gap with their predecessors, such that a 'Greek Miracle' needs to be invoked. One aim of this volume is to avoid invoking a non-explanatory 'Greek Miracle' by looking at how technology may have inspired or influenced early Greek thought on nature, denying an *ex nihilo* beginning for it. A further line I pursue in this paper is looking at influence from and reaction to the poets on maritime issues.

There is no intent here to reduce moves in the early enquiry into nature and cosmology to changes in technology, nor to advance any form of technological determinism. What is sought is an explanation of why certain ideas seemed plausible in their contexts and how those ideas may have been inspired by and anchored in technologies of the time.

It is of course very difficult to prove influence, inspiration, or reaction, though that depends on the degree of proof required. Here I try to show that maritime technology had a wide influence on poets, playwrights, enquirers into nature, and medical writers and a specific influence on a major theme in some early Greek enquirers into nature.

2 Unguru 1975, 71.

3 Gregory 2020, 12 ff. and Ch. 1 generally.

4 See Roggo-van Luijn in this volume; cf. Gheerbrant 2017, 383–385.

2 Early Maritime Analogies

It should be no surprise that in a maritime culture like the Greeks the new attempts at natural explanation from the 6th century BCE onwards should feature the sea.[5] Thales was the first, with the earth resting on water and earthquakes explained by waves.[6] Anaximander explained many meteorological phenomena naturally, lightning being a rent in a black cloud,[7] to which Anaximenes added that this was similar to what happens with the sea when oars break the surface.[8] Xenophanes explained the eerie St. Elmo's fire, which manifests itself as a blue or violet glow at the tops of masts or the ends of cross members during storms as 'small clouds which glimmer due to a certain kind of movement.'[9] Leucippus and Democritus had the motion of the waves sorting pebbles of similar shape together where like to like phenomena had previously been explained with reference to the gods.[10] Against this background, let us look at some cases where maritime technology generated key analogies and inspiration for important cosmological ideas.

3 Modularity

Robert Hahn has argued that an important aspect of early Greek architecture,[11] which can also be found in some early Greek cosmology, is the idea of the module, which can then be replicated or scaled up in the construction of the final object.[12] The key module in much archaic Ionic temple architecture work was the column diameter, which was then used to determine the proportions of the building and replicated in all the columns.[13] With Anaximander, we again have the idea of column diameter in that the earth is likened to a column and given proportions, and we then see the rest of Anaximander's

5 See also here Lebedev, in this volume.

6 See Aristotle *De Caelo* 294a28 ff. See Thibodeau in this volume for Thales and the sea.

7 Aetius III, 3, 1.

8 Aetius III, 3, 2.

9 Xenophanes fr. 39.

10 See Sextus Empiricus *Against the Mathematicians* VII 116–118, cf. Homer *Odyssey* XVII.218 'the god leads like to like' (*ton homoion agei theos hōs ton homoion*). For further discussion see Gregory 2020, Ch. 7.

11 See Hahn in this volume.

12 Hahn 2003. Modularity is also significant in relation to the gnomon, coinage, and the production of textiles.

13 Vitruvius (III,7). See Hahn 2003, 80–1, 105, 107–9, 118, 138, 150.

cosmos being generated in due proportion.[14] As Hahn emphasizes, it is not that Anaximander copied the architects, rather he 'embraced techniques and methods used by them in order to imagine the design of the cosmos'.[15] What I want to do here is suggest some ways in which modules were also used in the design and construction of ships. This is not to undermine Hahn's points about Anaximander and the architects, but rather to support them by showing that modular design and construction was not something unique to the architects. One can cite modular design in other areas as well. In numismatics, we have the *statēr* as the standard and then 1/2, 1/3, 1/12, 1/24, 1/48, 1/96 as sub-multiples of the standard. One classic use of modularity in natural philosophy was Plato's *Timaeus* with the two basic triangles of sides 1, 1, $\sqrt{2}$ and 1, $\sqrt{3}$, 2, combining to make complex triangles or squares, these combining to make tetrahedra of fire or cubes of earth or octahedra or air of or icosahedra of water. All of the phenomena of the natural world are constructed from the two basic triangles. In each case, a craftsman must make many of the module, whether that be the stonemason making many column drums, the coin maker many coins or Plato's craftsman god, the *demiourgos*, generating all the entities of geometrical atomism 'by means of forms and numbers'.[16] In each case there are strong relations of proportion as the product is built out of the modules. So as a temple was built out of proportional modules, Anaximander and Plato could envisage a cosmos generated in a similar way and exhibiting similar proportionality and aesthetics.[17]

The earliest boat designs were essentially a shell of planks with no internal bracing or support. The planks were connected in various ways, from sewing them together to more sophisticated wood joins. It was soon realised though that a much stronger boat could be made by the addition of frames, pieces of timber fitted across the bottom of the boat, matching the curve of the planks and joined to them. When we see overhead pictures of decayed boats, it is usually the frames which have survived best giving a skeleton or rib cage look to

14 Pseudo-Plutarch, *Miscellanies* 2 (= Eusebius, *Preparatio Evangelica* 1, 8, 2): 'The earth he says is cylindrical in shape and its depth is one third of its width', Hippolytus, *Refutation of All Heresies*, 1, 6, 1–7: 'The earth is suspended, not held up in any way, remaining because of the equal distance of everything. Its shape is curved, rounded, like a stone column drum.'

15 Hahn 2003, 150.

16 See Plato, *Timaeus* 53b.

17 A further consideration here is how Plato was influenced by musical technology, constructed a scale out of proportional and aesthetic musical modules (tones, semi-tones) and then generated a large scale harmony in the heavens by applying the proportions here to the orbits of the celestial bodies. See Plato, *Timaeus* 35b ff. and Gregory 2022.

the boat.[18] One Greek term for ship's frames is *pleurai*, 'ribs'. The space between two frames was effectively a module for the ship designer and constructor. It set the relevant proportions and was replicated along the length of the ship. During construction, the shipwright would score lines on the inner surface of the planking indicating where each frame would go. There are some differences with architecture here, in the sense that the curve of the ship's planking, and its beam would differ between frames, more so on merchant craft which had a broader beam and were constructed for seaworthiness and load carrying, than on warships which were significantly more slender and built for speed. It is also the case that the spacing of frames was not always entirely regular, though that may be related to other factors such as supposed cargo load or the need to support superstructure. It may also be important that ships were created from wood, which is not uniform, so the best construction might use a strong piece of wood slightly off its theoretical place where that piece of wood might lose too much strength if whittled down too far. Despite those differences, the idea of modularity is still there, with one module of the ship setting the basic proportions and being replicated as far as possible throughout the ship.[19]

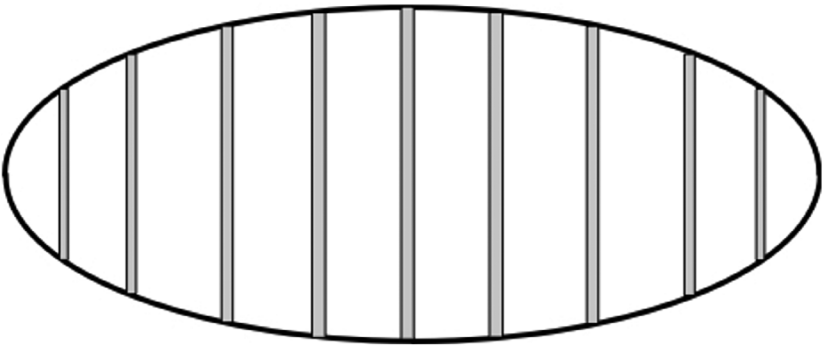


FIGURE 3.1 The first plank boats were made simply of the planks joined together to form a hull, with no internal bracing. Internal frames make the hull considerably stronger, as in the diagram. They also make the ship an instance of modular design, as each section can be seen as a module and the proportions of the first module influence the proportions of the rest and of the boat as a whole.
IMAGE BY THE AUTHOR

18 See illustrations in Casson 1971, 162, 163, 164 and 194; Morrison, Coates, and Rankov 1986, xxii.

19 In modern shipbuilding, ships may be built in modules in different yards to be assembled elsewhere, with the division mark being a frame/bulkhead. Ship designers will often refer to frames as a means of mapping out a ship, e.g., 'at frame 11'.

The second example of modularity in ship design and construction is related to the rowers and their spacing. Initially, ships had a single line of rowers on each side. Again, the spacing of the rowers can be thought of in modular terms, as the spacing was replicated to accommodate more rowers. This is all straightforward, as is the arrangement of two banks of rowers on each side of the ship, introduced sometime before the 7th century BCE to give increased speed, vital in naval engagements where the ram was the prominent weapon. Things become slightly more complex with the introduction of the trireme, around the 7th or 6th century BCE, which had three banks of rowers each side. The lowest rowers were the *thalamites*, above and forward of each *thalamite* were the *zygites* of the second bank or rowers, each of these rowing from inside the hull. Above, slightly forward of and slightly outboard of the *zygites* were the *thranites*, the third bank of rowers. They were on benches which projected over the gunwales, making them more outboard than the *thalamites* and *zygites*. The issue here is of getting as many oars in the water as possible, while allowing the rowers to generate a co-ordinated stroke together without any clashing of oars. Each co-ordinated group of *thalamite*, *zygite*, and *thranite* can be considered to be a module which was repeated along the length of the ship, where the beam would allow. A typical arrangement for an early Greek trireme would be 27 sets of this module of *thalamite*, *zygite*, and *thranite*, on each side, along with 4 further *thalamites* aft. In terms of a time line, 7th century BCE Corinth is the most likely origin of the trireme, which was gradually adopted around the Mediterranean and became the dominant naval ship type by the end of the 6th century BCE. The placing of *thalamite*, *zygite*, and *thranite* is quite intricate to allow for maximum rowing power, and generated a set of proportions for their relative placement which was replicated throughout the ship. A possible link here to architecture is the idea that the columns along the sides of temples may represent rowers. A more striking link is McEwen's hypothesis that Ionian double peristyle temples, such as those at Ephesus, Samos, and Didyma, with two rows of columns along each side, imitated two banks of rowers.[20]

To a lesser extent, a ship's hull planks can also be thought of as modules. These planks were joined to each other by mortise and tenon joints, with holes drilled through the joints for locking pins, known as *gomphoi*, to fit. This is not to suggest that the planks were of uniform size or that the proportions of one plank determined the proportions of others or of the ship (though there would be some relation); rather, that there was a standardized way of fitting the planks together to make the hull, and that there was considerable precision

20 McEwen 1993, 118–9; cf. Hahn 2001, 86–95.

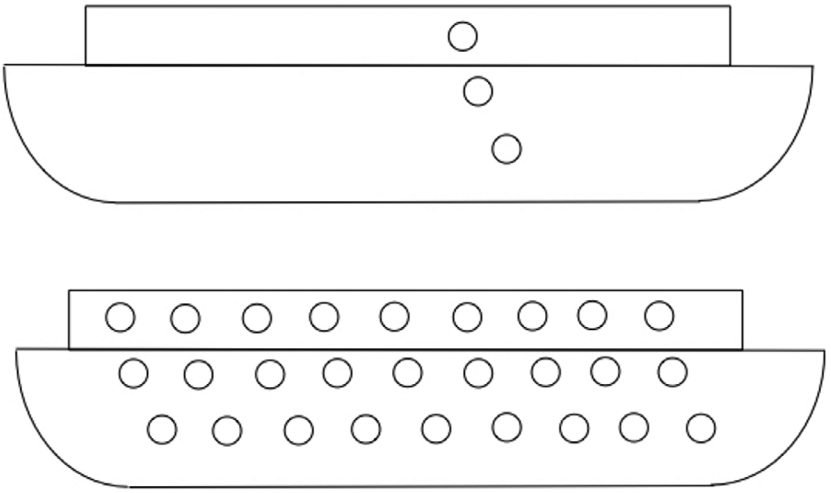


FIGURE 3.2 Rowers in a Greek Trireme. In the first diagram, we have a group of three rowers, *thalamite* at the bottom, *zygite* in the middle and *thranite* at the top. This diagram is not meant to be historically precise in terms of proportions, just to suggest that there were groups of three and there were important proportions between them. In the second diagram, the modularity of this group of three rowers can be replicated along the ship.
Note: See Casson 1971, illustrations 74, 99–102; Morrison, Coates, and Rankov 1986, xxvii, 16, 139, 239; Morrison and Williams 1968, illustrations 23–25, 31.
IMAGE BY THE AUTHOR

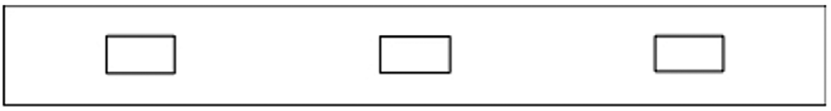


FIGURE 3.3 A ship's plank, seen from above, with the mortise holes gouged out
IMAGE BY THE AUTHOR

involved in making these joints. There is an interesting relation between this and Plato's highly modular geometrical atomism, as we shall see later.[21]

Each plank is effectively a module in the structure of the ship, even if there are variations in plank length, they will have the same height and depth and will be joined together in a standard manner.

21 The oarsmen had to be very skilled, both for rowing in unison, and placing their oars in the water as they were very tightly spaced. Trials for the *Olympias*, the modern trireme reconstruction Morrison, Coates, and Rankov 1986, 249 found that the rowing chants in Aristophanes' *Frogs* (*O opop* and *ryppapai*) to be good for rowing rhythm!

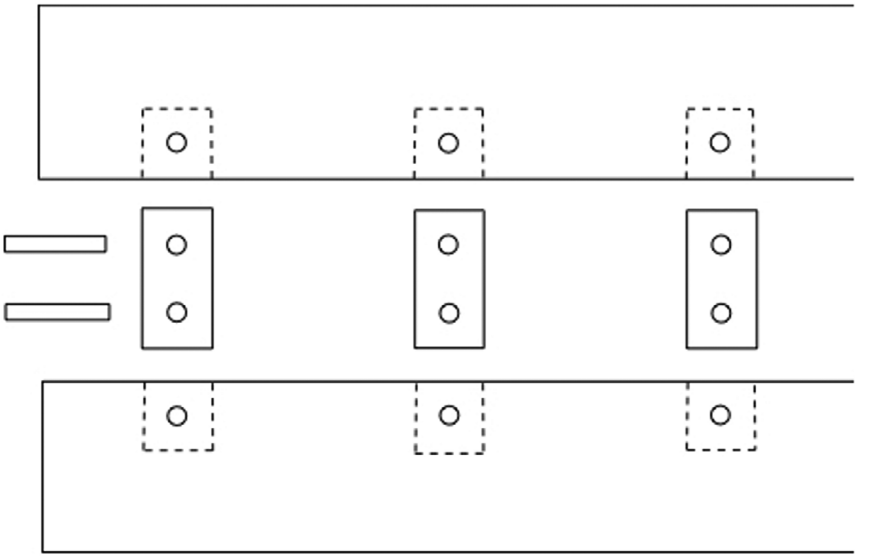


FIGURE 3.4 Ship's planks, this time seen from sideways on. Again we have the mortise holes in the upper and lower planks, this time with hatch lines. These are drilled through with holes. Between the two planks are the tenons, pieces of wood shaped to fit tightly in the mortise holes. Finally on the left are two *gomphoi*, treenails, round pieces of wood which will be driven into the holes, again with a tight fit, in order to secure the joins in place.
Note: See Casson 1971, illustrations 159–161, 166; Morrison, Coates, and Rankov 1986, 203.

The modularity of these three aspects of ship design and construction was brought home to me in constructing these diagrams. Using CAD (computer assisted drawing) one does not draw every line here. One does the outline of the boat, then one frame, then you do the rest of the frames by copy/paste and resizing. With the rowers, you do the arrangement of the rowers, make them into a group (a single CAD entity) then copy/paste these groups of three along the ship. With the planks, one does one mortise and one tenon then copy/pastes the rest.

4 Seacraft, Poets, Playwrights, Enquirers into Nature, Doctors

The central issue for this paper is how the technologies and skills associated with ships and seamanship formed an interesting material basis for early enquirers into nature to think of the world about them and cosmology more generally. However, it is also important to look at how these maritime technologies and

skills influenced early Greek poetry and playwrights. If we can establish that the early poets and playwrights were influenced by maritime technologies and skills, this lends plausibility to the idea that early enquirers into nature were as well. Homer for one clearly had a significant knowledge of ships and shipbuilding.[22] For similar reasons, we must not neglect the earlier medical writers and be open to maritime influences on their work as well. I will not say much here about the relation of the poets and playwrights to the early enquirers into nature, other than we underestimate it at our peril. The pre-Socratics and Plato quote or clearly allude to Homer and other poets and playwrights as well. I would also argue that we should not treat early medicine and the enquiry into nature as separate enterprises either. The Hippocratic *On the Sacred Disease* has much to say about nature (*phusis*), as does *On Regimen*. Plato clearly did not perceive these as separate enterprises, and when talking about skill or a right to govern, Plato often paired together a knowledgeable doctor in charge of your well being and a knowledgeable *kubernētēs* in charge of the safety of a ship against unskilled or rogue practitioners.[23] This approach is important for two reasons. Firstly, early enquirers into nature may well have been influenced by maritime technologies directly, but may also have been influenced by seafaring ideas which have been transformed by the poets. Important here, I will argue, is Homer and the Phaeacian ships which are capable of steering themselves. Secondly, while it is clear that many early Greek thinkers were interested in the idea of steering, it is not so easy to grasp exactly what they meant by this. We may be able to get some traction on this problem by looking at how steering was though of, both in terms of ships and the gods, in the early poets.

5 Knowledge or Power?

The idea of the 'ship of state', and a link between ideas of shipbuilding, seamanship, and political philosophy is well known, so I will not dwell on it here.[24]

22 Ships and life at sea feature large in both *Iliad* and *Odyssey*. In *Odyssey* v, Homer gives a very good and knowledgeable description of how to build a Greek ship. As Homer uses *schedia,* this is often thought to be just a raft, but the description, including planing trees to planks, jointing them with *gomphoi,* fitting decks to frames etc., is clearly of a ship. It is certainly not a raft in the modern castaway literature sense, of a few logs lashed together. *Schedia* is best translated in the sense of something improvised in contrast to a shipyard built *naus*. Not only is *Odyssey* v a good description of boat building, it follows the sequence in which an ancient Greek ship would have been built.

23 See Gregory 2021.

24 For some well known examples see Alcaeus (*c*.625–580) Fr. 6 and Fr. 208, Aristophanes (*c*.446–386), *Wasps* 29–30, Sophocles (*c*.497/6–406/5), *Antigone* 162–3.

I do want to point out one important theme though, which is that the authority of the *kubernētēs* should derive from knowledge rather than power. We can see this early in Greek thought with the lyric poet Theognis in the sixth century BCE. At 671–681 he complains that his companions on a voyage refuse to bail although waves are washing over the ship, and that:

> It is very difficult to be saved
> with what they are doing. The *kubernētēs* they have disposed of,
> the worthy one, who was guarding (*phulakēn*) with his knowledge.
> They seize property by violence, order has perished.
> Equitable distribution no longer obtains.
> Merchants rule, the bad are above the good.
> I am afraid that perhaps a wave will swallow the ship.
> Let these be riddles devised by me for the good
> One might come to know something bad, if one is wise.[25]

Plato, in the *Euthydemus*, picks up directly on the opening lines of Aeschylus (525–456 BCE),[26] *Seven Against Thebes*, as he has Socrates say:

> And simply as according to Aeschylus' Iambic verse, alone
> sitting in the stern of the state, steering all (*panta kubernōsa*), and
> ruling over all and making all worthwhile (*panta chrēsima poiein*).[27]

Plato's most famous use of the ship of state analogy though is *Republic* VI at 488a ff. We are asked to picture a shipowner (*nauklēros*), larger and stronger than any of the others on board, but somewhat deaf and with poor sight,[28] whose knowledge of seafaring matters is equally poor. All of the crew are squabbling for control of the steering, each claiming it is their right while none has any training. What is more, they claim that such a skill cannot be taught, being ready to cut to pieces anyone who claims it can be. There is much intrigue to depose the shipowner. The true *kubernētēs* on the other hand must give his attention to the time of the year, the seasons, the heavens, the stars,

25 Cf. also Pindar *Pythian Odes* 1:86 'Guide the people with a rudder of justice.'

26 Aeschylus, *Seven Against Thebes*, 1–3: Citizens of Cadmus' city, whoever guards the affairs of the state from the stern and guides its steering oar, with eyes not lulled to sleep, needs to speak in a timely fashion.

27 Plato, *Euthydemus*, 291d1–3.

28 Cf. Aristophanes *Knights*, 42 ff. Demos of the Pnyx is a brutal master, intolerant and half deaf.

and the winds and all else that relates to his skill. However, he is likely to be called a stargazer, a babbler and useless.[29]

Here it is important to translate *nauklēros* as ship owner rather than master or captain, as his claim to command comes through being larger and stronger than the others on board, not through seafaring skill. There is an important contrast here between a *nauklēros* and a *kubernētēs* frequently accented by Plato referring to 'a real *kubernētēs*'.[30] One might also compare the Theognis passage here, where the worthy *kubernētēs* has been disposed of, merchants rule, and the bad have the upper hand over the good.

There are of course many Platonic themes in this passage. The poor state of politics without expert/philosophical leadership, the idea that skill is real and can be taught, the idea that the person who really is expert is likely to be unrecognised, ridiculed, or ostracised. There are further comparisons between seamanship and the state throughout Plato. So at *Laws* 758a, just as a ship at sea must always have a watch set, day and night, so must the state have an unbroken succession of magistrates, day to night and night today. At *Politicus* 299a–d, magistrates will have to justify themselves and anyone can bring a charge against them that they have failed to command the ship properly, in accord with the laws and customs, during their year of office, and at 302a, states may founder like ships at sea,[31] due to the lack of skill of their *kubernētēs* or crew.[32]

6 Steering Gear

I am now going to move to discuss a more subtle influence on early cosmology, that of the idea of steering, and how the cosmos was thought to be steered. Although it may initially sound a little pedantic, there is an important point to be made about the actual steering gear of Greek ships. They were not steered by means of a stern rudder, but by a steering oar, *pēdalios*, over the side, or a pair of steering oars linked together. The sophistication, permanence, and style of the mounting varied, depending on the size of the ship and whether it was a merchantman or warship. Where an oar was used on each side of the ship, they were linked together by a bar, forming a tiller, in Greek either *kamax* or *oiax*.

29 Cf. what Plato has to say about the 'true astronomer' in *Republic* VII, and the tale of Thales tripping because his eyes were on the heavens.

30 See Casson 1971, 314 ff. on roles and names for them on a merchant ship.

31 Cf. Sophocles, *Antigone* 162–3: 'People, the gods have again safely set the state right after disturbances with much tossing on the sea.'

32 See also *Laws* 945c, which I discuss in a slightly different context below.

This may sound a little crude to the modern mind, used to a central rudder with a tiller attached or linked to a ships wheel in larger craft. However, this was a remarkably easy and efficient means of steering a ship. Casson says that:

> The side rudder has often, through ignorance, been condemned as inefficient. Quite the contrary: It is not a whit inferior in performance to the stern rudder.[33]

This can be confirmed in two ways. Firstly, replica ships using side rudders have been shown to be easily manoeuvrable, as with the case of a Viking ship, where it was said that:

> It was possible to hold the helm in position with a single finger in spite of the energetic efforts on the part of the rowers to turn the ship the other way.[34]

There is also the *Olympias* project, the full reconstruction and testing of an Athenian trireme.[35] The conclusion of those who tested the steering of the reconstructed trireme was that the ship was well balanced between masts, hull, and steering, that steering was generally unproblematic, that steering astern was not a problem, and that the ship passed a rigorous modern steering test.[36] The *Olympias* was also impressive when steered by the oars alone, that is one side rowing, the other not, a manoeuver at the discretion of the *kubernētēs*.[37]

Secondly, we have similar testimony from the ancient world. The pseudo-Aristotle *Mechanics* 850b30–35 asks:

> How is it that a *pēdalios*, which is small and set to the rear of a ship, has the capability such that the strength of one man, using a small tiller bar (*mikrou oiakos*), and doing this with ease, can produce something so great as to move the vast mass of a ship? Is it because the *pēdalios* is a lever, and the *kubernētēs* works a lever?

33 Casson 1971, 224.

34 Crumlin-Pedersen 1966, 257.

35 See Morrison, Coates, and Rankov 1986.

36 Morrison, Coates, and Rankov 1986, 247, 257, 261. The Kempf test where the helm is put over then reversed at specific later times to cause the ship to zig zag. The test gives important information on maneuverability.

37 Morrison, Coates, and Rankov 1986, 261.

Lucian, at *Navigium* 6 tells us that:

> All this vast ship and cargo, was saved by a tiny and puny old man (*mikros tis anthrōpiskos gerōn*), who turned the large steering oars with a delicate tiller (*leptē kamaki*) … his skill is wonderful, say the crew, a veritable Proteus of sea wisdom.

Lucian gives us some dimensions for this ship, the *Isis* – 180 feet long,[38] more than a quarter of that wide (so beam greater than 45 feet) and 44 feet from keel to deck. There are estimates of her tonnage based on these figures, the most reliable of which give around 1,250 tons, less than many of the estimates but still a substantial ship.[39]

The conclusion of this section is simple. It was not physically difficult to steer ancient ships, and they could be steered with some precision by a single person. It required skill, certainly, but it was not physically hard to do. The import of this is that the idea of a god steering the cosmos or the cosmos steering itself or being steered by one of its constituent elements would not have been a problematic one for the ancient Greeks. One might rightly say that omnipotence and omniscience were not characteristics of the early Greek gods or of the elements thought to make up the cosmos. However, omnipotence would not be required of either god or elements, as steering large ship could be accomplished with relatively little effort. While skill and knowledge would be required to some extent, steering the cosmos would not require omniscience. As we will see in a while with Homer's Phaeacian ships, they could go anywhere in complete safety without the idea of an omnipotent or omniscient entity to steer them. So just as a single human *kubernētēs* could steer a large ship safely without undue physical effort, with skill but without omniscience, so could a cosmos steer itself, or be steered by a component of itself or a god. This has heuristic value, both in locating how the analogy was arrived at and in suggesting how the cosmos might be effortlessly and safely steered.

7 Who Used the Idea of Steering?

In the *Philebus* Plato has Socrates say:

> Well, Protarchus, should we say that the whole universe is ruled by unreason, irregularity, and chance, or on the contrary, just as some of those

38 120 cubits is the original text in Lucian *Navigarium* 5, around 180 feet or 55 meters.

39 Casson 1971, 186–189.

> who came before us said (*hoi prosthen hēmōn elegon*), say that *nous* and a marvellous organising intelligence steer (*diakubernan*) it.[40]

Plato then recognized that there were people before him who believe that an intelligence steered the whole universe.[41] Who were they? These are now well established, so I will be brief on each. Aristotle, *Physics* III.4, 203b says:

> This is why we say that this has no *archē* but this seems to be the *archē* of all other things, and *surrounds all and steers all* (*kai periechein hapanta kai panta kubernan*), as with all those who do not suppose other explanations, such as mind or love, beyond the unlimited. This is the divine, for it is immortal and indestructible, as Anaximander and most of the physiologoi say.

With Heraclitus we have Fr. 41:

> All things are steered (*ekubernantai*)[42] through all.

We also have Fr. 64:

> The thunderbolt steers (*oiakizei*) all things.

With Fr. 64, according to LSJ *oiakizein* means to 'steer: hence, govern, guide, manage.' Thus it seems to have roughly the same sorts of meaning as *kubernan*. There are no other early Greek uses of *oiakizein*, but as the Greek for a tiller between two steering oars was *oiax*, the literal meaning here must be 'to tiller'. Possible extra connotations here are that the thunderbolt steers easily (as steering with two oars and an *oiax* was physically easy or that thunderbolt can steer everything as an *oiax* and two oars can steer a large ship). The Hippocratic author of *On Regimen* tells us that:

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40 Plato, *Philebus* 28d, cf. *Philebus* 30d. Plato also uses *diakubernan* for the relation of the demiurge to the cosmos at *Timaeus* 42e and for the relation of god to all that is at *Laws* 709b.

41 *Gorgias* 508a1–5 is also important in showing that Plato recognized traditions in cosmological explanation other than the purely physical 'The wise (*hoi sophoi*) said this, Callicles, that heavens and earth and gods and humans hold together by partnership, friendship, propriety, self-control, and justice. This is why they call this whole a cosmos, O friend, and not disorder or intemperance.'

42 See KRS 1983 for textual variations here.

> The hottest and strongest fire, which controls (*epikrateitai*) all things, manages everything according to nature (*kata phusin*), it is imperceptible to sight or touch. In this are soul, mind, understanding, growth, change, diminution, separation, sleep, waking. This steers all things though all (*panta dia pantos kuberna*) both here and there and is never still.[43]

Diogenes of Apollonia, Fr. 5 says that:

> That which has intelligence is called air by men, and all men are steered by this and it has a power over all things (*kai hupo toutou pantas kai kubernasthia kai pantōn kratein*). This seems to be a God to me and to have permeated everywhere (*kai epi pan aphichthai*), to arrange (*diatithenai*) all things and to be in all things.

Finally, Parmenides Fr. 12 says that:

> The narrower rings are full of unmixed fire, those close by are full of night but with some measure of flame. In the middle of this there is a goddess, who steers all things (*panta kubernai*), ruling the hateful birth and mixture of all things, sending female to have sex with male, and conversely male with female.

8 Ongoing and Thoroughgoing

I take it that has also now been well established that steering is ongoing and thoroughgoing. By this I mean that steering is for all time and for all places, against those who have attempted to marginalize steering to certain times or certain places in the cosmos. Aristotle is clear on this this and gives us another use of *kubernan* in interesting cosmological contexts. At *Meteorology* 1.2 he says that:

> The entire terrestrial realm is composed of these bodies [earth, water, air, fire], and as we have said it is the processes which affect them that concern us here. This realm is of necessity contiguous with the upper motions, which means that all of the motions here are steered (*kubernasthia*) by the upper motions. As the source of all motion, the upper

43 Hippocratic author, *On Regimen* 1/10.

> motions must be accounted as the primary cause. These are eternal, unlimited with respect to place but are always complete. In distinction, all of the other bodies comprise separate regions from each other. The result of this is that fire, earth, and their kindred must be accounted as the material reason for coming to be, while the ultimate reason for their motion is the motive ability of the eternally moving things.

As steering permeates everything that happens in the terrestrial realm this is clearly thoroughgoing. As there is no cosmogony for Aristotle, nor any end for the cosmos, this is also ongoing. In the myth section of the *Politicus* Plato refers to god as the helmsman of the *cosmos* (*tou ho pantos ho men kubernētēs*) who has control of the tiller of the steering oars (*pēdaliōn oiakos*) and it is clear that this god steers all things,[44] so too at *Laws* 709b a god steers everything (*theos men panta … diakubernōsi*). Here one might also connect the knowledge a true *kubernētēs* has of the 'time of year, the heavens, the stars, winds and all else that pertains to this skill' at *Republic* 488d with the control that these Platonic gods exert. One might also connect the benevolent, knowledge based control the *kubernētēs* exerts on a ship and the subsequent good behaviour of the ship with the roles of these gods. The idea of steering had a significant cosmological dimension for Plato, who in these cases went back to the idea of a god steering, though an invariant and omnibenevolent god.

9 Poets and *Kubernan*

How steering worked is another matter on which we have relatively little information.[45] I now want to try to throw some light on this idea of steering in two ways. Firstly, I want to look at the use of *kubernan* and its cognates by the poets, looking at who or what did the steering for them, and suggest a way in which the early enquirers into nature transformed that. Second, I want to look at what a *kubernētēs* actually did on a ship, as a translation of steersman or helmsman may significantly underplay his role.

For the poets, *kubernan* was something usually done by the gods. Pindar, *Pythian Ode* 5.122 says that:

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44 On whether this is ongoing, see below on the *Politicus* myth.

45 KRS 1983, 35n1. 'How does the Boundless 'govern' or 'steer' all things? By virtue, obviously, of surrounding or containing them; but what actual control can it exercise within the cosmos, if the idea of innumerable destructions and re-creations is rejected? The question is difficult to answer on any hypothesis.'

> The great mind of Zeus steers (*kuberna*) the fortune/souls (*daimon*) of men he loves.

So too *Pythian Ode* 4.274:

> Unless a god becomes a helmsman (*kubernatēr*) for those who lead.[46]

We can also look at Bacchylides *Ode* 12:

> Like a wise (*sophos*) steersman (*kubernētas*), Klio queen of song guide (*euthune*) my thoughts now if you ever did before.

It is interesting that the steersman can be wise, also, as we have seen that a god can be described as steering human thoughts. So too we can see this in Sophocles *Ajax*, 35 where it is the hand of Athena which steers (*kubernōmai*) Odysseus. Bacchylides *Ode* 14, 10 talks of:

> When a man has steered (*kubernasen*)[47] what is at hand with a just mind.[48]

Finally, Bacchylides *Ode* 13, 146 says:

> With garland-loving Eucleia she steers (*kuberna*) the state, along with sound-minded Eunomia, possessor of festivities, who guards (*phulassai*) the cities of pious men in peace.

So according to these lyric poets, the gods can steer and in some of these fragments there is also a sense of steering with justice and steering with safety, especially the last passage from Bacchylides, where the steering god guards (*phulassai*) the cities of pious men in peace. There is also, unsurprisingly, a political dimension to *kubernan* in the sense of governing or steering cities, yet

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46 See also Pindar's *Pythian Ode* 10.72: "With the good lies the governance (*kubernasies*) of cities"; *Olympian Ode* 12.3: "For you guide (*kubernōntai*) on the sea swift ships, on land quick battles and assemblies which give advice"; *Incert* Fragment 214: "With him lives sweet Hope, Heart-fostering nurse of old age, Which most of all steers (*kuberna*) mortals' Much wandering judgments."

47 There is an alternative reconstruction of some missing text here, *kubernatai*, in the Loeb. I am following the TLG text.

48 Bacchylides *Ode* 5, 47 has a horse's jockey as a *kubernētan*.

even here there is an important sense of steering or governing with a sense of safety and with a sense of justice.[49]

10 Homer and the Phaeacian Ships

While Homer used guiding verbs for what his gods do (*agein*, *ithunein*) he did not specifically use *kubernan*, though *ithunein*, to guide, was what a *kubernētēs* did in Homer. It is also implied the Phaeacian ships steer themselves.

> Tell me your country, people and city, so that our ships may discern the course with their minds (*tituskomenai phresi*).[50] The Phaeacians have no helmsmen (*kubernētēres*) nor any steering oars (*pēdali'*), but the ships themselves know the thoughts and minds of men (*isasi noēmata kai phrenas andrōn*).[51]

These ships then have some mental function (they discern the course with their minds) and are able to steer themselves. They are able to know the thoughts and minds of men. They also have considerable knowledge (they know the cities and rich fields of all men, *Odyssey* VIII.560) and they are capable of crossing the sea quickly, even in adverse weather conditions, without damage or disaster (*Odyssey* VIII.561 ff.). So here we have a physical entity, a Phaeacian ship, which is capable of discerning the required course and steering itself, and seems to be conscious to some extent. This seems a good precursor for the *apeiron* being to some extent conscious and being capable of steering itself to a desired goal. Another question to consider here is if the steering of Anaximander's *apeiron* is modelled on the Phaeacian ships, what might the *apeiron* know? The thoughts and minds of men? Full geographical knowledge? Full knowledge of weather conditions? It is significant that for the Hippocratics nature can know. *On Regimen*, I.XV says on the physician's art that 'Nature herself knows how to accomplish these things (*ē phusis automatē tauta epistatai*)'. So too in the Derveni papyrus air/Zeus knows everything that was,[52] is and will be and Anaxagoras' nous has similar knowledge as well.[53]

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49 See also Thibodeau in this volume, for the significance of steering/guiding in Homer, Hesiod, and Thales, and Gregory 2020 Chapter 3 for guiding and straightness in Hesiod.

50 Cf. *Il.* XIII.558 for a similar construction showing consciousness and intent.

51 *Od.* VIII.555.

52 Derveni papyrus, Col. 19.

53 Anaxagoras fr. 12.

I have argued elsewhere for something a little stronger than precedent or background interest for this material.[54] Jaeger argued that some of the attributes of the gods, specifically being ungenerated, incorruptible, undying, and indestructible were transferred to the *archai* of some of the early Greek inquirers into nature.[55] I would add to that the steering function was as well, so where in the poets the gods steer, in Anaximander it is the *apeiron*, in Heraclitus and the Hippocratic author it is fire, in Diogenes it is air. In this context it is very interesting that Terpander, Fragment 2 is:

> *Zeu pantōn archa, pantōn agētōr.*
> Zeus is *archē* of all, leader of all.

While at Aristotle *Physics* III.4, 203b the *apeiron* for Anaximander:

> *Periechein hapanta kai panta kubernan.*
> Surrounds all and steers all.[56]

So we have a similarity in structure (the double 'all') as well as content, the *apeiron* is the *archê* for Anaximander as Zeus is *archē* of all for Terpander, and with these similarities we have the intriguing possibility that Anaximander was alluding to Terpander.[57] I am aware that Pindar (*c.*518–438 BCE) and Bacchylides (*c.*518–451 BCE) both postdate Anaximander (611/610–547/546 BCE), so there is no simple poets to inquirers move here.[58] Indeed in Parmenides and Plato we have it that a god steers.[59] What this does show is that poets did use *kubernan* for what their gods did, and there may have been an ongoing dispute between poets and early inquirers into nature/medics on the use of *kubernan*.

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54 See Gregory 2020, Ch. 2.

55 Jaeger 1939, 204 ff.

56 It is important here to translate *kai periechein hapanta kai panta kubernan* 'surrounds all and steers all', as 'surrounds and steers all' would mask the double 'all' structure in the Greek. As Aristotle's Greek is notoriously terse, it is likely that he is quoting Anaximander.

57 As allusion is notoriously difficult to demonstrate, I leave this simply as a possibility here, though in my view it is a strong one and one which illuminates both of the statements.

58 Though cf. Thibodeau in this volume on the evidence for dating Anaximander.

59 Parmenides Fr. 12, Plato *Laws* 709b8, *Politicus* 272de, *Timaeus* 42d.

11 The *Kubernētēs*

What actually did a *kubernētēs* do in the ancient world? This is worth examining, as they were rather more than the usual translation of helmsman or steersman. This may affect understanding of both the role of the *kubernētēs* and the verb *kubernan* in cosmological contexts. Firstly, while in modern vessels the helmsmen is well down the command structure and their only task is to turn the ship's wheel under the instructions of a superior, this was not the case in the ancient world. Larger ships would have three officers, the *kubernētēs* who was the commanding officer, the rowing officer (*keleustes*), and the bow look out (*prorates*), a far more important role when navigating without charts. According to Plato a *kubernētēs* was so called for their leadership of the crew, not for their navigation abilities. Pindar refered to a *kubernatēr oiakostrophos*, a 'tiller wielding captain'. On larger ships the *kubernētēs* would delegate the actual steering to a subordinate, the *pēdialiouchos*, the person who held the steering oar (*pēdalios*). Casson's *Ships and Seamanship in the Ancient World* has the *kubernētēs* as the 'executive officer.' Aristophanes' *Knights* 544 ff. says that for someone to be a *kubernētēs*, they must first know how to row, then how to keep watch at the bow, then how to gauge winds.[60] It is also significant that Plato in the *Republic* treats a *kubernētēs* as an intelligent, multi-skilled person, often paired with doctors and contrasted with lay people, this contrast being used to illustrate the role of the philosopher rulers. At *Cratylus* 390c, it is the *kubernētēs* who directs the ship builder. So the *kubernētēs* had a significantly greater role than simply doing the steering.

12 Steering and Safe Passage

There are strong associations of the *kubernētēs* with safety and the preservation of life. Plato *at Gorgias* 511d ff. has the knowledge of the *kubernētēs* saving souls, bodies, and property from danger and the *kubernētēs* deserving pay whether he brought people and property safely from Aegina, Egypt, or the Pontus. *Republic* 346a has the main task of the doctor as health and the main task of the *kubernētikē* as safety, *sōtēria*. This association of the *kubernētēs* with safety can be found throughout Plato and Aristotle, e.g., *Politicus* 273de,

60 Cf. Sophocles, *Oedipus Tyrannus* 923, we are all afraid as with those who see fear in the helmsman (*kubernētēn*) of a ship.

Symposium 197e, *Laws* 707a, 961e, *Physics* 195a, *Metaphysics* 1013b, and *Protrepticus* 69–70 echo the doctor/health and *kubernētēs* with safety formula of the *Republic*. Homer thought that a *kubernētēs* did his job by skill (*mētis*) when he guided (*ithunein*) a ship being buffeted by winds (*Il.* XXIII, 313). This association of the *kubernētēs* with safety/the preservation of life can also be found in Herodotus *Historiae* 8.118. There the Persian king asks the *kubernētēs* if there is any possible salvation from a storm. At Herodotus 118, 11 we have the tale of the Persian nobles throwing themselves off of a stricken ship in order to save the king. The point here is not whether the tale is true or not,[61] but that it is the *kubernētēs* who is held responsible for the ship's safety, which can be seen by the facts that he is consulted in the storm as to what to do, he issues the orders, and he is subsequently beheaded.[62] Xenophon, *Cyropaedia* 1.6.6 talks of those who do not know how to steer should not pray to save the ship by taking the helm of the ship. Aeschylus, *Supplices* 765 also associates safety and skilled seamanship with the *kubernētēs*. In the Hippocratic *Ancient Medicine* IX, a bad *kubernētēs* is akin to a bad doctor, unnoticed in good conditions, but problematic in a storm when salvation is required. It is also interesting that in some Christian writing, such as Theodoretus, Joannes Chrysostomus, and Gregorius Nazienzenus there is a sense that Christ is a *kubernētēs* with the same word, *sōtēria* being used for the salvation of the soul. If we then go back to early Greek usage, when a Greek god is called a *sōtēr*, it is because they have saved us from impending death rather than saved our soul for a better afterlife.[63] The gods certainly have this function, with the practice of offering the third drink at a symposium to Zeus, with the words *to triton tō sōtēri*, 'the third to the preserver'.[64] Poseidon is also a preserver of ships (*sōtēra te nēōn*; *Homeric Hymn* 22, 5), as are the Dioskouri who save swift ships (*sōtēra … ōkuporōn te neon*, *Homeric Hymn* 33 6–7, see also Euripides, *Helen*, 1500–5 and 1658–65; *Orphic Hymn* 75, 6–8). In Plato, the *kubernētēs* is a *sōtēr*: *Symposium* 197e1–2 talking of 'The best *kubernētēs*, defender, comrade, and preserver (*sōtēr*).' It is also significant that there is a language of defending and guarding (*phulassein* and its cognates) associated with gods in seafaring contexts and with a *kubernētēs*.[65]

Plato's myth in the *Politicus* is worth looking at in some more detail for its use of a god as *kubernētēs* of the cosmos, whose aim is safety, and the sea

61 Herodotus quite rightly has his own doubts, VIII, 119.

62 Herodotus VIII, 118 and 119.

63 See Menn 2013, 192. My thanks to Jonathon Griffiths for drawing my attention to this paper.

64 It is better in this context to use 'preserver' or 'saver' rather 'savior' or 'salvation' with their Christian connotations.

65 See Theognis 671–2, Aeschylus, *Seven Against Thebes* 2–3, Bacchylides, *Ode* 13, 146.

related language and metaphors. In the myth there is a contrast between the *cosmos* under the guidance of this *kubernētēs* god and the deterioration into chaos when this god releases control of the *cosmos*. So at *Politicus* 272d ff. we find that:

> When the time of all these things came to an end and change was to occur, and all of the earth born race had been used up, each soul having given back all of its births, each having fallen into the earth as seed the prescribed number of times, the helmsman of the universe (*tou ho pantos ho men kubernētēs*) let go the handle of the steering oars (*hoion pēdaliōn oiakos aphemenos*).[66]

Note that the *kubernētēs* does not let go of a 'rudder' as this is usually translated, but of the connecting bar (*oiakos*) between two steering oars (*pēdaliōn*, note the plural). The myth continues from *Politicus* 273b ff., emphasising god's role as orderer and *kubernētēs* of the *cosmos*:

> When the world nurtures within itself living things under the guidance of the helmsman (*kubernētou*), it produces little evil and much good. However, when it becomes separated from him, it fares best during the time immediately after the release, but as time proceeds and it grows forgetful, the old condition of disorder gains sway more and more, and towards the conclusion of time little good and much of its opposite flourishes, and there is danger of the destruction of the world and those in it. At this moment God, the orderer of the world (*theos ho kosmēsas auton*), perceives that it is in trouble, and being concerned that it should not be storm driven by confusion and broken up into an endless sea of unlikeness, he takes his old place at the steering oars (*tōn pedaliōn*),[67] and reverses the sickness and destruction of the first period when the world moved itself, and he orders and sets it right again, forming it deathless and ageless.

So as with the poets, we have a god as the *kubernētēs* and also as the orderer of the cosmos. It is clear that here too the *kubernētēs* has a strong safety role. It is his job to rescue the cosmos from becoming an 'an endless sea of unlikeness'. Steering here is clearly thoroughgoing in that it affects all aspects of the world. Whether for Plato it is ongoing is trickier to answer, depending on how

66 Plato, *Politicus* 272d.

67 Again, steering oars and not a rudder in the modern sense and note this is a plural.

much of Plato's cosmology we can read out of this myth. Is the reversing world something he believes in, or a myth through which he can make some political points, and perhaps some veiled criticisms of Empedocles?[68] I would tend to the latter, especially as the *dēmiourgos* of the *Timaeus* ensures from the beginning that the cosmos is deathless and ageless, and at *Laws* 709b a god steers (*diakubernōsi*) all that is.[69]

13 Plato and *Hupozōmata*

There is also a cosmological dimension to this issue of safety. Ancient ships used to employ cables called *hupozōmata* to strengthen the hull. These passed under the ship from stem to stern and were deployed prior to storms. The *kubernētēs* had the discretion of when to deploy them, another part of his function of being in charge of the safety of the ship. The *hupozōmata* could be huge, five inches in diameter, weighing 250 pounds and 100 yards long.[70] It took several men to fit them and they needed to be tensioned. Their function was to stiffen the hull longitudinally. In calm water, the ship is supported throughout its length by the water. Now imagine a ship balanced on one support, roughly amidships. The ship will be under pressure from gravity to drop at either end (known as hogging), and if it is not strong enough it will break in the middle. Alternatively imagine the ship on two supports, one forward and one aft, and it will be under pressure to drop in the middle (known as sagging). Waves passing under the ship can have these effects.[71] A large wave under the middle of the ship will generate hogging, waves at either end of the ship will generate sagging.

The *hupozōmata* were then rigged fore and aft around the hull and put under significant tension by twisting them. The effect of this is to make the ship a much stronger 'girder', less prone to hogging or sagging in the waves. This stiffening also helped the *gomphoi* stay in place. Waves passing under a ship may induce alternate hogging and sagging, which produces alternate forces on the *gomphoi* holding the joints together, with the result that they can work loose.

68 Even then steering clearly lasts longer than just for cosmogony here.

69 A further interesting use of the sea in Plato is in the *Republic*, where Socrates face a succession of three waves against his argument, the third being the largest, a possible reference to tsunamis. See Sedley 2005.

70 Morrison and Williams 1968, 296.

71 Hogging and sagging can also be caused by poor design or poor loading, giving an inappropriate distribution of weight through the ship. Indeed, some ships have been known to take on a permanent hog as their timbers bent.

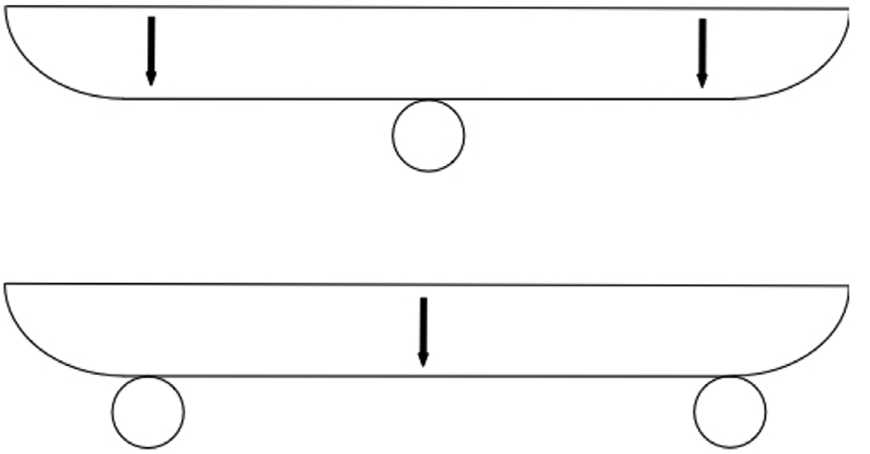


FIGURE 3.5 Hogging and Sagging. A large wave passing under the ship will make the ship tend to bend up in the middle ('hogging') as gravity pulls both ends down, while a wave at either end of the ship will make it drop in the middle ('sagging') under gravity. Alternate hogging and sagging can loosen mortoise and tenon joints or cause metal fatigue in modern ships.
IMAGE BY THE AUTHOR

This was well known. Apollonius of Rhodes in his *Argonautika*, 1 367–9, speaks of fitting a rope and twisting it such that the *gomphoi* will hold the planks securely and withstand the opposing force of the sea. Greek triremes, which were very long relative to their beam and the depth of the ship, and so had relatively poor girder strength, were prone to hogging and sagging.[72] They typically carried four *hupozōmata*, with probably two being used at any one time. In naval inventories of ship's gear, first named are the *hupozōmata*.[73]

In Plato's Myth of Er at *Republic* 616bc, a light, like a rainbow but purer, acts as the bond of the heavens (*sundesmon tou ouranou*) and is specifically like the *hupozōmata* of triremes (616c3), in the same manner holding together (*sunechon*) the revolving whole.[74] The spindle of Necessity is attached to the two ends and turns between them. It is possible that the spindle twists the *hupozōmata* as would happen on a ship to give them the tension to hold the hull together.[75] As the main function of the spindle is to turn the heavens

72 Especially as they did not have a continuous deck which would make them into a box girder and more rigid. See Morrison, Coates, and Rankov 1986, 196.

73 Morrison and Williams 1968, 296–7; Morrison, Coates, and Rankov 1986, 169.

74 Cf. Plato *Laws* 945c4 for the state as a ship and *hupozōmata*.

75 See Morrison and Williams 1968, 297.

that may push things too far, but Plato does seem to be well versed in seafaring technology and does recognize the need for this tensioning elsewhere.

Plato use of *hupozōmata* has a political dimension as well, with the ship of state metaphor being employed again at *Laws* 945c:

> πολλοὶ καιροὶ πολιτείας λύσεώς εἰσιν,
> καθάπερ νεὼς ἢ ζῴου τινός, οὗς ἐντόνους τε καὶ ὑποζώματα
> καὶ νεύρων ἐπιτόνους, μίαν οὖσαν φύσιν διεσπαρμένην,
> πολλαχοῦ πολλοῖς ὀνόμασιν προσαγορεύομεν·
>
> There are many things which contribute to the dissolution of a state,
> as with some ship or living being, such as tensioners (*entonous*) and *hupozōmata*
> and sinewy bracing ropes, which are one in nature but are separated
> into many parts and we call them by many names.

The *entonoi* here are most likely to be a device for tensioning the *hupozōmata*, as naval inventories use this term in relation to *hupozōmata*. So there are things which help to bind the state together which need to be kept in good order, just as with the tensioners and *hupozōmata* of a ship.

If we now return to Aristotle's report on Anaximander, that the *apeiron periechein hapanta kai panta kubernan*, 'surrounds all and steers all', we might consider an alternate sense of *periechein*, 'to protect' rather than 'to surround', given the safety function of a *kubernētēs* and the cosmological role for the *hupozōmata* in the *Republic*. If the *apeiron* acts for the safety and the ongoing integrity of the cosmos, this has some implications for the fate of the cosmos in Anaximander.

14 Steering and Ends

This strong association of the *kubernētēs* and safety may allow us some traction on questions of fate of the cosmos. I am in agreement with the modern view that there is no cosmogony and no end to the cosmos in Heraclitus. I take Fr. 30 to be important:

> This *cosmos*, the same for all, was not made by Gods or men, but has always existed and will always exist. It is an everliving fire, kindling in measures and going out in measures.

As the cosmos for Heraclitus is steered (Fr. 41, 64) and steering aims at safety, this is no surprise. More controversial is whether Anaximander believed in one unending cosmos, a cyclical cosmos like Empedocles or many co-existent *cosmoi* like the early atomists. I have argued in favour of one unending cosmos, and again if safety is an aim of the *kubernētēs*, this would be no surprise. I would add here that it seems that the gods have a saving from death function specifically in relation to ships (Zeus, Poseidon, the Dioskouri as we saw above), they are the *sōtēr*, and that the *kubernētēs* has a similar function. Note also that we find 'guarding' language (*phulassein* and cognates) with both gods and the *kubernētēs*. So here we may have a further small extension of Jaeger's thesis. The gods steer, as do some *archai*, the gods save and guard, as do some *archai*. If saving from death and guarding are a function of an *apeiron* which steers, one would expect an unending cosmos.

It should be clear that steering is towards a good end and towards safety, whether we look at the poets or playwrights. In Homer, the Phaeacian ships steer themselves with absolute safety even in bad weather. So too in Plato, steering is associated with safety and with doing good. The god of the *Politicus* myth steers well and saves the world from deteriorating into an endless sea of unlikeness, the *dēmiourgos* of the *Timaeus* ensures the cosmos is endless and the demi-gods steer (*diakubernan*) humans in the fairest and best (*kallista kai arista*) way.

It has been claimed that there is no teleology before Plato, on the basis that the passage in the *Phaedo* known as 'Socrates' Autobiography' rejects all pre-Socratic natural philosophy. Both claims are false. Plato does not have Socrates reject all pre-Socratic natural philosophy, only that which does not use teleology.[76] *Philebus* 28d as we have seen above recognizes that there was a tradition of steering with a role for *nous* in previous thinkers.[77] It may well be that no one prior to Plato had thought about teleology in any great depth, given it a name, or produced a fully comprehensive teleological cosmogony and cosmology as Plato did in the *Timaeus*. That does not mean that there were not interesting entities which acted with an end in mind or interesting entities which acted with the good in mind. Homer's Phaeacian ships clearly have a *telos*, which is to reach port safely, and that is clearly seen as good. A *kubernētēs* must act with safety as his *telos*, and again that is clearly seen as good. There is also a sense in some of the poets that when their gods steer, they do it justly and for the good. It is quite possible then that the *archai* of Anaximander, Heraclitus, the Hippocratic author, and Diogenes all steer with safety and the good in mind.

76 See Gregory 2021.

77 See also *Philebus* 30d, *Gorgias* 508a1–5.

15 Anaximander

The idea of steering is fundamental to Anaximander's cosmology. It allows Anaximander an answer to two key questions. First, how does the undifferentiated *apeiron* become a differentiated, organized, and symmetrical cosmos? This is not something which could occur by chance and there is no mention of chance in Anaximander. The *apeiron* is able to steer this cosmos into being and is able to do so with foresight and with a good end in mind.

Secondly, why does Anaximander's world exhibit law-like behavior, what underpins its regularities? Again, it is the ability of the *apeiron* to steer with a good end in mind.[78] Anaximander's extant fragment says that:

> The source of generation for extant things is that into which destruction occurs, *according to what is proper* (*kata to chreōn*). *For they pay penalty and retribution to each other for injustices according to the ordering of time*, as he says in a poetic fashion.[79]

The *apeiron* then is able to steer 'according to what is proper (*kata to chreōn*).'[80] The regularities in the extant fragment are framed in terms of civil law. This is not a modern conception of physical law in different garb, but a different conception of how regularities can be modeled. It fits well with the idea that the *apeiron* steers and that it does so in an ongoing and thoroughgoing manner. Those regularities are underpinned strongly. The choices of intelligence were a good model for regularities for the early Greeks and note that the Phaeacian ships, which steered themselves, always got home safely.[81] This maritime influence is no merely linguistic or some form of metaphor, but is critical to how Anaximander's cosmology works at a fundamental level. In line with modern analogy theory, it has explanatory and heuristic value. It allows us to understand how the cosmos forms and how regularities are underpinned. It has an important heuristic component, in two senses. We can understand where the link to steering came from, generally in seeing or knowing about the work of the *kubernētēs* but also as mediated through the poets and the idea of the transfer of the functions of the gods, including the steering function, to the

78 For a more extended discussion of these issues, see Gregory 2014 and 2020.

79 Simplicius, *Physics* 24, 13.

80 For a discussion of this translation against the more common 'what is necessary' see Gregory 2014, 68, and Gregory 2020, 101 ff.

81 For more on this see Gregory 2020, 105 ff. and cf. Plato who has celestial intelligences underpinning the regularities of the heavens in the *Timaeus*.

archai. Aristotle, *Physics* III.4, 203b tells us that the *apeiron* steers but also tells us that it is the divine, for it is immortal and indestructible, as with the gods.

16 Plato's *Timaeus*

Plato's *Timaeus* will always be an important work for the influence of technology on cosmology, as Plato's creator god is the *dēmiourgos*, a skilled worker or craftsman, and we should bear in mind here that according to *Gorgias* 455b3 and 503e5 a ship builder is a *dēmiourgos*.[82] At *Timaeus* 42 d ff. the *dēmiourgos* hands over to the demi-gods the role of steering (*diakubernan*) humans in the fairest and best (*kallista kai arista*) way possible. A further important factor here is that the *dēmiourgos* does not generate the cosmos *ex nihilo*, but like any craftsman, he has to use materials which are already in existence. The *dēmiourgos* is benevolent,[83] wishing all things to be as good as possible, but there are limitations.[84] The contrast between reason and necessity is interesting from a technological perspective. When a technological object is built, it is well known that the design must to some extent be a compromise. So increasing the performance of a car will have a detrimental effect on fuel consumption, or improving the road handling will have a detrimental effect on passenger comfort. In the ancient world, this would be well known from ship design as well. Warships were effectively built for ramming, high speed, and maneuverability on relatively calm seas. They rarely ventured very far from land, went out only in relatively calm seas, and were usually beached for the night. They were long, narrow of beam, and could not carry a great deal of cargo. Merchant ships were the converse. They were relatively broad of beam to carry large loads and their sea-keeping was much better, though they were not as fast. They were known as *strongula ploia*, round ships.[85] A good example of this sort of consideration

82 A ship builder is also an expert: see *Protagoras* 319b8; see too *Laws* 709b8 where God controls (*diakubernōsi*) all that is.

83 *Timaeus* 30a: 'For the god desired that all things should be good, and nothing paltry (*phlauron*) as far as was possible, he took over all that was visible, which was not at rest but in discordant and disorderly motion (*alla kinoumenon plēmmelōs kai ataktōs*), and led it into order out of disorder, judging the former to be entirely better than the latter.'

84 *Timaeus* 48a: 'The generation of this universe was the bringing together of a combination of necessity and intelligence. Intelligence ruled necessity by persuading her to lead the greatest part of the things that were generated towards the best. It was in this way, through necessity submitting to sensible persuasion, that this universe was in the beginning brought together.'

85 Casson 1971, 169.

in the *Timaeus* is the issue of the human skull at 75bc. In order for us to have acute perception, the skull ought to be as thin as possible. In order for it to protect our brains and ensure a long life, it should be as thick as possible. Similarly at 75e there must be some flesh around the skull for the purpose of temperature control, but as little as possible so as not to obstruct perception.[86]

The influence of shipbuilding technology also shows through in several places, such as *Timaeus* 43a2–3, where the discussion concerns how the bodies of the demi-gods are put together and how human beings are put together. So humans are constructed by the demi-gods:

> οὐ τοῖς ἀλύτοις οἷς αὐτοὶ συνείχοντο δεσμοῖς,
> ἀλλὰ διὰ σμικρότητα ἀοράτοις πυκνοῖς γόμφοις συντήκοντες
>
> not with the indissoluble bonds they themselves where put together with, but with close fitting treenails too small to be seen.

So we have an interesting maritime analogy, as we have *gomphoi*, which hold ship's planks together, being used for holding humans together. Unfortunately this passage has been badly translated and badly misunderstood in places. The main culprits here are Cornford, 'Welding them with a multitude of rivets too small to be seen',[87] Warrington, 'Welding them with numerous rivets too small to be seen',[88] and Taylor, 'The metaphor passes easily from that of fastening of the planks of a ship by *gomphoi* 'rivets' into that of soldering of metal plates'.[89]

I will put this bluntly. You no more weld with rivets than you conjugate nouns or decline verbs. Welding is a process where metal on both sides of a join is melted and flows together so you have one piece when the metal cools.[90] Riveting is a process where holes are drilled through two overlapping pieces of metal, a red hot metal rivet is inserted (a metal rod with a round cap

86 See Gregory 2000, 4. This is not to say that all instances of the reason/necessity contrast can be analyzed in this way.

87 Cornford 1937, 148.

88 Warrington 1965, 41.

89 Taylor 1927, 267. Cf. 'Fastened together the portions with numerous pegs, invisible for smallness' Bury 1929, 95.

90 Usually welding is done by with a torch, gas, arc (electric) or MIG (metal-inert gas, a more sophisticated electric technique). It is also possible to forge weld, where the two metal pieces are heated in a blacksmith's forge to near melting point and are then hammered, the pressure generated by the hammer making the weld.

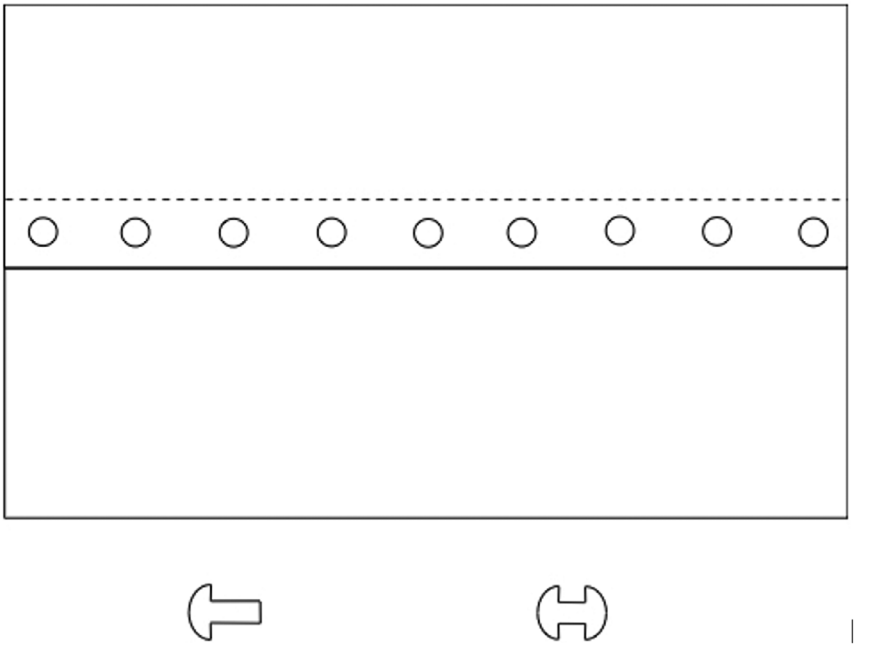


FIGURE 3.6 Rivetting. Here we have two pieces of metal, one overlapping the other, with holes drilled through both to receive rivets. The rivet, bottom left, is heated to red hot and then inserted into the hole. The rivet is then beaten with hammers to the shape of the rivet bottom right, the new head holding the plates together. As the rivet cools it shrinks, holding the plates together tightly.
IMAGE BY THE AUTHOR

on one end) and the rod end of the rivet is then beaten to form another cap.[91] Soldering is a process where molten solder, usually an amalgam of metals and different from the metal being soldered, is applied to a join between two pieces of metal. The solder sticks to both pieces and when it solidifies you have a rigid joint between the two pieces.[92]

None of these processes are present either in ancient Greek shipbuilding or in the text of the *Timaeus*. The Greek *gomphos* is in modern terminology a treenail, a round rod of wood driven into a hole drilled through two pieces of

91 As the rivet cools from red hot, it contracts so generating a very tight join between the two pieces of metal. This u-tube link shows shipyard riveting https://www.youtube.com/watch?v=CVjS1DsqYvo. This one goes into some more detail: https://www.youtube.com/watch?v=DLtfgM2xabo.

92 Solder is an alloy with a melting point lower than the metals which are being soldered. Typically it was tin and lead, now superseded by tin, silver, and copper for most uses due to the toxicity of lead.

wood. It is not a rivet in that it does not have a cap on one end and nothing is done to the other end. It is a tight fit in the hole and has to be hammered home. The modern translation of *gomphois* as rivets has also led to a mistranslation of *puknois*. It is true that where rivets were used in modern shipbuilding, a great number of them were employed, hence the temptation to translate *puknois* as 'many'. However, it is not the case that many *gomphoi* were used, but they were very tight fitting. It is best then to give *puknois* its other sense of close fitting here. In later ship construction technology, the *gomphoi* were first hammered into place and then a nail was driven through them lengthwise, with the nail being longer than a *gomphos*, and then being bent over to give a stronger join. LSJ give 'fuse into one mass, weld together' for *suntēkein*. Other uses of *suntēkein* in Plato also suggest the first alternative here. So at *Symposium* 192d8, 192e8 *suntēkein* is used for fusing people together while at *Symposium* 183e6 the good person is fused together with the abiding. At *Timaeus* 83b7 fluids given off by inflamed flesh fuse together.

A really good cabinet maker can put together furniture where you cannot see the joins between some of the pieces of wood. So too stonemasons could make column drums look like a monolithic column. In a sense, the pieces have been 'fused together,' but they have certainly not been melted as is required for welding. This I think is Plato's sense here. The demi-gods are very good at what they do, with tight fitting and small *gomphoi*, so in effect we cannot 'see the joins', but the joins in humans, as those between a ship's planks fastened by *gomphoi*, will come apart again. The moral here is that if we want to understand the influence of technology on early enquiry into nature, we need to understand early technology properly.

Timaeus 81b also uses an interesting maritime technology phrase, this time in relation to geometrical atomism. Plato talks of triangles which are *ek druochōn*, 'fresh from the props', the props being those which would hold a ship in place while it was being built. Incidentally, LSJ are wrong to say that these props were 'upon which is laid the frame of a new ship'. The usual Greek practice was to begin to assemble the hull, joining the planks together, then to fit the frames (that is the internal supports for the hull) and it would only be at this stage that the ship would need external props. The contrast Plato wants here is between triangles which have been freshly out together and have all their joints tight, as with a ship which is *ek druochōn*, and triangles which have loosened joints due to having fought many fights over long periods. The fresh triangles of the body can cut up and assimilate incoming triangles, the older triangles conversely are themselves cut up and assimilated. Plato is here talking of the complex triangles, that is the equilateral triangles that are made up

from six of the simple 1, √3, 2 triangles, the complex triangles in turn making up the tetrahdra of fire, octahedral of air, and ikosahedra of water.[93] There is an interesting modularity comparison here. Greek ships were composed of modules of planks, which would stay together for a certain time, while for Plato the world is composed ultimately of modules of basic triangles, what is composed out of these (complex triangles, three dimensional 'elements') also will stay together for a time, until the joints are loosened by 'many fights over long periods'. (See here also Lebedev, Chapter 5 in his volume on Philolaus's Demiurge beginning to construct the cosmos like the hull of a ship and on influences between the Pythagoreans and Plato.)

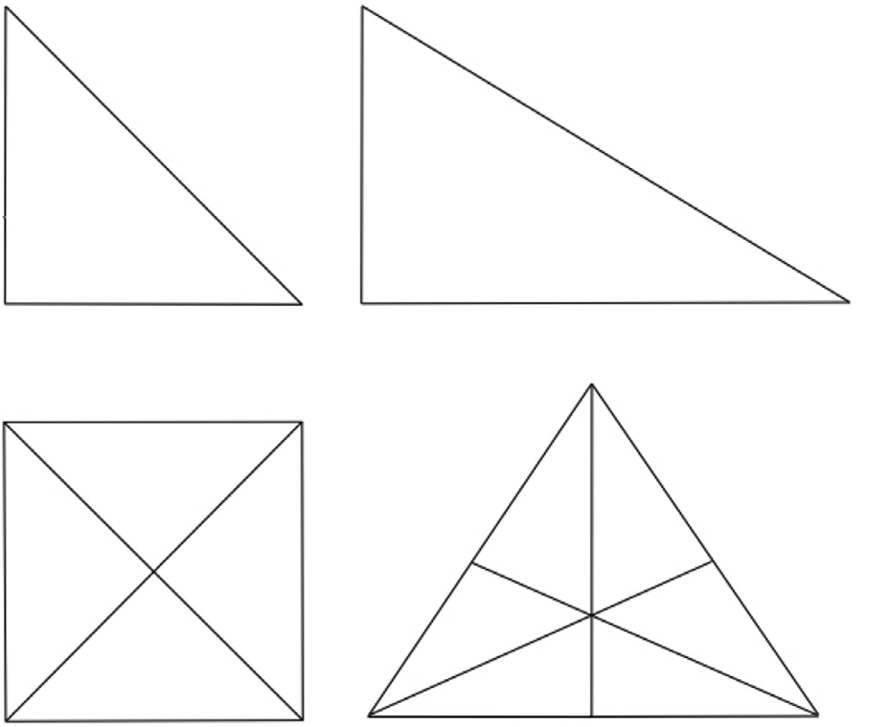


FIGURE 3.7 Plato's triangles. First the, 1, 1, √2 and then the 1, √3, 2 triangle. Four of the first type join up to make a square six of the second type form up to make complex triangles.
IMAGE BY THE AUTHOR

93 For further discussion of this issue, see Gregory 2021.

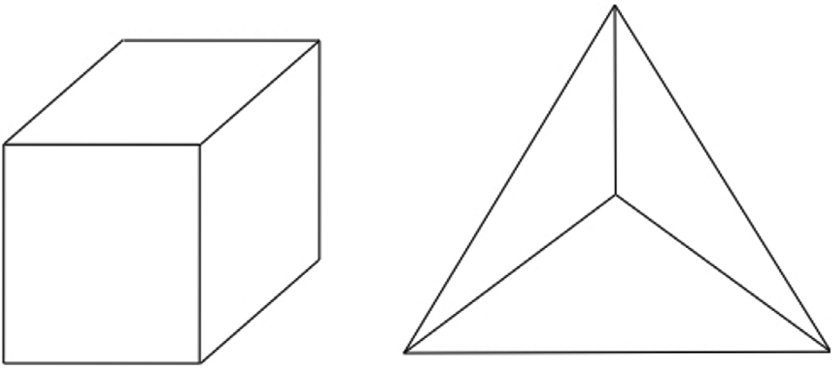


FIGURE 3.8 Complex squares and complex triangles form up into three dimensional entities. 'the squares make cubes of earth, the complex triangles make tetrahedra of fire, or octahedra or icosahedra.' The two basic triangles are the modules from which these three dimensional shapes are constituted.
IMAGE BY THE AUTHOR

17 Conclusion

The influence of Greek ships, shipbuilding, and seamanship on the early investigation of nature and cosmology is significant, and deep. The idea that the cosmos was steered by an *archē* in the manner that a *kubernētēs* might steer a ship, with intelligence, knowledge, skill, and with safety in mind is important for many early thinkers. The influences here may have been direct, or may have been mediated through the poets who were clearly influenced by maritime technology as well, with their gods steering. Homer's Phaeacian ships, capable of steering themselves, having great geographical knowledge to always getting there safely may have been a significant precursor here. The steering analogy is not disposable, exchangeable, or ornamental, nor can it be substituted for or translated into something more modern. It is a fundamental part of a large tradition of early Greek cosmological thought. It has explanatory value and heuristic value, both in indicating where the inspiration has come from and how the analogy might work further. This is very much in line with the modern historiography of analogies.

There are also some broader aspects of early maritime technology which should be taken in conjunction with other technologies as significant for the instigation and development of early investigation of nature. Greater sophistication in technology would doubtless have bred greater objectivity in that unless you get it right, the technology will not work properly. Ships, particularly warships, come apart unless the design is good, the materials and

workmanship are good, and the *hupozōmata* are appropriately deployed. It would also have become clear that materials and technological artefacts all had an objective nature, a *phusis*, and so too by extension did the *cosmos*. That technology could progress, at a reasonably rapid pace, provide significant benefits, and that humans could gain useful knowledge of the world through their own efforts ran counter to Homer where mortals could only gain information from unreliable and capricious gods. Such progress was evident in ship design, with the move from one bank of rowers to two and then three and the design of larger and more seaworthy merchant ships. The modular nature of some technologies may also have been important in cosmology and matter theory and there are some interesting aspects of modularity in ancient ship design and construction, the spacing of the frames, the positioning of groups of rowers, and the standardised joining of the planks as the basic construction concept. Maritime technology, then, was a significant basis for early Greek thinkers, whether they were poets or playwrights, doctors or investigators of nature, and gave them important ideas in cosmology.[94]

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CHAPTER 4

The Gods and the Machine

Ancient Automata and Divine Causation

Sylvia Berryman

For those interested in the impact of experience with the material world on intellectual theorizing, the reception of mechanics in ancient Greece forms a fascinating case study. Mechanics constitutes one of the most robustly empirical fields of ancient Greek science, concerned with building devices that *work* – not merely with theoretical speculation – and thus was well-placed to contribute ideas about the functioning of the natural world. Although it is a difficult story to tell – the ancient evidence is plagued by lost texts, terminological hazards, and frustratingly vague reports – I argue that we can indeed find evidence that practical mechanics played a role in constraining and shaping ideas about what could be achieved by the mere arrangement of material parts. The development of actual working artifacts served a function that could not be replicated by pure speculation about what was possible.

In order to appreciate the implications of the claim that technology helped establish what was possible to achieve by merely material means, consider whether a Bronze Age poet like Homer might have imagined mechanical robots constructed from ordinary human technology. In the *Iliad*, Hephaestus is said to enter the assembly of the gods with his own retinue of golden handmaidens and self-moving tripods.[1] Some scholars have viewed literary accounts like this as a kind of early science-fiction, an imaginary anticipation of later mechanical automata. I argue that it is a mistaken to assume that modern understanding of the workings of mechanical devices stem from ahistorical, commonsense conceptions that could have been anticipated without experience of comparable technology. In the texts themselves, stories from archaic times are inseparable from ideas about divine animation and magic. A scoffer might try to debunk an illusion by claiming vaguely that 'it's all done with mirrors'; Homer's gestures towards the technology of the wheel and the blacksmith's forge do not indicate

1 *Iliad* 18, 414ff.

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a credible understanding of ways that material craftsmanship could produce self-moving devices.[2]

Scholarly attention to artifact analogies in early Greek philosophy and medicine has illuminated the complex ways that experience with real technology informed ideas about the possibilities for material interactions. As mechanical technology grew more complex in the Hellenistic period, we find increased filtration of ideas drawn from mechanics into natural philosophy.[3] While much study of ideas about causation and material explanation has focused on the formative period of natural philosophy, there is nonetheless much to learn about the conceptual impact of Hellenistic mechanics, as 'working artifacts' and automata appeared on the scene.

As an illustration, I focus here on the impact of a particular invention, the *schastêria* or trigger-release mechanism. I argue that this mechanism offered a new possibility for conceptualizing the relationship between a designing intelligence and the ongoing operation of natural processes, especially in cosmology. While a 'mechanistic worldview' is broadly considered to be a modern invention, and to be inspired by modern mechanical clockwork,[4] there are in fact ancient Greek precedents for the idea that the cosmos runs like a machine. In antiquity, this had a quite different source of inspiration.

The ancient Greeks built increasingly elaborate models of the heavens of various kinds, from star maps to armillary spheres and astrolabes, as well as calendrical calculators. Our understanding of ancient Greek calendrical devices has been changed considerably by reconstruction of the Antikythera mechanism, a device recovered in 1900 from an ancient shipwreck.[5] Recent breakthroughs in understanding this device have inspired scholars to speculate about a 'clockwork universe' motif in antiquity.[6] The modern association of the 'mechanical' with gearing may contribute to the focus on this kind of model.[7] Nonetheless, the best ancient analogues for the functioning of the cosmos may lie elsewhere.

I argue that the most compelling ancient parallels to a modern 'clockwork universe' motif are those drawn, not to cosmic models or calendrical calculators, but to theatrical displays. Like modern clockwork, the trigger-release

2 I argue the conceptual point in Berryman 2003 and Berryman 2009; cf. Mayor 2018. There are some difficulties in delimiting exactly what counts as 'material' technology here.

3 For a survey of the evidence, see Berryman 2009.

4 Berryman 2021.

5 The classic work on this, Price 1975, has been augmented by a new team of researchers: see especially Freeth et al. 2006; Edmunds 2014; Jones 2017.

6 See esp. Edmunds 2014; Jones 2017; cf. Sedley 2020.

7 Edmunds 2014, 274.

mechanism allowed devices to be pre-wound and left to operate by themselves. While artifact analogies had long been used throughout ancient Greek natural philosophy, automata – self-moving devices – take the analogy into different territory. Unlike hand-driven cosmic models, trigger-release mechanisms demonstrated that material composites could be constructed that run by themselves through a complex *sequence* of causal changes to a predetermined outcome. They thus offered a compelling demonstration that apparently goal-directed processes could operate without ongoing intelligent direction.

And that possibility was noted. Evidence survives of ancient Greek intellectuals who supposed that the gods might have created the world to run like a mechanical device. Unlike Cicero's better known discussions of astronomical devices built by Archimedes and Posidonius, these are not hand-operated cosmic models. A trigger-release mechanism allows for more thoroughly mechanical analogies for the functioning of the cosmos without ongoing direction or control. There may still be a role for divine intelligence in *constructing* such a device, but Hellenistic mechanics shows that devices can be built to *operate* without ongoing intelligent direction. We are a long way from Homeric stories here.

The *de Mundo*, an anonymous text in the Aristotelian corpus,[8] uses a technical device with a starting-trigger to illustrate the nature of divine governance. A comparable analogy can also be found in the *Egyptian Tales* of Synesius of Cyrene, (4th–5th century CE), a bishop and former student of the mathematician Hypatia. Synesius puts in the mouth of an Egyptian sage the suggestion that divine providence works by designing the world like a device that runs by itself unassisted, for a time, requiring only periodic interventions. A third text, Proclus' *de Providentia*, is written in response to the ideas of a certain mechanic Theodorus, who had written to Proclus detailing a proposal that the world worked like a machine. Proclus (6th century CE) seeks to refute the deterministic implications of Theodorus' view. It is unfortunate that the surviving Latin version gives scant technical detail about Theodorus' conception, as this seems to have been the most thorough articulation of a mechanistic picture of the universe on record from Greek antiquity. Although it has been understood as a clock or a calendrical calculator, I argue that the mechanism Theodorus uses as comparison is also a wind-up theatrical display.

The analogies drawn here are not based on isomorphism, as the devices used in comparison are not modelling the cosmos. The analogy points to abstract

8 See Mansfeld 1995 and the essays in Thom 2014, especially Thom's 'Introduction' and the *Rezeptionsgeschichte* by Kraye 2014. Its authenticity was defended by Reale 1974 and Bos 1977, Bos 1978: cf. Barnes 1977.

capacities of the device: to continue working by itself, without ongoing intervention; to execute a sequence of motions that produces a determinate result; and to transform an initial trigger into a complex and diverse sequence of motions. Theatrical automata do not so much *look* like the heavens, as they suggest how it might *function*. The machines that provide the most philosophically compelling analogues to the role of the gods may be found in surprising places.

1 Archimedes' Cosmic Model as Analogue

Cicero defends the 'design argument' for divine governance of the cosmos. He is responding to a claim that the world might work like the cosmic models built by Archimedes and Posidonius. Apparently, in Cicero's day, the construction of mechanical models of the movements of the heavens was being used by contemporary materialists to challenge the argument for divine design. Graeme Hunter argues that Cicero's version of the design argument is superior to the classic 'watchmaker' argument articulated by William Paley, inasmuch as Cicero points to a case where a structural isomorphism exists between a cosmic simulacrum and the movements of the heavenly bodies that are thought to show design.[9] I argue, conversely, that superficial isomorphisms can be a misleading criterion for assessing the conceptual value of analogues.

Merely accounting for circular rotation of the heavens was not the puzzle. The challenge was rather to show how the movements of sun, moon, and stars were coordinated with one another, and produced the regular cycles of change in the sublunary world around us. One of the classical options in pre-modern cosmology is that celestial bodies are free-standing beings that move independently to realize the cosmic plan; another is that the orbits of celestial bodies are coordinated because stars are attached to invisible intersecting spheres.[10] The so-called 'wandering stars' complicated the latter picture: attempts to account for the stations and retrogradations of the planets occupied geocentric astronomy. New mechanical devices using intersecting toothed wheels promised to show how multiple different orbits could coordinate with one another without each separately needing an intelligent guide – internal or external – to link their movements.[11]

9 Hunter 2009.

10 Grant 1996.

11 Evans and Carman 2014 offer the intriguing suggestion that mechanical modelling may even have contributed to the development of the epicycle hypothesis.

Cicero refers to a celestial device in three texts: two mention a model built by Archimedes, while *On the Nature of the Gods* discusses a device ascribed to Posidonius.[12] While there are significant differences in detail, in each case the device was turned by hand and showed the relative positions of heavenly bodies over time as they moved in their respective orbits. Other sources echo the story, perhaps drawing on Cicero's version, with increasing divergence on details.[13] While a hand-turned model of the kind Cicero describes did not remove the operating agent, it did suggest that the *coordination* amongst celestial spheres could be achieved by material interactions. Motions imparted to one rotating body intersect with and move other spheres by means of intersecting toothed wheels.

Cicero's most extensive report, in his *Republic*, has a textual lacuna at a critical point:

> This kind of *sphaera*, in which were present the movements of Sun and Moon and those five stars that are called wanderers and as it were straying, could not be fashioned in that solid *sphaera*, and one had to wonder at the inventiveness of Archimedes in it, that he had figured out how a single revolution could furnish unequal and diverse courses in unlike motions. When Gallus set this *sphaera* in motion, the Moon caught up with the Sun in the same number of turnings in that bronze object as it does in days in the actual heavens, and as a result the same eclipse of the Sun takes place in the *sphaera*, and the Moon falls within that cone that is the shadow of the Earth, when the Sun is situated.[14]

The precise topography here is a little unclear. Some twentieth century readers have speculated that Archimedes modelled a heliocentric solar system.[15] While a heliocentric cosmos had been suggested by Aristarchus and was known to Archimedes,[16] Neugebauer notes that Aristarchus' model lacked a corresponding planetary theory, so would not live up to Cicero's description here.[17] Michael Wright's modern construction of a geocentric model using slotted arm gears to turn epicycles – techniques from medieval clockwork – establishes

12 Archimedes was one of those semi-legendary figures around whom tales gather: see Simms 1995; Cuomo 2001, 197–8; Jaeger 2008.

13 These include Ovid (43 BCE–17 CE); Lactantius (*c.*240–320 CE); Claudian (b. circa 370 CE); Sextus, *Adv. Phys.* 1.115. Michael Edmunds 2014 collects the ancient references to *sphaerae.*

14 Cicero, *On the Republic* 1.14.21–3, trans. Jones 2017.

15 Russo 1996, 80; Evans 1998, 78–83; cf. Simms 1995.

16 Archimedes, *Arenarius* 136,1–2.

17 Neugebauer 1975, vol. 2, 697.

that it is technically possible to build a geocentric model for sun, moon and the five known planets.[18] Nonetheless, the technical sophistication required leaves room for scepticism about the accuracy of Cicero's report. Alexander Jones questions how literally we should take the 'eclipse' story, noting that Cicero has literary reasons for connecting the construction of a *sphaera* by Archimedes with a demonstration of the causes of an eclipse.[19]

The technological and astronomical challenges for displaying solar eclipses would have been considerable. Although the cycles were known that predicted the approximate alignment when solar eclipses *might* occur, it would not have been possible, before Hipparchus' work in the 2nd century BCE on the relative sizes and distances of earth, sun, and moon, to know when and where an eclipse would be visible.[20] Cicero does not claim that the device could *predict* eclipses, however. Alan Bowen notes the political importance of demonstrating the *causes* of eclipses, since the ability to quell public panic would have enormous strategic as well as intellectual value.[21] Cicero could be describing a demonstration model showing how the relative positions of earth, moon, and sun produce the kind of shadow we experience as eclipse. Given the importance of diffusing fears about divine omens, there would be much value in a three-dimensional demonstration showing how eclipses come about *in general*, without needing to be very accurate as to particulars.

The Antikythera mechanism, a calendrical calculator recovered from an ancient shipwreck, offers a new perspective on the kind of celestial model that was available in Cicero's day.[22] It displayed the relative positions of various celestial bodies using dials moved by interconnected toothed wheels. Jones argues that a device Cicero references in *On the Nature of the Gods* is a cousin of the Antikythera device, i.e., a two-dimensional plane calculator showing planetary positions with pointers, not isomorphic three-dimensional representations.[23] There, Cicero credits a device to the Stoic Posidonius, a friend of his. The device is less elaborate than the one ascribed to Archimedes. It is said to show motions of the five planets known to the ancients, but not to present the causes of eclipses:

18 Marchant 2015; Jones 2017.

19 Jones 2017, esp. 187, 217.

20 Neugebauer 1975, vol. 2, 664–9; Keyser 1998, 246; Evans 1998, 20, 213; Bowen 2002; Jones 2017.

21 Cicero, *Rep*. 1.16.25; Bowen 2001; Bowen 2002.

22 On proposals for dating before 60 BCE, cf. Jones 2017, 157.

23 Jones 2017.

> Suppose a traveller to carry into Scythia or Britain the *sphaera* recently constructed by our friend Posidonius, which at each revolution reproduces the same motions of the sun, the moon and the five planets that take place in the heavens every twenty-four hours, would any single native doubt that this *sphaera* was the work of a rational being?[24]

Jones notes that Posidonius was working in Rhodes, the likely location of the workshop where the Antikythera mechanism was built. It would thus be plausible that Cicero knew of a two-dimensional calendrical device, and only in *Republic* takes the literary license of conflating it with a three-dimensional aid for teaching about eclipses.

This is an attractive proposal for reading the complex evidence found in Cicero.[25] Cicero is evidently responding to an argument that, if a human being could model the observed coordination of heavenly motions using inert matter alone, there would be no necessity for celestial orbits to be directed by divine intelligence. The assumption behind the objection is that appeal to divine intelligence is only justified if it would be impossible to produce the apparent order observed in the heavens by material means alone. Archimedes' model is taken to counter those assumptions with an existential demonstration: 'we don't need to posit divine intervention to explain the coordination of heavenly motions, because – look! – this device can produce something relevantly similar.'

Cicero's reply is succinct. The objector is pointing to the capabilities of a cleverly crafted device as new evidence of what matter can be made to do by brilliant engineering. How much *more* ingenious this would make a designer God, then, to have constructed the actual cosmos to coordinate its own motions! If we were to discover that the movements of the heavenly bodies are mechanically coordinated, we would not have removed the argument for divine intelligence, but rather pushed it back from the *ongoing coordination* of the heavens to the *design*. There would still be a mind behind the heavens, a mind as proportionally more ingenious as Archimedes towers above ordinary men. *Tusculan Disputations* claims, rather, that it is only because he shares in divine intelligence that Archimedes is able to conceptualize his device. By building a heavenly model, Archimedes is not disproving the need for intelligent design, but is rather imitating the divine process of creating a world.[26]

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24 Cicero, *De Natura Deorum* 2.88, trans. Rackham, slightly modified.

25 Edmunds 2014 notes my hesitation in Berryman 2009 about the importance of cosmic *sphairai*, in part because of an earlier uncertainty about the new reconstructions.

26 *Tusc. Disp*. 1.63.

There are other instances of this strategy of turning the argument from mechanical analogy back upon itself. In a different context, Gregory of Nyssa also redirects the machine analogy into a defense of the design argument. Gregory suggests that the possibility of self-moving artifacts shows us that human beings have intelligence and thus cannot be purely material. He is arguing for the existence of soul rather than for the existence of God, but the strategy parallels Cicero's: once any concession is made towards dualism, the case for strictly material explanation is undermined. In *de Providentia*, Proclus invokes evidence that constructed devices demonstrate the existence of human rationality, a phenomenon that raises the greatest difficulties for a materialist natural philosophy.[27] Nonetheless, considerable ground would have been conceded to the materialist if human rationality were the only problem left unresolved.

Cicero's response to the machine analogy does not take it seriously as an explanatory option: understanding the ancient cosmic models as *simulacra* of the heavens would be difficult. The gearing in devices like the Antikythera device may be impressive, but have no apparent analogue in the heavens. Moreover, the devices Cicero references require ongoing operation. A closer analogue for the idea of a 'mechanical cosmos' might be a device that superficially *looked* less like the heavens, but exhibited greater causal autonomy than cosmic calculators or simulacra.

2 Wind-up Devices as Analogue

The earliest use of a wind-up mechanism as a cosmic analogue may be the Aristotelian *de Mundo*, a text that is often dated to about the turn of the common era.[28] Widely circulated in antiquity, the text employs a machine analogy to heighten the glory and dignity of the divine architect.[29] The claim is that design of a complex artifact to works unassisted more clearly shows divine magnificence:

> the most divine characteristic would be this: to produce all kinds of forms with ease and a simple motion, just as indeed the engineers (*mêchanopoioi*) do, producing by means of a single trigger-release mechanism (*schastêria*) many varied activities. In the same way men who run

27 *Prov.* 12.65.

28 On its dating and authenticity, see note 9, above.

29 See Thom 2014 for the reception of the text.

> puppet-shows (*neurospastai*), by pulling a single string, make the neck and hand and shoulder and eye and sometimes all the parts of the creature move with a rhythmical movement. So also the divine being, by a simple movement of the first region, gives his power to the next things and from these again to those further away, until it permeates the whole.[30]

The text distinguishes two different specialties, *mêchanopoioí*[31] and the makers of *neurospastai*. The latter term – literally 'string-pullers' – was the traditional term for marionettes. However, the first reference here clearly refers to a wind-up device with a trigger-release mechanism (*schastêria*), such as those described by Hero of Alexandria (1st century CE) in his treatise on theatre-making.[32] The reference to a *schastêria* or trigger-release starting mechanism employs a technical term found in both ballistic and theatrical contrivances. The *schastêria* allowed the device to be prepared ahead of time and released at will.[33] The theatre operator was able to improve the show by releasing the trigger and disappearing from view, bolstering the illusion that the device moved unassisted. Moving parts were used to animate individual scenes with a narrative background: in one display, a statue of Hephaestus in his workshop has a moving arm. A trip-hammer device behind the scenes is operated as a moving weight unwinds, turning a spoked wheel.

Puppet analogies are nothing new: Aristotle himself refers to 'automatic puppets,' which may be an early version of this kind of wind-up device.[34] Aristotle sees it as a way of demonstrating that a cause can act without being in contact, or that a small initial change can result in an amplified effect. Nonetheless, it is striking how *little* potential he sees in this analogue. The *de Mundo*, conversely,

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30 … ἀλλὰ τοῦτο ἦν τὸ θειότατον, τὸ μετὰ ῥᾳστώνης καὶ ἁπλῆς κινήσεως παντοδαπὰς ἀποτελεῖν ἰδέας, ὥσπερ ἀμέλει δρῶσιν οἱ μηχανοποιοί, διὰ μιᾶς ὀργάνου σχαστηρίας πολλὰς καὶ ποικίλας ἐνεργίας ἀποτελοῦντες. ὁμοίως δὲ καὶ οἱ νευροσπάσται μίαν μήρινθον ἐπισπασάμενοι ποιοῦσι καὶ αὐχένα κινεῖσθαι καὶ χεῖρα τοῦ ζῴου καὶ ὦμον καὶ ὀφθαλμόν, ἔστι δὲ ὅτε πάντα τὰ μέρη, μετά τινος εὐρυθμίας. οὕτως οὖν καὶ ἡ θεία φύσις ἀπό τινος ἁπλῆς κινήσεως τοῦ πρώτου τὴν δύναμιν εἰς τὰ συνεχῆ δίδωσι καὶ ἀπ' ἐκείνων πάλιν εἰς τὰ πορρωτέρω, μέχρις ἂν διὰ τοῦ παντὸς διεξέλθῃ· *De Mundo* 398b13–28, trans. Thom, slightly modified.

31 Although the manuscripts read μεγαλότεχνοι, Lorimer and Furley amend this to μηχανοτέχνοι or μηχανοποιοί ανοποιοί; cf. Thom 2014, p. 64n99.

32 Here I follow Betegh and Gregoric 2014 in reading these as two distinct analogies.

33 Ballistic devices were a strain to charge, and the ability to separate the loading and the discharge allowed for a combination of accurate aim and maximum fire power: see Marsden 1969; Rihll 2013.

34 *De Motu Animalium* 7, 701b2ff; *de Generatione Animalium* 2.1, 734b9ff and 2.5. These texts have been extensively discussed, e.g., by Bodnar 2004; Henry 2005, De Groot 2014; Johnson 2017; Berryman 2009 and Berryman 2022.

considers the device as a model for divine action in the world. Despite the apparent step backward to the marionette picture, the earlier reference to wind-up devices allows a temporal separation between construction and operation of the device. Unlike the puppet analogy found in Plato's *Laws*,[35] which is employed to emphasize that we are under direct divine control, *de Mundo* stresses the *minimal* involvement of the operator.[36] The divine role is made more remote and, in the author's eyes, correspondingly more august.[37]

We can only speculate as to why the 'hands off' role permitted by the use of a trigger-release mechanism might seem more appropriate to the divine than direct administration of the cosmos. The notion of permanence, tranquility, or unchangeability was frequently linked to images of the divine in the philosophical tradition, in a way that would speak against ongoing management of daily life.[38] Only the Stoic school seems to have rejected this trope, insisting on the activity of Zeus in everything and even ridiculing the Epicurean belief that activity was irksome to the gods.[39]

The divine adoption of labor-saving technology finds echo in a text by Synesius of Cyrene. The bishop of Cyrene offers a fictional story about an Egyptian sage, invoking a familiar association between Egypt and ancient wisdom. The task is to explain how the different degrees of involvement in human affairs means that human beings still need to take responsibility for actions in the mundane world. An analogy is drawn between the operation of the natural world as a whole and *ta neurospasta organa*, string-pulled devices:

> And just as string-pulled devices are still agitated even when the man who has given the impulse of motion to the machinery has desisted, but are not agitated forever (for they hold not the source of motion within them, but move only so long as the force communicated to them is strong and is not dissipated by the continuance of the movement), in the same way, my dear Osiris, you must consider that what is well done and divine

35 *Laws* 644D, 803C; cf. *Critias* 109C; Berryman 2010.

36 Betegh and Gregoric 2014 argue that the multiple competing analogues in *de Mundo* indicate that the author is not using them to show *how* a process is accomplished, but only to indicate what is possible or what is appropriate.

37 The introduction of the *neurospastai* makes less clear that the author of *de Mundo* appreciated the greater independence granted by the *schastêria*: I thank an anonymous reviewer for noting that Apuleius seems not to have appreciated the difference in his Latin translation of *de Mundo*.

38 Cf. Thom 2014; Betegh and Gregoric 2014.

39 Cicero, *de Natura Deorum* 2.59: See Bénatouïl 2009 on the trope of divine activity in Stoicism.

> at once belongs and does not belong to this place, but is sent down from elsewhere.[40]

For Synesius, the mechanical device offers a context whereby divine intervention can be an occasional, but still definitive, feature of the natural order. Wind-up devices continue on their own for some period of time but still require divine intervention to re-set them periodically. Synesius embraces this difficulty to suggest that the gods actively intervene at certain points. His interest seems to be in the points where natural processes fail: the notion that the world might be a wind-up device creates a conceptual space for moral order to be restored by direct divine intervention. The notion that wind-up devices might better model divine activity seems to be used here to understand the distinction between ordinary, ongoing operation of natural processes and extraordinary events that intervene and alter that operation.

Miracles are one situation where exactly this distinction becomes pertinent. Pseudo-Dionysius, another Christian author from the fifth century CE, draws such a distinction in his discussion of the darkening of the sky during the Passion. Two alternatives are considered: *aut deus nature patitur, aut machina mundi dissolvetur*.[41] The skies darkened either because the divine governor of nature was emotionally affected by the Passion, or because the natural order was suspended.[42]

The context thus indicates that Synesius is using *neurospaston* to refer to a wind-up theatrical device.[43] We can find this usage of *neurospaston* to refer to wind-up puppets in the work of Marcus Aurelius, an author with whom Synesius was familiar. Marcus uses the idea that unenlightened human beings act like automata to indicate that the workings of the natural world are deterministic, contrasting this with the freedom of the sage.[44] Synesius has a very different agenda. Of the two traditional alternatives – ongoing divine governance and automatic, impersonal operation – Synesius' proposal goes between the horns of this dilemma. He harnesses the machine analogy to allow for occasional interruptions of a self-moving automaton. Moreover, the presence of intermediary instruments is exploited to reconcile divine providence with the existence of evil in this world, and with the necessity for human involvement.

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40 Synesius, *On Providence* 1.9.3, trans. Jona Lendering, slightly modified.

41 Thorndike 1949, 117.

42 As noted above, the term *machina* alone is insufficient to establish that the author intended to invoke a device analogy.

43 Marcus Aurelius, *Meditations* 3.7; 3.16; 6.16; 7.3; Simplicius, *In Phys.* 310.36ff.

44 Berryman 2010.

Prior to his appointment as bishop, Synesius studied at the school of Hypatia in Alexandria. Although we know little about the school curriculum, we do know that it focused on a Platonized mathematics, within which astronomy would have played a central part. In the context of the late fourth century CE, cosmic models like those detailed by Theon of Smyrna would likely be known. But theatrical devices would likely be more familiar to his audience.

Neither Synesius nor the author of *de Mundo* spends much time on the implications of the mechanical analogy for understanding the natural world. Indeed, some ancient readers seem not to notice the technical innovation behind their use of the analogy, assimilating the devices to ordinary hand-operated marionettes.[45] Unfortunately, the most promising text from late antiquity on the mechanical model for the universe is lost, and we know of the ideas of the mechanic Theodorus only through Proclus' rebuttal. Translation may further obscure any technical terminology echoed in Proclus' response, as only a Latin version has survived. Theodorus apparently argued that the world works like a mechanical device, all things depending causally on the action of a single driving motion. In reply, Proclus defends the notion of free choice and denies that divine providence is identical to this kind of causal necessity.[46] Proclus focuses on the implications for his own philosophical position, which Theodorus seems to know. The text suggests that Theodorus was once a fellow student, familiar with the Neoplatonic system.

Because of Theodorus' mechanical aptitude, it is especially unfortunate that Proclus' account does not give much information – at least in the surviving Latin translation – about the device pictured. The best clues to the construction of the device that serves as analogy come early:

> Rather, to use your own words, the inescapable cause, which moves all things that this cosmos 'comprehends within itself', is 'mechanic', and the universe is, as it were, one machine, wherein the celestial spheres are analogous to the interlocking wheels and the particular beings, the animals and the souls, are like the things moved by the wheels, and everything depends upon one moving principle. Perhaps you have entertained such views to honour your own discipline, considering the maker of the

45 See note 36, above. Medieval Latin translations also miss the significance of the trigger-release mechanism: Lorimer 1933, 78–79.

46 Proclus, *On Providence* 1.2.

> universe to be some kind of engineer and yourself as the imitator of 'the best of all causes.'[47]

We don't get much detail on the device that is the point of analogy. Michael Edmunds includes this text on his list of ancient references to *sphaerae*, i.e., cosmic models,[48] while Carlos Steel regards the device used in comparison as a clock.[49] Alexander Jones takes the reference at the end to a *parapêgma* to indicate that the comparison is to a hand-operated calendrical device, since *parapêgma* is the traditional term for a pegged board for keeping track of celestial phenomena. However, the *parapêgma* is introduced at the end to make a different point, and may not be the device that is the main point of comparison.[50] The point about deterministic causation by sequential consequences of a single motion would fit theatrical wind-up devices of the style mentioned by *de Mundo* and Synesius' *Egyptian Tales*. The treatise, moreover, opens with some theatrical references.

Some of the arguments Proclus responds to could be drawn from any philosophical position that embraced necessitation, and are not specific to mechanical causation. Only one argument takes on a less-well-trodden path in confronting Neoplatonist beliefs in providence, and may give us clues to Theodorus' world picture. Proclus suggests – by his response – that Theodorus' positive view depends on the idea of a single 'vital force' analogous to the aether permeating everything. Carlos Steel sees this as evidence that Theodorus holds a Stoic view, whereby the organizing principle is thought to lie with an intelligent *pneuma* that manifests in different degrees according to the capacity of the material it permeates. It seems unlikely, however, that a Stoic theorist would make use of a machine analogy, since organic metaphors better fit their worldview. There are other schools of thought that exploit the notion of *pneuma*, a material substance often invoked in explaining the functions of the

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47 magis autem – ut tuis verbis assequens dicam – mechanica facientem quidem esse irrefragabilem causam omnia moventem, quecumque mundus iste comprehendens in se ipso habet; mechanemate autem uno quasi ente universo, tympanis quidem implicatis proportionaliter totas esse speras, hiis autem que ab hiis moventur partialia, animalia et animas, et omnia ab uno dependere movente. Et forte tuimet artem honorans et hec estimasti, ut et universi factor mechanicus quidam sit et tu imitator optimi causarum: *Prov*. 2.14–21; trans. Steel 2007.

48 Edmunds 2014, 275.

49 Steel 2007, 13–14. While there is a closing reference to an astronomical calculator, *parapigma*, this reference is making a different point about our capacity for foreknowledge: *Prov*. 65. Cf. Steel 2007, 3 and 91n279.

50 This is how Carlos Steel understands the text at *Prov.* 12.65.8: Steel 2007, 71.

soul and compared to the *aether* of the cosmic spheres in Aristotle's cosmos. In Hellenistic medical theory, we find a view that the functions of the soul can be explained by the nervous system, which offers a material basis for the functions of soul through the hollow nerves filled with *pneuma*. The discovery that the nervous system governed both perception and motor functions led to the notion that *pneuma* connected the sense organs to the brain and conveyed information and signals throughout the body by changes in tension of *pneuma* within the nerves.

Although Proclus is thin on detail in his reply to Theodorus, the hints we can discern better fit this kind of theory than they do Stoicism. Proclus' response critiques Theodorus for placing too much emphasis on sense perception, apparently treating sense images as critical to explain intellectual thought and not as dim reflections of the conceptual realm, as the Platonists believe. This implies that Theodorus employed an empiricist approach to the understanding of abstract thought, as would be expected of a materialist. When Proclus complains that Theodorus makes 'the essence of the divine soul emanate from the *aether*,'[51] it is plausible that what he refers to obliquely here is an empiricist psychology grounded in medical theory. Proclus' complaint, somewhat obscurely phrased, seems to be that, rather than recognizing the divinity of the soul, the materialists treat psychological functions as produced by *pneuma* in the human case and *aether* for the divine. If this is right, Theodorus would be using *pneuma* theory of perception as a basis for understanding cognition. Platonist criticisms of these empiricist theories are telling: they faced considerable difficulty in explaining how mental capacities can develop on the basis of abstraction from the contents of sense perception. We know of mechanical analogies between Hellenistic pneumatic devices and other bodily functions, although Proclus does not tell us whether Theodorus knew of or refers to these.

Despite the sparse evidence, it is clear that Theodorus saw the potential of mechanical devices to model the idea that complex causal sequences follow automatically from a single cause. The Latin transliterates a Greek term – *heirmos* – that other philosophers use when they point to mechanical devices as a model for complex causal sequencing, which identified with the action of fate, *heimarmenê*.[52] The notion of fate is understood by both philosophers to represent a kind of blind necessity, challenging the notion of divine providential care. Theodorus tries to argue that there is nothing more to apparent

51 *Prov*. 3.42.

52 *Prov*. 1.2.8. Although the similarity in the terms is not preserved in Latin, Steel helpfully notes the similarity of the likely Greek equivalents.

providence than the working out of fated necessity. The analogy to mechanical devices provided a material instantiation of this possibility.

3 The Machine as Causal Model

We cannot fully understand the context of the mechanical analogy in late antiquity without recalling the state of causal theory at the time. In the 18th century, Laplace articulated the idea of a demon who might know all the laws of nature and all the initial positions of all the particles of matter in the universe, and thus be able to calculate in advance what happens next. The physical theories of antiquity lack the precise quantificational laws that would permit the formulation of such a conception. Aristotle's physics – the dominant and most sophisticated – supposes that causal impetus dwindles to nothing unless it is renewed. Although the atomists supposes that atoms keep moving until they strike other bodies, they lacked the resources to quantify the causes of motion in a manner that would allow for such precise notions of conservation.

In such a context, causal explanation would be limited to a qualitative account of a single event: fire heats, a ball strikes and sets another in motion. Little supports the Laplaceian idea that the outcome of a long sequence of connected causes would be determinate or predictable. A prevailing model of causation was what A.C. Lloyd called the 'transmission' model, and Barnes called 'causal synonymy':[53] the idea that causation consisted of transferring a property possessed by the causing object onto the receiving object. Even in late antiquity, cases that seem to violate the expectation that a cause possesses the property it causes in another object are treated as exceptions to explain. This model is essentially qualitative rather than quantitative or conservationist: there is no assumption that the causing agent has only so much of a given property to transfer, or that it runs out of the property – heat, motion, life – that it conveys to other beings. The object receiving a property by gift does not possess it essentially, however, and so its shelf life is limited. An impetus impressed on a projectile dwindles; the heat of a kettle fades once it is taken from the fire; matter can no longer sustain the soul of an aging animal. Causation simply peters out.

A complex device where one event leads to another in tight sequence – the classic Rube Goldberg device – visibly illustrates a particular way of conceptualizing determinate causal sequencing. An engineer releases the trigger:

53 Lloyd 1976; Barnes 1982.

a weight begins to fall and an attached rope unwinds, turning the wooden axle around which it is wound. Wheels fixed to the axle turn, and the device rolls along the ground. This precisely determined *sequencing* is unique in the ancient imagination to mechanical devices. When Aristotle wants to illustrate the idea that the male seed might instigate a complex sequence of transformations, without itself being any longer physically in contact with the resultant embryo, he turns to automatic puppets to make the case. Aristotle's use of the mechanical analogy is limited to the idea that the instigator is no longer in contact. But later philosophers and medical theorists treat devices as illustrating the possibility that longer, interconnected sequences could be engineered to bring about a determinate result.[54] Simplicius, commenting on Aristotle's use of the automatic puppets to explain the transmission of effect, stresses the ability to model *sequences* of causes, *heirmon* or *diadochê*. Where Aristotle focused on the absence of the instigating cause, by late antiquity it is the ability to model causal sequences that stands out.[55]

Proclus' text links Theodorus' use of the machine analogue to a particular way of conceiving of causal sequences. The mechanical device provides a context wherein the idea that a determinate outcome is produced by a *sequence* of causally connected motions, using the engineering of the device to produce a predetermined outcome after several transformations: a trigger-mechanism releases a weight which falls, pulling a rope which turns a drum, spinning a toothed wheel intersecting with another cog at right angles, etc. Both the sequential determination and the transformation of one kind of motion into multiple different motions are distinctive here. In Theodorus' text, the machine shows us how a divine designer might have engineered the world to run by itself, using the organization of the material components to execute a predetermined sequence of events.

Proclus' criticism of Theodorus' programme includes a defense of the presence of 'powers' in organisms.[56] He defends the Aristotelian view of the organism as a self-maintaining unit. In late antiquity, there seems to have been a felt tension between teleological approaches to explanation, which accorded organisms a special kind of unity and cohesion, and those intrigued by the idea that material-causal processes might be sufficient, given the complexity of effects that could be produced in engineered devices. Proclus' concern may be that the mechanical view of causal sequencing undermines the

54 See Berryman 2010. De Groot 2014, 123, notes the emphasis on sequences in Furley 1967, 210–16.

55 Henry 2005; Berryman 2009.

56 *Prov*. 3.11. See Steel 2007, 76n48.

explanatory autonomy that is accorded organisms by an Aristotelian teleological framework.[57] A machine model of the universe would tend to erase the explanatory boundary between organism and environment, since it accords no special causal priority to the natures of substantial individuals.

The association of the mechanical with predictable, incessant, unintelligent processes may come as no surprise to modern ears. But it is worth highlighting quite *why* in antiquity the notion of a mechanical device would have such a strong link to the notion of deterministic processes, even apart from the context of modern industrial mass production. Devices provided the best analogue available for the notion that determinate results could be produced automatically through a sequence of complex causes. Mechanical devices provided a clear visual depiction of the notion of a causal sequence: like a Rube Goldberg device, one event leads to another and to another in a determinate sequence that produces a given result without ongoing intelligent direction.

Derek de Solla Price noted that mechanical analogies in antiquity clustered into two distinct varieties, those concerned with the motions of the heavens and those appropriate for organisms.[58] I suggest that the comparisons between automata and the workings of nature in general form a distinct third variety, more abstract than either of those Price identified. Structural isomorphisms are less important than the kind of extended autonomy exhibited by complex and manifold causal sequences all governed by a single trigger-release mechanism. This is why we find theatrical devices used in analogies for the action of the gods on the cosmos. The relevant notion that inspired a mechanistic picture of the universe is, I suggest, that of running by itself, and not that of operating by gears.

4 Conclusion

Although there has been more focus on the role of experience with material devices in forming ideas about the natural world during the early days of ancient Greek natural philosophy, I argue that specific idea can be traced to ancient Greek mechanics, a field that was only forming in the fourth century and really came into its own during the Hellenistic period. Here I have traced the impact of only one small invention, the trigger-release mechanism, on ideas about the relationship between an intelligent designer and the ongoing

57 *Prov.* 3.11: I take this to be the point of the reference to Aristotle's claim that organic processes can go against fate. Cf. Steel 2007, 76n50.

58 Price 1964.

operation of the cosmos. It offers a suggestive instance of the impact of technological innovations on conceptions of the natural world and its functioning.

The virtuosity of calendrical devices like the Antikythera mechanism may lead us to expect that similar devices would have inspired ancient appeals to a 'clockwork universe.' Cicero apparently reported – and dismissed – such a comparison as a way to undercut the need for divine direction in the cosmos. However, other authors from late antiquity may have seen theatrical devices as a more compelling analogue for a mechanical universe. In two eclectic theological texts, 'hands off' governance – perhaps with the possibility of occasional intervention by the gods – is presented as a superior way to operate the cosmos. For a causal determinist, the causal sequencing in ancient mechanical devices offered a new way to think about the functioning of material processes without ongoing teleological direction. Appeal to such devices undermined claims made about the limited capacity of material means to regularly realize complex, determinate sequences. In this vestigial evidence, we have evidence of an important conceptual turn.[59]

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PART 2

Thinking with Objects

∴

CHAPTER 5

Using a Household Artefact as an Epistemological Tool

The Clepsydra in Anaxagoras, Aristotle's De Caelo*, and Empedocles*

Nathasja Roggo-van Luijn

Imagine you are a slave in fifth century BCE Greece, assigned with the task of cooking dinner. The oil is stored in a large amphora in the pantry and you need to take some oil to the kitchen. Or imagine that you are a symposiarch, in charge of mixing the wine for your guests. The wine is stored in some large vessels and you wish to transfer some into your krater so that you can mix it. How do you manage this? Given the size and weight of the vessels these liquids are saved in, it is unfeasible to simply lift them to pour some of the oil or wine into a smaller jar. Luckily, the Greeks had a solution to this problem: the household device called 'clepsydra' (κλεψύδρα).

Designed to transfer liquids from one vessel to another, the clepsydra (literally 'water-thief') is a vessel made of either baked clay or metal.[1] It is characterised by a narrow neck with a thumbhole at its top and a broader base pierced with small holes. Most archaeological finds feature a round handle containing this thumbhole (see figure 5.1),[2] but Simplicius describes the clepsydra as 'a container with a narrow mouth and a wider bottom pierced by little holes' (ἀγγεῖον στενόστομον πλατυτέραν ἔχον βάσιν μικραῖς ὀπαῖς κατατετρημένον),[3] which could suggest a vessel like the one in figure 5.2. The number of clepsydras dating to the sixth century BCE that have been found in a wide geographical area, including Eleusis, Tanagra, Boeotia, Galaxidi, and even the Caucasus,[4]

1 According to pseudo-Aristotle, *Problems* 16.8 the clepsydra was made of metal, and Hero's *Pneumatics* 1.7 discusses a bronze vessel. The archaeological evidence primarily consists of clay (e.g., Bulle 1897 and Pottier 1899). For the water-clock used in law courts that goes under the same name, see Allen 1996, 157–163.

2 Based on the sixth century BCE example of the Louvre depicted in Bollack 1969, 484.

3 Simplicius, *In De Caelo* 524.19–20. The discrepancy between these two shapes could also be the result of a change in design: Simplicius lived several centuries later and also remarked that this device is no longer called a clepsydra in his time, but a *hydrarpax* ('water-snatcher').

4 These findings were published by Bulle 1897, 387; Zahn 1899, 339; Pottier 1899, 7–8 (who did not understand the purpose of this vessel; clarification of the functioning in Clermont-Ganneau 1899, 324–325); de Ridder 1894, 27; and Kieseritzsky 1899, 56–57 respectively.

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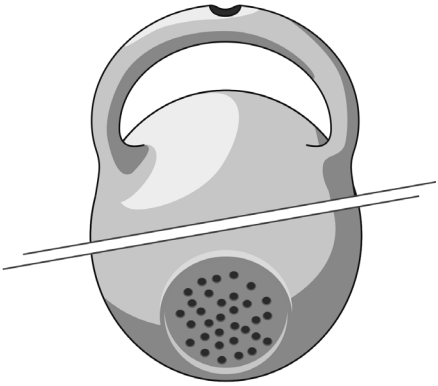


FIGURE 5.1
Clepsydra with round handle
IMAGE BY MARTIN KLÖCKENER, BY PERMISSION

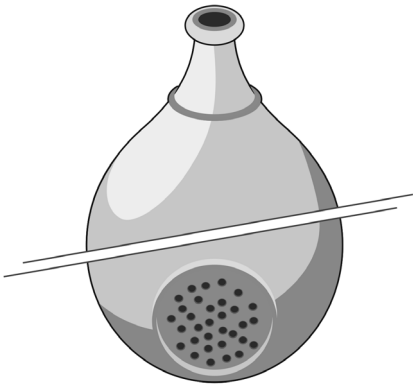


FIGURE 5.2
Clepsydra with narrow neck
IMAGE BY MARTIN KLÖCKENER, BY PERMISSION

indicates that the clepsydra was a common household device in archaic and classical Greece.

Early Greek philosophical comparisons with the clepsydra can be found in Empedocles, Anaxagoras, and Aristotle's *De Caelo*. The majority of scholarship on these comparisons has focused on the former two thinkers, and especially on the questions of whether Empedocles conceived of breathing through the nostrils or through pores in the skin and whether he employed the clepsydra for an experiment.[5] While the exact correspondences between the clepsydra and the target domains in all three authors have received ample attention,[6] few scholars (as we shall see) have discussed the heuristic and explanatory contribution of the references to the clepsydra.[7] Why did these thinkers employ the household device and what difference would it make if the comparisons were left out? What role do these comparisons play for the intended audience for whose benefit they were employed – whether that be a small number of specialists like themselves or a growing number of educated laypersons? How did the demands of communicating new ideas to a particular audience influence the formation and expression of a thinker's theories, including their choice of comparisons?

5 For the latter question, see, e.g., Cornford 1952, 5–6; Furley 1957, 36; Guthrie 1965, 225–226; Lloyd 1966, 331–333; and McKirahan 2010, 282. I return to both questions below.

6 See footnote 41 for the debate about the correspondences in Empedocles' analogy.

7 Gheerbrant 2017, 383–385 suggested that Empedocles' analogies have both a heuristic and a didactic value.

The lack of scholarship on these questions is not coincidental. Scholars have tended to follow one of the following trends. Firstly, some secondary literature calls those comparisons 'examples', which means that they merely illustrate some aspect of a theory. Although examples can thereby clarify features to an audience, they lack a heuristic aspect. Secondly, some scholars tend to call all kinds of comparisons 'analogies' and are influenced in their understanding of analogies' functioning by the so-called 'comparison theory' of analogy (explained below), which does not allow an audience to learn something new from a comparison. Thirdly, at times scholars collapse the difference between 'examples' and 'analogies' and use both terms almost interchangeably for the same passages.

This paper argues that a) so-called examples are better understood as instantiations of the property of an entity, because they are often employed in both the heuristic and explanatory sphere, b) the structure-mapping theory of analogies can account better for the heuristic aspect of comparisons than the comparison theory, which therefore allows us to pinpoint the heuristic and explanatory advantages of the use of such comparisons, and c) instantiations of the property of an entity and analogies do not work in the same way epistemologically, but since both comparative practices encompass heuristic and explanatory advantages, they both form essential parts of the theory rather than ornamental additions. Let me unpack each of these theoretical claims a bit more before turning to the early Greek clepsydra comparisons.

With 'instantiations of the property of an entity', I refer to specific and individual manifestations of a property of an entity, which can be any kind of property. This kind of comparisons can be used both heuristically and explanatorily. Within the heuristic sphere, this process is called 'induction': from a limited number of observations, a broader conclusion is drawn about the property of an overarching category of entities, to which all the examples belong. For example, the conclusion that 'all swans are white' is drawn from the observation of twenty white swans, or Democritus concludes that 'like tends to like' from the observations of sorting seeds in a sieve, the waves of the sea sorting pebbles according to size, and birds flocking together in groups (because he thinks all those instantiations can be explained by referring to this property of like things; DK68 B164=LM 27 D55). The explanatory aspect of such an instantiation of a property of an entity is commonly termed 'example', as this specific instance helps an audience to understand the general claim or wider overarching category to which all instantiations belongs: the claim that 'all swans are white' is then supported by the individual manifestations of several white swans, which aid an audience to comprehend the broad category of swans. I group induction and examples together under the overarching 'instantiations

of a property of an entity' because they are two sides of the same coin, referring to the same process of moving between a general category and a specific instance within that category, but in opposite directions.

This process has heuristic advantages, as sometimes a thinker would not have arrived at their theory without the process of induction from specific instantiations. Moreover, presenting an audience with specific instantiations can have several explanatory effects. The elucidation of a thinker's own heuristic process and the support of their generalization by some instantiations persuades an audience of the truth-value of the property of all entities of the overarching category. By providing examples a thinker also implicitly invites their audience to make further observations themselves. Presenting their audience with the opportunity to check their inductive generalisation by observing singular instances similar to the ones mentioned by the thinker can involve the audience in the epistemological process and already have a persuasive effect on its own, especially when observations which could strengthen or refute the thinker's general claim or property of all entities within a certain category can be carried out in daily life and do not require specialistic equipment.

Another kind of comparisons is formed by analogies. Implicitly or explicitly, most scholars of ancient philosophy have been influenced by the so-called 'comparison theory' of analogy, which was popular until the 1960s and ultimately goes back to Aristotle. According to this theory, a reader activates all their knowledge about the source domain (the familiar entity or process) and the target domain (the entity or process which the comparison aims to explicate or illuminate) upon hearing an analogy. The overlap between the two lists of properties would convey the meaning of the comparison.

One major difficulty with the comparison theory which led the majority of more recent scholars of cognitive linguistics to reject it concerns the irreversibility of analogies. Metaphors and analogies are fundamentally asymmetrical: the reversed statement does not make as much sense as the forward version. For example, the analogy 'My job is like a jail' is perfectly coherent, whereas the reversed statement 'A jail is like my job' fails to make any sense, or at least to make the same sense. The comparison theory, however, cannot account for this phenomenon of asymmetry, as the order in which the two domains are compared should not influence the degree of property overlap.[8]

8 Cf. Glucksberg and Keysar 1990, 4. Any apparent exceptions of this reversibility, e.g., 'My surgeon is like a butcher' and 'My butcher is like a surgeon', are due to both statements having an entirely different meaning. In this example, the sentiment shifts from an insult to a compliment (Chiappe et al. 2003, 87–88).

Unfortunately, the comparison theory of analogies has remained one of the most widespread ways to interpret ancient Greek scientific comparisons, even if this often happens unconsciously. Scholars tend to take a quick look at the source and the target, and upon seeing one or two salient features which can be attributed to both domains, they assume they have found the *tertium comparationis* and move on with their analysis. Analysing analogies in this way reduces those comparisons to mere illustrations of a certain aspect of the theory or hypothesis in question. The second core objection to the comparison theory is that it does not allow for discovering or learning something new about the target domain, as those new features would not yet be in our list of properties about the target domain. The comparison theory of analogy, in short, systematically neglects the heuristic function of analogies.

The advantage of contemporary cognitive theories of analogy, such as Gentner's 'structure-mapping theory' of analogy,[9] is that they allow for an analogy to teach something new, either to the thinker coming up with the analogy or to the thinker's intended audience. The central claim of this theory is that an analogy is understood by the processes of alignment and projection. Upon hearing an analogy, somebody retrieves all information about the source domain and the target domain (as in the comparison theory). But rather than seeing all overlap as the meaning of the analogy, they focus on the relation between all those properties, and perform a mental mapping of the largest interconnected structure of properties from the source domain to the target domain. Lastly, candidate inferences are retrieved: those properties of the source domain which are related to the interconnected structure of properties we already know to match between the source domain and the target domain. When approved for their aptness in the target domain, these candidate inferences form the means through which analogies can transfer new information. Looking at early Greek clepsydra comparisons from this theoretical viewpoint gives comparisons a central place in epistemology: rather than assuming that these comparisons could have been left out without any consequences, I claim that these comparisons can form the means through which a thinker arrives at a theory, and that they can convey new information to the thinker's intended audience.

In short, instantiations of a property of all entities of an overarching category and analogies do not function in the same way epistemologically. Whereas for an instantiation both the specific instantiation and the property somehow

9 This structure mapping theory of analogy is set out among others in Gentner 1983, Gentner 1986, Gentner 1989, and Gentner and Bowdle 2001. For more recent evidence in favor of this theory, see also Holyoak and Stamenković 2018, 650.

belong to the same overarching category of things in which the world is divided according to the ancient thinker in question, the source domain and target domain of an analogy necessarily belong to different realms.[10] Another distinction is the amount of properties involved in the comparison. In case of an induction or example, one particular feature is observed in a number of instantiations, and subsequently this property is inferred about the whole category of entities. In the case of analogies, however, a plurality of features is mapped from the source domain of the analogy to the target domain. Both practises can be employed with familiar entities or processes, or with source domains of the comparison especially created for the purpose of the comparison. The former case constitutes more explanatory support, for the comparison is more easily processed or invented by an audience or thinker when they are at least somewhat familiar with the source domain, whereas the latter constitutes a heuristic advantage, as new artefacts or unfamiliar uses of familiar artefacts can spark new ideas or fresh explanations of the procedures carried out with them.

From this theoretical viewpoint, I shall argue that the references to the clepsydra in the *De Caelo* and the works of Anaxagoras and Empedocles are not mere ornamental examples that could easily have been omitted, but a significant part of their respective argumentations. These comparisons with the clepsydra, although employed for different target domains and in different epistemological practices (instantiations of a property of a category of entities for Anaxagoras and Aristotle's *De Caelo* – namely that air cannot be squeezed and that air can carry other substances – and analogy for Empedocles), have one thing in common: they are valuable tools in either the invention and/or the dissemination of the theory in question. By showing how the references to the clepsydra are vital to both these authors and their audiences, I provide an example of how these thinkers were embedded in the material world around them. This article therefore offers a contrasting opinion to Barnes, who in the preface of *The Presocratic Philosophers* claims that 'philosophy lives a supra-celestial life, beyond the confines of space and time',[11] because it demonstrates how taking the material context of the fifth and fourth centuries BCE into account can improve our understanding of the philosophical and scientific argumentations in which the references to the clepsydra are included.

Before examining the significance of the three references to the clepsydra, let me set out the way it is used in everyday life as presented by the

10 If they belong to the same realm, we are dealing with literal similarity, e.g., 'A grapefruit is like an orange' (because both belong to the same overarching category of citrus fruits); cf. Gentner 1983, 159.

11 Barnes 1982, xii. See also the introduction.

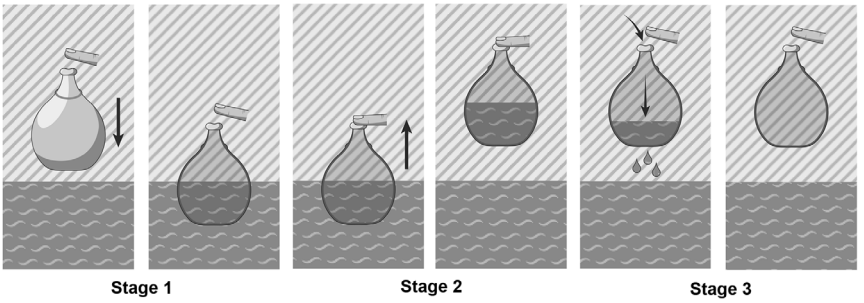


FIGURE 5.3 The use of the clepsydra according to Hero of Alexandria
IMAGE BY MARTIN KLÖCKENER, BY PERMISSION

first century BCE writer and engineer Hero of Alexandria.[12] In his *Pneumatics*, he describes how somebody pours wine from one vessel into another with the help of a clepsydra. This process can be divided into three stages, illustrated in figure 5.3. First, one holds the clepsydra at the neck, while keeping the upper vent open. The clepsydra is submerged into the liquid, which enters the vessel through the holes in the strainer at the bottom as the air leaves the clepsydra through the thumbhole at the top (stage 1). Once the instrument is full, one covers the upper vent with a finger and lifts the device out of the liquid. The liquid now remains in the clepsydra and does not fall because the air exerts pressure on the small holes in the strainer and because a vacuum would arise if the water were to fall out, since the closure of the top vent means that no air can enter to replace the space left by the water (stage 2). Having moved the clepsydra to a position above the vessel to which the liquid is to be transferred, one removes their finger to open the upper vent. The liquid flows out through the strainer because air can come in through the thumbhole at the top to replace the space left by the falling liquid (stage 3).

The remaining part of this article is divided into three sections, each dedicated to a reference to the clepsydra. Rather than following the chronological order, I have organised the texts according to epistemological practice, starting with the inference of a general property of an entity from a single stage of the clepsydra's use in Anaxagoras and in Aristotle's *De Caelo* and ending with

12 Hero of Alexandria, *Pneumatics* 1.7 (for a translation of the passage, see Cohen and Drabkin 1948, 326–327). Other ancient descriptions of the clepsydra's functioning can be found in Pseudo-Aristotle, *Problems* 16.8 914b9–915a24 (a Peripatetic treatise stemming from an original collection by Aristotle himself or his closest collaborators and adapted in the following centuries, see Quarantotto 2017, 101) and Simplicius, *In De Caelo* 524 (sixth century AD).

the analogy of several stages of the clepsydra's functioning in Empedocles. Section (i) discusses how Anaxagoras employs the clepsydra for the inference of a general property of air in an unusual way: submerging it with the upper vent closed in order to demonstrate that air cannot be squeezed. The household artefact likely plays a heuristic role for Anaxagoras and invites the audience to verify his theory at home. A similar possible role is addressed in section (ii), which treats the reference to the clepsydra in Aristotle's *De Caelo*, that induces a characteristic of air from one usual stage of clepsydra's household functioning. The reference to the clepsydra is persuasive because the audience can verify whether air indeed possesses the claimed property by using their clepsydras at home. In section (iii), I discuss what may be the earliest use of the clepsydra comparison, Empedocles' four-step description of a girl playing with the clepsydra. I argue that his analogy provides a mnemonic aid to the members of his audience, and also helps them understand why inhalation works, since both respiration and Empedocles' way of handling a clepsydra require the absence of void.

1 Anaxagoras

According to Aristotle, Anaxagoras and 'others' supported their theory about the nonexistence of void with two different demonstrations. When a clepsydra is submerged into a liquid while a finger keeps the upper vent closed, the air inside the vessel prevents the liquid from entering the clepsydra. Similarly, when one blows air inside a wineskin, it resists pressure from outside when one tries to squash it flat.[13] In both cases the air inside cannot be compressed. Together with the implicit premise that only bodies have this kind of resisting force, this supplies an argument against the hypothesis of some other thinkers who argued that air was void. Although these demonstrations do not conclusively show the absence of void, they do refute an easy argument in favor of void's existence, stating that air seems to be an empty space.[14]

> Those who attempt to prove that it [sc. the void] does not exist do not refute what men mean by void but only what they erroneously say; e.g.,

13 Aristotle must be referring to wineskins, and not to the type of closed vessel with a stirrup handle and a spout also called an ἀσκός, because it is impossible to twist (στρεβλοῦντες) such vessels.

14 Barnes 1982, 399. According to Burnet 1958, 332–333, the argument would have needed to be directed against the Pythagorean theory on void, because it fails to refute Leucippus' theory.

> Anaxagoras and those who refute it in that fashion. For they show that the air is something, by twisting wineskins and proving that the air is strong, and by capturing it in clepsydras.[15]

Anaxagoras thus used the generic property of air that it can resist pressure as a premise in his argumentation against the existence of void. He based this general claim about this specific property of air on two specific instantiations (the wineskin and the clepsydra), in which air can be observed to exert a resistant force. Enclosing air in those two artefacts was a fairly familiar procedure. As we know from some literary sources, the normal purpose of an ἀσκός was the transport of wine or solid food for consumption.[16] However, it was also regularly filled with air, both in literature and in (rural) daily life. In the *Odyssey*, Aeolus presents Odysseus with a wineskin filled with 'the paths of the blustering winds'.[17] Diogenes Laertius presents a story of how Empedocles, when the Etesian winds blew so strongly that they were damaging the crops, ordered asses to be flayed so that their skins could be used to make bags (ἀσκούς).[18] These bags were to be stretched near crests and mountain ridges to catch the winds and prevent them from damaging the crops further.[19] It has also been claimed that wineskins filled with air could have been used as pontoons[20] and in rustic sports (because they resist pressure when you jump on them).[21]

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15 Translation Barnes 1982. Aristotle, *Physics* 213a22–27 (=DK59 A68=LM 25 D60), text Ross 1950: οἱ μὲν οὖν δεικνύναι πειρώμενοι ὅτι οὐκ ἔστιν, οὐχ ὃ βούλονται λέγειν οἱ ἄνθρωποι κενόν, τοῦτ' ἐξελέγχουσιν, ἀλλ' ⟨ὃ⟩ ἁμαρτάνοντες λέγουσιν, ὥσπερ Ἀναξαγόρας καὶ οἱ τοῦτον τὸν τρόπον ἐλέγχοντες. ἐπιδεικνύουσι γὰρ ὅτι ἐστίν τι ὁ ἀήρ, στρεβλοῦντες τοὺς ἀσκοὺς καὶ δεικνύντες ὡς ἰσχυρος ὁ ἀηρ, καὶ ἐναπολαμβάνοντες ἐν ταῖς κλεψύδραις.

16 For wine, see e.g., Homer, *Il.* 3.247 and Homer, *Od.* 9.196. For solid food, see Thucydides, *History* 4.26, who describes a wineskin filled with poppy-seed mixed with honey and bruised linseed (Hurschmann 2010, 607).

17 Homer, *Od.* 10.20: βυκτάων ἀνέμων [...] κέλευθα.

18 Diogenes Laertius, *Lives* 8.60.

19 Although this story is in all likelihood a later invention and should therefore not be taken at face value, it shows that the notion of enclosing winds or air into something called an ἀσκός was at the very least deemed imaginable in Antiquity and probably even a fairly common practice.

20 Elders 1966, 251. Not having been able to find any evidence to support this claim, I would not rule out the possibility that shepherds, for example, could have used such an object which they carried with them to stay afloat in water.

21 Cornford 1952, 6. Although jumping on air-filled animal skins is attested in the fourth century BCE (e.g., in comedy, see Latte 1957, 389–390) and became a more popular pastime known as ἀσκωλιάζειν in the early imperial period (Latte 1957, 387 and Taillardat 1967, 71), we can only speculate as to whether they were already used in this manner in Anaxagoras' time. I thank Jonathan Griffiths for pointing me to this use of an ἀσκός.

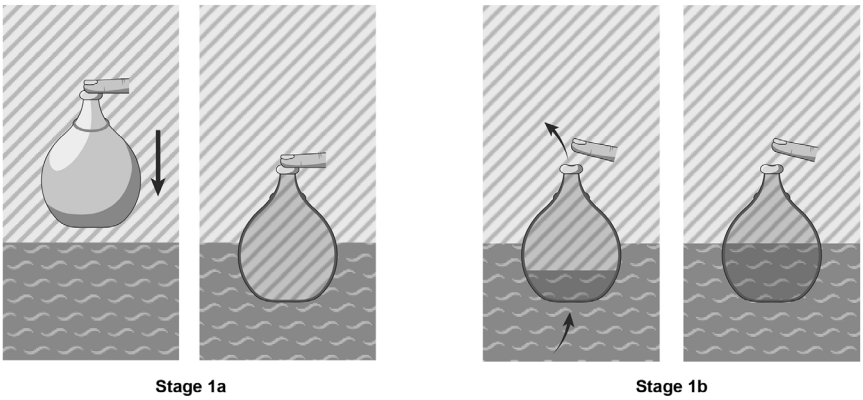


FIGURE 5.4 Submerging the clepsydra with the upper vent closed
IMAGE BY MARTIN KLÖCKENER, BY PERMISSION

Although the enclosing of air within the clepsydra Anaxagoras describes is not part of the practical daily usage of this artefact described by Hero of Alexandria, this does not mean it is unfamiliar. Compared to Hero's outline of the use of the clepsydra (see my introduction), Anaxagoras refers to an alternative way of filling the clepsydra with liquid (stage 1): instead of submerging the vessel with the upper vent open, the user keeps the upper vent closed with a finger while plunging the vessel under water. The water cannot enter the vessel in this situation because the air is trapped inside without any possibility to leave (see stage 1a in figure 5.4). Only when the upper vent is reopened can the air exit the vessel through the top, giving way to the water to enter through the strainer at the bottom (see stage 1b in figure 5.4).[22] Stages 1a and 1b do not form a part of the common household usage of the clepsydra, since submerging the vessel with the upper vent open, allowing the water to enter immediately,

22 But how could Anaxagoras have known that no water entered the clepsydra during stage 1a? For the household device was made of clay or metal and therefore not transparent. Firstly, the water entering the vessel during the usual stage 1 might have been audible, and this sound would be absent in stage 1a, signalling that the water remained outside. Moreover, if the width of the larger vessel from which the clepsydra would transfer liquid was relatively narrow, the liquid would visibly rise when the stopped-up clepsydra was submerged, and then return to its original level in the larger vessel once the user removes their finger and the liquid rushes into the clepsydra. The rising and falling of the liquid might have been visible from above. Alternatively, Anaxagoras could have performed stage 1a, and instead of lifting his finger to let the water enter (stage 1b), immediately proceeded with stages 2 and 3. When you lift an empty clepsydra and then remove your finger, no water could fall out during stage 3, indicating that it had not entered in stage 1a.

is more efficient. For Anaxagoras' purpose of providing proof that air cannot be squeezed, however, stage 1a is crucial, for his conclusion follows from the observation that no liquid enters the vessel when one submerges it with the upper vent closed: if the air could be compressed to occupy a smaller volume of space, the water or wine would enter through the strainer at the clepsydra's bottom to the hollow inside. However, even though this stage might not be a part of the most efficient way to use the clepsydra for the transfer of a liquid, submerging the clepsydra with the upper vent closed is not necessarily unfamiliar. Anaxagoras might have been familiar with it through his knowledge of Empedocles, who, as I show in section (iii) of this paper, used the same stage 1a in his analogy for respiration instead of the 'default' stage 1 as described by Hero. Furthermore, it is easy to alter the 'standard' process in such a way, and thereby very conceivable that children would have submerged the clepsydra with the upper vent closed in their play.

Anaxagoras' references to the wineskin and the clepsydra likely contained a heuristic dimension: he probably received the idea that air cannot be squeezed from his encounters with wineskins and clepsydras, whether in accidental or purposeful situations. He might have been acquainted with Empedocles' poetry and come up with his notion of the incompressibility of air, because he was inspired by the behaviour of the girl in Empedocles' B100 (although the relative dating of Anaxagoras and Empedocles is contested),[23] or gain the idea that air exerts pressure during his observation of the behaviour of air during his daily use of a wineskin or clepsydra (or his direct observation of another person using these artefacts, for example in a symposium). Alternatively, Anaxagoras could have arrived at his idea through something like an 'experiment': the purposeful creation of an entity or phenomenon for the sake of using it as the source domain of a comparison.[24] With the purpose of investigating a specific

23 The relative dating of Empedocles' and Anaxagoras' references to the clepsydra is contested. Empedocles seems to have been slightly younger than Anaxagoras (Wright 1981, 3–4), but both thinkers were active more or less contemporaneously. O'Brien and Mansfeld conclude on the basis of an analysis of Aristotle, *Metaphysics* 3.984a10–13 that Anaxagoras' treatise was made available before Empedocles' poem (O'Brien 1968 and Mansfeld 2011, 364–365), but that does not exclude the possibility that they mutually influenced each other (as, e.g., Thibodeau 2019, 184–185 argues). Most scholars interested in the clepsydra seem to assume that Empedocles' analogy slightly predates Anaxagoras' use of the clepsydra (e.g., Wilkens 1967, 135; Lonie 1981, 367; and Cherniss 1983, 146n.15). This issue cannot be resolved with certainty: Anaxagoras could have been inspired and influenced by Empedocles in the use of the clepsydra, or vice versa, or both thinkers employed the clepsydra simultaneously but independently.

24 Whenever I use the phrase 'experiment' in this paper, I mean it in this limited sense, not in the sense of a repeatable, controlled observation it acqu ired in later science.

property of air, he would have enclosed it in household items that were easily available to him. Finding that the presence of the air inside these artefacts meant that he could no longer squeeze the wineskin and that the liquid could not enter the clepsydra as long as he held his finger on the top vent, he would have concluded from these observations that air cannot be squeezed.

The heuristic role of the clepsydra in Anaxagoras' thinking is also strongly suggested by the pseudo-Aristotelian *Problems* 16.8, which describes Anaxagoras' explanations of a wide range of observations one could make with the clepsydra.[25] This passage describes Anaxagoras' discussion of the clepsydra's features, agreeing with him that air plays a causal role in the functioning of this device, but insisting that Anaxagoras' theory needs some refinement. Submerging the clepsydra with the upper vent closed is not the only action explained by Anaxagoras which differs from its daily usage. For example, this treatise describes how a half-filled clepsydra is turned upside-down while the upper vent is closed. From the fact that the water does not flow out immediately when the 'upper vent' (now facing downwards) is opened but takes some time to do so, Anaxagoras is said to have concluded that during the inversion of the vessel, the water did not move from the strainer to the now inverted 'top'. Anaxagoras' apparent interest in explaining this kind of phenomena suggests that carrying out 'experiments' with the clepsydra led him to provide explanations for it (or at least that a third-century BCE thinker thought that it did), so it seems likely that searching an explanation as to why water cannot enter the clepsydra while the upper vent is closed played an equally central role in arriving at his theory about the non-existence of void. Alternatively, it could have played a significant corroborative role in the next stage: having come up with a theory or hypothesis about void and air, he would have attempted to test this theory and endeavor to observe it with his own eyes. In that case, he would have used everyday items like an *askos* and a clepsydra for this corroboration because they were so easily available to him.

What does the probable 'experimental' heuristic background of Anaxagoras' comparisons with the askos and clepsydra mean for their didactic functioning? Aristotle tells us that twisting wineskins and enclosing air in clepsydras was a way for Anaxagoras and others to show (ἐπιδεικνύουσι) that air is 'something' (or perhaps that air is a kind of body and not mere void). If we trust Aristotle's

25 The *Problems* is assumed to be an accumulation of work from different Aristotelian philosophers (for a list of possible authors, see Mayhew 2011, xvii n.4). Some parts of the *Problems* date back to Aristotle himself, others are added in the centuries afterwards, until the second century CE (Louis 1991, xxiii–xxv; cf. Quarantotto 2017, 101 who traces the origins of the *Problems* to Aristotle himself or his closest collaborators). *Problems* 16 was most likely written in the third century BCE (Louis 1993, 69).

authority, we could confidently conclude that Anaxagoras also used wineskins and clepsydras to convey his argumentation of the impossibility to compress air and the non-existence of void to his audience. Anaxagoras did not simply state that air cannot be equated with void but chose to refer to air enclosed in wineskins and clepsydras to prove his point, because the general claim that air exerts pressure can clearly be observed in those two familiar situations. Anaxagoras might even have demonstrated his point physically during a discussion about the topic of void. Especially for the inner circle of his audience in Athens,[26] it seems possible that Anaxagoras literally showed the resistive force of air in a clepsydra, for example during a symposium with friends and acquaintances. A wineskin or clepsydra could also have been part of a demonstration during a public *epideixis* of Anaxagoras' work, which we know from Plato's *Phaedo* took place during the fifth century BCE.[27] The artefacts could also hold a more indirect persuasive power conveyed in Anaxagoras' written work for a more general audience.[28]

The fact that both the wineskin and the clepsydra are common household items which most people (a) are familiar with and (b) have access to in order to examine what happens when they enclose air in them means that people could repeat Anaxagoras' proofs at home regardless of whether they had previously encountered the described practices. Both showing the phenomenon in person and the 'do try this at home' incentive are didactically effective ways of persuading an audience of the correctness of a theory. Once the audience agrees to the premise that air in these cases cannot be squeezed, it is hard to resist the conclusion that Anaxagoras is right in claiming that air cannot be void, because the advantage of using a comparison for the inference of the property of an entity is precisely the fact that both the source domain and the target domain belong to the same overarching category (in this case 'air').

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26 Anaxagoras' style probably originated in oral communication, likely to have taken place during his time in Athens as a friend of Perikles (Thesleff 1990, 117). See also Basile in this volume.

27 Plato's *Phaedo* 97b refers to Socrates' presence at a public *epideixis* of Anaxagoras' work in Athens. See Sassi 2018, 172 for the significance of the oral dimension of the written text, as displayed by *epideixeis*. On the need for traveling thinkers to seek patrons, see Wians in the volume.

28 Anaxagoras' written work was presumably intended for a (slightly) wider audience than his closest friends and associates; see Thesleff 1990, 117 for the relation between the audience of the written text and oral performance; see also Kahn 2003, 141. As authors might have been aware that the audience of written works is hard to control once they are disseminated (cf. Totelin 2018, 34), it cannot be excluded that they adapted their rhetoric, and thus the use of persuasive comparisons, accordingly; see Tarrant in this volume.' According to two Platonic dialogues (*Apology* 26d and *Phaedo* 98b), Anaxagoras' work could be bought relatively easily in Athens.

Because air plays a crucial role in both domains, and because the claim is inferred from the literal similarity between the two situations that air cannot be squeezed, the conclusion in the target domain that air in general cannot be squeezed and therefore cannot be void becomes more persuasive, because it does not depend on the audience's agreement to the level of similarity between the source domain and the target domain (because nobody would deny that air plays a role in both), but only on the audience's agreement that this property of air is the best explanation of the observed phenomenon. Using the demonstrations with the wineskin and the clepsydra in his argument about the nonexistence of void was therefore a core element of Anaxagoras' persuasive strategy.

To summarize, the clepsydra was not a mere example of the resistance of air for Anaxagoras but played an important heuristic role for him. Including the references to the wineskin and the clepsydra in the exposition of his argument is both a record of his own path to discovery and a persuasive strategy to convince his audience of the resistance of air when enclosed in such artefacts.[29]

2 Aristotle's *De Caelo*

A similar heuristic and explanatory use of the clepsydra for the inference of a generic property of air can be found in Aristotle's critical discussion

29 Anaxagoras' use of the clepsydra to make a point about corporeality and void had a long-lasting influence, visible, e.g., in Arabic philosophy on this topic. In the context of discussing the Aristotelian doctrine that water tends to move to the earth's centre and not horizontally, Al-Bīrūnī discusses the clepsydra in his *Chronology of Ancient Nations* 262,22–263,6; see Hullmeine 2019, 116–119. What happens when one fills the clepsydra with water and subsequently holds both its ends inside vessels which are both also filled with water reaching to the same level? He observes that the water inside the clepsydra remains there and does not flow out into the other vessels, presenting his audience with two different explanations for this phenomenon, before moving on to his original investigation on the movement of water: the clepsydra cannot become empty lest a void be produced (for the opponents of the existence of void) or the attractive power of void is responsible for keeping the water inside the clepsydra (for those who defend the void and its ability to attract bodies). Needless to say, holding both ends of the clepsydra simultaneously into water is not part of the 'normal' use of a clepsydra. Al-Bīrūnī thus describes an 'experiment' with the clepsydra, the results of which can be used to reach opposite conclusions. The facts (i) that Al-Bīrūnī did not refer to the clepsydra before or after this passage, (ii) that opposite explanations for the phenomenon are given, (iii) that Al-Bīrūnī was familiar which Aristotle's *Physics*, in which Anaxagoras' use of the clepsydra was described, and (iv) that Al-Bīrūnī chose to refer to a clepsydra instead of to a pipe for this experiment, suggest that the clepsydra had become something of a 'stock example' in his time for thinkers dealing with the (im)possibility of void: whatever your position, you would need to be able to explain why the clepsydra worked as it did.

of his predecessors' opinions on the position of the earth in the universe. Anaximenes, Anaxagoras, and Democritus are said to hold the position that the earth remains at rest because it is supported by the air under it, and this view is compared with what happens in the clepsydra. From observing the household device, we can learn that air apparently has the property to carry another substance on top of it, which shows that it is not unimaginable that the earth as a whole would be held in place by the sustaining capacity of the air under it.

> Anaximenes, Anaxagoras, and Democritus name the flatness of the earth as the cause of its remaining at rest. It does not cleave the air beneath it, but settles on it like a lid, as flat bodies to all appearances do: owing to their resistance, they are not easily moved even by the wind. The earth, they say, owing to its flatness behaves in the same way in relation to the air immediately underneath it, which, not having sufficient room to change its place, is compressed and stays still owing to the air beneath, like the water in clepsydras.[30]

According to the first comparative image in this passage, the earth does not cleave the air beneath it, but 'settles on it like a lid' (ἐπιπωμάζειν). The earth and a lid are similar in that they are a flat and thin entity supported by some substance underneath. Whereas the earth rests on air, a lid can be held up by the steam boiling water in a cooking pot produces.[31] To be sustained, the object in question needs to be flat, so that its weight can be divided across a large area of the sustaining material underneath.

While the first image emphasizes how the earth's flatness contributes to its being sustained, the second image of the clepsydra highlights a characteristic feature of air: it can carry other substances. When somebody lifts the full clepsydra out of the liquid while keeping the upper vent closed, the liquid inside will not fall (see stage 2 described above). One of the reasons available to explain why the liquid remains inside the vessel is the pressure exerted upon the clepsydra's strainer by the air. From this observation, the conclusion can be reached

30 Translation Guthrie 1939, slightly adapted. Aristotle, *De Caelo* 294b14–21 (=DK13 A20= LM 25 D58=LM 7 D19=LM 27 D110), text Allan 1936: Ἀναξιμένης δὲ καὶ Ἀναξαγόρας καὶ Δημόκριτος τὸ πλάτος αἴτιον εἶναί φασι τοῦ μένειν αὐτήν. οὐ γὰρ τέμνειν ἀλλ' ἐπιπωμάζειν τὸν ἀέρα τὸν κάτωθεν, ὅπερ φαίνεται τὰ πλάτος ἔχοντα τῶν σωμάτων ποιεῖν· ταῦτα γὰρ καὶ πρὸς τοὺς ἀνέμους ἔχει δυσκινήτως διὰ τὴν ἀντέρεισιν. ταὐτο δὴ τοῦτο ποιεῖν τῷ πλάτει [φασὶ] τὴν γῆν πρὸς τὸν ὑποκείμενον ἀέρα (τὸν δ' οὐκ ἔχοντα μεταστῆναι τόπον ἱκανὸν ἀθρόῳ τῷ κάτωθεν ἠρεμεῖν), ὥσπερ τὸ ἐν ταῖς κλεψύδραις ὕδωρ.

31 Cooking vessels which could be closed by a lid include the *chytra* and the *lopas* (Ault 2015, 209).

that air in general has this sustaining capacity. Presuming that air possesses the same properties everywhere, this characteristic of air can be transferred to the case of the earth. The same reason can thus be given to explain both the source domain of the clepsydra and the target domain of the earth: air has the property that it can sustain other substances, and both the source domain and the target domain are part of the overarching 'category' of entities containing air, or, more precisely, containing states of affairs which can be explained by reference to this carrying property of air. The two comparisons therefore work together: the conclusion that the flat earth remains at its place due to the air beneath it becomes more plausible because of the premises that 1) flat objects, such as a lid, are easier to hold up than items of another shape and 2) air is able to support something solid, as can be seen in the case of the clepsydra.

But who inferred this general property of air from the instantiations of a lid and a clepsydra? The attribution of both images is uncertain: did Aristotle introduce them to explain the point being made by these earlier thinkers, or were they established by (one of) the three early Greek natural philosophers Aristotle is discussing here? Did both images originate in the same thinker or not? Scholars are divided on the subject.[32] Because of the phrasing of the passage, I doubt that the comparisons with the lid and the clepsydra should be attributed to Aristotle himself: he reports the opinions of his predecessors in an indirect clause dependent on the repeated φασί, so the most natural way to read the fragment is to take the comparisons as a part of the indirect statement.

To which of the thinkers should we attribute the images? I argue that Aristotle most likely took the comparison with the clepsydra from Anaxagoras, since aside from this passage in the *De Caelo* there is no further evidence that Anaximenes and Democritus referred to the clepsydra.[33] As I showed in the

32 KRS 1983, 153 have argued that the comparison with the lid is Aristotle's own. Kranz 1938, 110 ascribes the comparison with the clepsydra to Anaximenes, Anaxagoras, and Democritus; Leggatt 1995, 259 takes it to be from the hand of Aristotle; Worthen 1970, 524–525 remains neutral. Hankinson and Sassi have both noted that the illustration of a lid does not seem to fit well into Anaximenes' conception of an unlimited mass of air surrounding the earth (Hankinson 2001, 21 and Sassi 2018, 61n.49).

33 Cf. Wright 1995, 40. Those arguing that the introduction of the clepsydra in this passage is entirely Aristotle's own invention could point to Simplicius' commentary on the *De Caelo*, in which he states that 'he [Aristotle] brings forth the water in the clepsydras as an example' (παράδειγμα φέρει τὸ ἐν ταῖς κλεψύδραις ὕδωρ, *In De Caelo* 524.16–525.4). Although the Greek could indeed mean that Aristotle himself invented this example, it seems more plausible to me that Simplicius here wished to indicate that the three Presocratics gave many proofs, as Aristotle himself said in the *De Caelo* 294b22–23 ('they give many proofs that air, when stopped up and at rest, is able to bear much weight'), and that Aristotle singled out this one example to present to his audience.

last section, however, Anaxagoras was interested in explaining the causes of the different observations one could make with a clepsydra, including the demonstration that air cannot be squeezed. Seeing how the air in the clepsydra possessed the capacity to keep the water inside could have led him to extend that observation to the conclusion that air can therefore sustain other substances, and maybe even projected this latter conclusion to the case of the earth, arguing that it remains at rest because it is supported by the air underneath. If the reference to the clepsydra was indeed made by Anaxagoras in this context of the position of the earth, the comparison would not only fulfil a persuasive function, but it also would have played a heuristic or corroborative role, since, as I set out in section (i), Anaxagoras made several observations with the clepsydra, which he subsequently tried to explain.

Aristotle, having found a comparison with the clepsydra in Anaxagoras, whether that be the comparison in the discussion of void I treated above or an additional comparison in an argument about the position of the earth, would have included the comparison with the clepsydra in his treatment of the general stance of all these three thinkers. Although Anaxagoras referred to the clepsydra in his denial of void, and Democritus as an atomist held that everything consists of atoms and void, Aristotle still included the comparison with the clepsydra in discussing both these thinkers and Anaximenes, because they shared the view (a) that the earth is flat and (b) that the earth is supported by air. Aristotle presumably took the clepsydra comparison from Anaxagoras and employed it to illustrate the views of all three thinkers, because it supports these commonalities so effectively.[34]

The question of why the earth does not fall was a topic of concern for ancient Greek thinkers. Thales thought it was supported by water (DK11 A14=LM 5 D7 and DK11 A15=LM 5 D8), Anaximander posited a more daring conception of a free-floating earth (D12 A26=LM 6 D30), and Anaximenes, Anaxagoras, and Democritus argued that it was held up by air. As Aristotle said,[35] only the mind of a careless person would not wonder why a small particle of earth moves

34 If the image of the clepsydra nevertheless only originated in Aristotle, only an illustrative effect remains. Having learned the theory of these three thinkers about the position of the earth, Aristotle searched a way to clarify their theory for his own audience of students in the Lyceum (Leggatt 1995, 3). Not interested in persuading his audience of the correctness of the posited theory, which he rejects in favour of his own worldview, he could have added the comparison purely for illustrative reasons: the reference to the clepsydra explains both that air can hold up other substances and how these thinkers might have arrived at such an idea, and therefore illustrates their position to Aristotle's audience without having a persuasive function.

35 Paraphrase of Aristotle, *De Caelo* 294a12–17.

downward when it is released, but the earth as a whole remains at its place. The variety of circulating hypotheses increased Anaxagoras' need to convince his audience of the correctness of his own theory, as educated people interested in such cosmological questions were presumably exposed to several other explanations of the position of the earth in the universe in the 'marketplace of ideas' of classical Greece.[36] So what could have been the persuasive effect of referring to the lid and the clepsydra in the context of the position of the earth?

Because the clepsydra and the lid are common household devices, many readers of Anaxagoras' work and listeners of a public *epideixis* will have had first-hand experience handling them. The references to the lid and the clepsydra therefore entail a didactic function: they invite the audience to verify the posited theory about air, either from memory or literally. Because the audience was able to observe at their own convenience how flat objects are easier to be held up by other shapes and how the air pressure at the strainer of the clepsydra contributes to the water remaining inside the vessel, they could, in a way, test the claim that air would be able to hold up a flat earth. If they agree that flat objects have this property of being more easily sustainable, that air has the property to sustain other entities, and that air has the same characteristics everywhere, this observation renders support to the claim that the earth is held up by the air beneath it. Because the reliability of the premises is amplified by the comparison, the audience is more likely to accept the conclusion. The comparison relates a large and invisible topic (why does the earth not fall?) to a mundane and well-observable fact (air can carry water in a clepsydra) and clarifies the argument by making the principles on which the solution depends visible on a much smaller scale. In short, the comparisons with the lid and the clepsydra to demonstrate Anaxagoras' claim that the earth is carried by air contributed to persuading his audience at a time when many other explanations of the same phenomenon were on offer, and likely also played an indispensable heuristic role for Anaxagoras.

3 Empedocles

In contrast to the previous two comparisons, in which one single general property was inferred from the clepsydra, Empedocles, in what may have been the earliest use of a clepsydra comparison, uses this household device for an analogy, a comparison in which a plurality of features is mapped. Taking his

36 Sassi 2018, 172.

source domain from the familiar image of a child playing with a clepsydra, Empedocles illuminates the process of human and animal respiration. The girl's play with the vessel can be divided into four phases: like Anaxagoras, she submerges the clepsydra with her finger on the upper vent (stage 1a), and then continues by letting the water enter, lifting the vessel, and letting the water flow out (stages 1b, 2, and 3 as described above).

> It is in this way that all [living beings] inhale and exhale: for all, tubes of flesh, partly filled with blood, extend to the surface of the body; and at the openings, the furthest limits of their skin are perforated through and through with numerous holes, so that the blood lies hidden, while easy access is cut by these passages for the aether. When from here the delicate blood then rushes backwards, the aether, boiling, rushes after it in a raging surge, but when it [i.e., the blood] leaps back, the other [i.e., the aether] is exhaled again – just as when a girl plays with a clepsydra of gleaming bronze: when she places the opening of the tube against her well-formed hand and dips it into the delicate body of silvery water, liquid no longer enters into the container, but it is prevented from doing so by the mass of air falling from inside upon the dense holes, as long as she restrains the thick flow [scil. of air]; but then, when the breath is lacking, water enters in the predetermined amount. In the same way, when she keeps the water in the depths of the copper vessel, blocking with her mortal skin the opening and the passage, the aether outside, desiring to come inside, repels the liquid around the gates of the dull-sounding sieve, dominating the surface, until she lets go with her hand; then again inversely, in reverse of earlier, the breath now falling into it, the water runs out in the destined amount. In the same way, the delicate blood, trembling through the limbs, when, turning back, it leaps toward the nooks inside, at once the flow of aether pursues it, rushing in its surge, but when it leaps back, it exhales again, in the same amount, backward.[37]

37 Translation LM 2016, 533–535, adapted. Aristotle, *De Respiratione* 473b9–474a6 (=DK 31 B100=LM 22 D201a), text Diels and Kranz 1951, 348: ὧδε δ᾽ ἀναπνεῖ πάντα καὶ ἐκπνεῖ· πᾶσι λίφαιμοι // σαρκῶν σύριγγες πύματον κατὰ σῶμα τέτανται, // καί σφιν ἐπὶ στομίοις πυκιναῖς τέτρηνται ἄλοξιν // ῥινῶν ἔσχατα τέρθρα διαμπερές, ὥστε φόνον μέν // κεύθειν, αἰθέρι δ᾽ εὐπορίην διόδοισι τετμῆσθαι. (5) // ἔνθεν ἔπειθ᾽ ὁπόταν μὲν ἀπαιξῇ τέρεν αἷμα, // αἰθὴρ παφλάζων καταισσεται οἴδματι μάργῳ, // εὖτε δ᾽ ἀναθρῴσκῃ, πάλιν ἐκπνέει, ὥσπερ ὅταν παῖς // κλεψύδρῃ παίζουσα διειπετέος χαλκοῖο – // εὖτε μὲν αὐλοῦ πορθμὸν ἐπ᾽ εὐειδεῖ χερὶ θεῖσα (10) // εἰς ὕδατος βάπτῃσι τέρεν δέμας ἀργυφέοιο, // οὐδεὶς ἄγγοσδ᾽ ὄμβρος ἐσέρχεται, ἀλλά μιν εἴργει // ἀέρος ὄγκος ἔσωθε πεσὼν ἐπὶ τρήματα πυκνά, // εἰσόκ᾽ ἀποστεγάσῃ πυκινὸν ῥόον· αὐτὰρ ἔπειτα // πνεύματος ἐλλείποντος ἐσέρχεται αἴσιμον ὕδωρ. (15) // ὣς δ᾽ αὖτως, ὅθ᾽ ὕδωρ μὲν ἔχῃ κατὰ

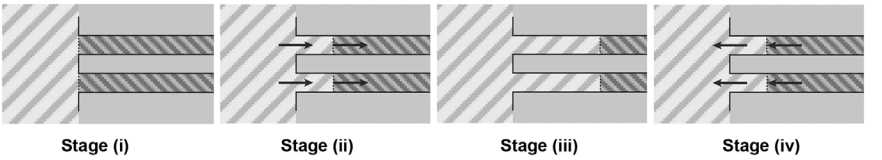


FIGURE 5.5 Empedocles' respiration
IMAGE BY MARTIN KLÖCKENER, BY PERMISSION

To understand the candidate inferences of Empedocles' analogy, and thereby its various functions, let us first take a closer look at respiration, so that we can establish the parallels between the process of breathing and the girl's play and can identify the candidate inferences following from this interconnected network of properties.[38] For Empedocles, breathing involves the interrelated movements of blood and aether. The blood alternatingly retreats to its original position in the periphery of the body, in proximity to the openings through which the aether enters and exits (whether they are pores or nostrils).[39] Like a pendulum, the blood starts resting close to the openings, moves to retreat inside the body, and remains motionless at the deepest point, before moving back again towards its peripheral starting position. The movement of the blood is followed by that of the aether: whenever the blood withdraws, the aether follows (inhalation), and whenever the blood returns to its peripheral position, the aether is pushed out (exhalation). Figure 5.5 illustrates the respiratory stages: during static phases (i) and (iii) the blood remains at its position, respectively at the periphery and retreated, whereas phases (ii) and

βένθεα χαλκοῦ // πορθμοῦ χωσθέντος βροτέῳ χροι ἠδὲ πόροιο, – // αἰθὴρ δ' ἐκτὸς ἔσω λελιημένος ὄμβρον ἐρύκει, // ἀμφὶ πύλας ἠθμοῖο δυσηχέος ἄκρα κρατύνων, // εἰσόκε χειρὶ μεθῇ, τότε δ' αὖ πάλιν, ἔμπαλιν ἢ πρίν, (20) // πνεύματος ἐμπίπτοντος ὑπεκθέει αἴσιμον ὕδωρ. // ὡς δ' αὖτως τέρεν αἷμα κλαδασσόμενον διὰ γυίων // ὁππότε μὲν παλίνορσον ἀπαιξειε μυχόνδε, // αἰθέρος εὐθὺς ῥεῦμα κατέρχεται οἴδματι θῦον, // εὖτε δ' ἀναθρῴσκῃ, πάλιν ἐκπνέει ἶσον ὀπίσσω. (25)

38 The next three paragraphs about the *tertium comparationis* in Empedocles' clepsydra comparison are derived from a more extensive discussion in Van Luijn 2021, 36–39.

39 The meaning of ῥινῶν in line 4 is heavily debated. Some scholars hold that it derives from ῥῖς, ῥινός (nostrils) and translate ῥινῶν ἔσχατα τέρθρα as 'the uttermost ends of the nostrils' (e.g., Timpanaro Cardini 1957, 252–256; Seeck 1967, 41–50; and Inwood 1992, 130); others argue that it is the genitive plural of ῥινός, ῥινοῦ (skins) and render the same phrase with 'the outer extremities of the skin' (e.g., Diels and Kranz 1951, 347n.16; O'Brien 1970, 173–174; and LM 2016, 533). Bollack 1969, 481 proposed that the ambiguity of the word ῥινῶν was intentional. The fragment would then refer to breathing through the skin, of which nose breathing is a particular example in the sense that the nostrils are nothing but two particularly large holes through which we breathe.

(iv) constitute the dynamic processes of the blood retreating and returning, while the aether follows this movement.

I argue that the water in the clepsydra is analogous to the aether in breathing and the air in the clepsydra to the blood in respiration because the latter two have the same influence on the movement of the former two substances through their own movement.[40] This renders the following parallels between the processes, which form the core of the analogy as the interrelated network of properties:

i) Analogous to stage 1a of the clepsydra. To start, the air, being trapped inside the clepsydra because the girl holds her finger on the top vent, prevents the water from entering the clepsydra. Likewise, the blood, occupying all the space inside the λίφαιμοι right up to the openings, keeps the aether outside the body.

ii) Analogous to stage 1b of the clepsydra. In the second phase, the girl allows the air inside the clepsydra to exit through the upper vent by the removal of her thumb. Since the air no longer keeps the water out, the liquid enters the clepsydra through the strainer at the bottom. Similarly, the blood inside the vessels retreats to deeper inside the body. The space coming free due to the movement of the blood is filled by the aether coming in through the openings: inhalation takes place.

iii) Analogous to stage 2 of the clepsydra. The clepsydra, full of water, is now held in the air by the girl, who closed the top vent again. Due to the air pressure at the clepsydra's bottom, the water remains inside. Similarly, a short static moment takes place in breathing: the blood has retreated to

40 Another way of interpreting this fragment, preferred by, e.g., Ross 1955, 316; O'Brien 1970, 151–153; Worthen 1970, 525–527; Phillips 1987, 22–23; and Arata 1997, 76, is aligning the water in the clepsydra with the blood in respiration, and the air in the clepsydra with the aether in respiration, which they also refer to as 'air'. This has the advantage of the logic of equating liquid to liquid and air to (presumed) air, but it runs into several difficulties. Certain elements that Empedocles describes about the clepsydra, e.g., the retention of the water inside the clepsydra by air pressure when the device is lifted out of the water, would have no counterpoint in respiration, and half of the process of inhalation would be based on something which Empedocles does not even mention: the fact that the water needs to make space for the submerged clepsydra in stage 1a. My interpretation follows i.a. Timpanaro Cardini 1957, 257; Booth 1960, 13 and 1976, 147; Guthrie 1965, 222; Lloyd 1966, 330–331; Wilkens 1967, 138; Wright 1981, 247; McKirahan 2010, 281; and Gheerbrant 2017, 381. Aligning the air in the clepsydra with the blood in respiration does not only stress the causal similarity between the processes, but it also does more justice to the lexical and syntactical symmetry in the sections about breathing and the clepsydra in B100, as e.g., Booth 1976, 147; Regenbogen 1961, 194; and Gheerbrant 2017, 367–370 have accurately pointed out.

its deepest point and the aether now occupies the maximum of space inside the body during the whole repeated process.

iv) Analogous to stage 3 of the clepsydra. After the girl removes her finger again, the air returns through the now opened upper vent. Like the return of the air enables the water to exit the clepsydra through the strainer, the return of the blood to its original starting position in the part of the vessels just inside the openings expulses the aether from the body.

Instead of the 'default' way of using a clepsydra as described by Hero, Empedocles adds an additional stage: he lets the girl submerge the clepsydra while closing the upper vent rather than leaving it open. As I argue elsewhere, he added this phase because he needed the static stage in which air occupies all the place inside the clepsydra and the water cannot enter in order to match respiration, which also starts from the basic position in which blood fills the whole vessels, leaving no space for the aether.[41] Since children tend to be more playful than adults, as demonstrated by the etymological connection between παῖς (child) and παίζω (to play),[42] Empedocles' choice for a child to play with the clepsydra provided him with the opportunity to deviate from the clepsydra's normal use and to include the extra stage he needed. Gender roles in Antiquity, according to which girls were more likely than boys to help with simple tasks in the household, such as transferring liquids with a clepsydra, mean that girls would be more acquainted with the functioning of the clepsydra. Knowledge of the default use of the clepsydra is required for the kind of play described in Empedocles, which explains his choice for a girl to play with the clepsydra.[43]

I argue that the advantage of the clepsydra analogy for Empedocles is fourfold: it likely functioned as an epistemic trigger, it adds to the poetic quality, it provides a mnemonic aid to the audience, and it helps the audience understand why inhalation works.

Chronologically, Empedocles' reference to a clepsydra in a philosophical work is possibly the earliest.[44] It might seem an insignificant point that Empedocles had to contrive the similarity between respiration and a clepsydra before he versified the comparison to present it to his audience, but this might tell us something about the way Empedocles attempted to gain knowledge

41 Van Luijn 2021, 39–45.

42 See e.g., Golden 2003, 45 and Kidd 2019, 20–25.

43 The fact that Empedocles took a familiar, everyday scene as the source domain of his comparison also means that he did not 'experiment' with the clepsydra in the sense of creating a source domain with the (sole) purpose of representing a target domain.

44 Although it might be the case that Anaxagoras' reference took place more or less simultaneously; see footnote 24.

about the world around him. He could either have come up with the analogy after his theory about respiration was formed, or the clepsydra could have functioned as an epistemic trigger to him. Although it is impossible to settle this issue with certainty, I believe it is probable that Empedocles used the clepsydra as a heuristic device, mainly because direct means to gain knowledge about respiration were largely absent to him. As Lloyd points out, even though dissections might have revealed the general structure of the lungs and the air-pipes connected to it, full knowledge about how inhalation takes place cannot be gained from such a section, because it requires an understanding of the moving of muscles and the diaphragm in a living body, which means that vivisection would be required.[45] Moreover, dissections were still extremely uncommon in Empedocles' time.[46] Empedocles could have gained some insight from the sacrifice of animals and analogically expanded his conclusions to humans, because his theory of respiration applies both to humans and to animals. Lacking the direct means to acquire an insight into how human breathing worked, Empedocles presumably turned to analogical inference in his heuristic process and found a helpful source domain in the clepsydra.[47]

If I am right that the clepsydra functioned as an epistemic heuristic device for Empedocles, this does not yet explain why Empedocles subsequently chose to include it in conveying his respiratory theory to his audience. Its inclusion must have been advantageous in some way. In Empedocles' comparison, we can see quite well how an analogy can function on different levels. The variety of effects on an audience was all the more convenient for Empedocles, as he was one of the early Greek thinkers aiming to reach a wide general audience.[48]

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45 Lloyd 1966, 333n.1.

46 Dissections might have been carried out by certain individuals by the late fifth or early fourth century BCE (see Lloyd 1979, 156–167 and Lloyd 1991, 164–186 for a critical discussion on dissection in Alcmaeon, Hippocrates' *On the Sacred Disease*, Aristotle, and others), but did not become a common practice until Herophilus and Erasistratus in the third century BCE (Lloyd 1991, 186).

47 I disagree with Obbink 1993, 83–84, who, in the context of comparing the relation between Empedocles and the addressee, his younger pupil Pausanias, to the Near Eastern wisdom literature, states that Empedocles' philosophy contains elaborate similes with minute correspondences because of Pausanias' simplicity. It seems to me that Pausanias cannot be said, at the very least in case of respiration, to be in a different epistemic position than the wider audience: nobody could gain direct knowledge about breathing, so the analogy is a necessary means to nevertheless infer some knowledge.

48 According to Diogenes Laertius, Empedocles' poetry was recited at Olympia at some point in the middle of the fifth century BCE (Diogenes Laertius, *Lives* 8.63). This does not necessarily mean that Empedocles *aimed* to reach a large general audience, but it does suggest that he did reach that audience. For Empedocles' audience, see Thesleff 1990, 116; Obbink 1993; Kahn 2003, 157–158; Sassi 2018, 162.

The advantage of the comparison in B100, then, is that even though not every member of the audience would pick up on all the subtleties conveyed by the analogy, already grasping some aspects would have a helpful or persuasive effect.[49]

On a literary level, the inclusion of this analogy contributes to a vivification of his poetic style. The Homeric simile is almost inseparably connected with the epic genre, and Empedocles, writing a didactic poem in the same metre as Homer and Hesiod, included many features of this genre in his own poetry.[50] Analogies simply belonged to hexametrical poetry, and including them offered an opportunity for adding a different set of imagery, playing with content variations, and surprising his audience. This link with the Homeric simile also might explain why Empedocles still gave a direct explanation of the process of breathing before the analogy (lines 1–8), rather than letting the analogy speak for itself: describing the target domain before drawing on the source domain of the analogy is in line with Homeric practice.[51] Embedding his new ideas in this familiar literary form might have helped to make Empedocles' theories more acceptable to a traditional part of his audience, very familiar with Homeric epic.

Moreover, the analogy is helpful for Empedocles' audience because it provides the opportunity of replicating the steps of the girl's play at home. Although the workings of the clepsydra do not prove that respiration works in the way Empedocles claims it does, familiarity with the device helps the audience to grasp the fairly abstract topic of respiration, because they can reconstruct the steps of the handling of the clepsydra in Empedocles' analogy at home and thereby remember the corresponding steps in breathing. Because the audience is familiar with it, the clepsydra can function as a mnemonic aid for the different phases of breathing.

Lastly, on a more implicit level the analogy with the functioning of the clepsydra could help some members of his audience with a possible puzzle they might have if they had only been presented with the basic description of respiration in B100.1–8. The account of exhalation, in which the blood pushes the *aether* out, seems comprehensible enough, but his audience might be wondering why the aether enters once the blood retreats from the periphery to the core of the body. Empedocles' account of inhalation rests on the implicit

49 Since, as Totelin 2018, 34–35 has argued, one text can address various audiences simultaneously.

50 For Empedocles' vivid style, see Toohey 1996, 45–46 and McKirahan 2010, 252. For Empedocles' appropriation and modification of the Homeric poetic features of Ritornell composition and episodic composition, see Gheerbrant 2018, 40–77.

51 Wright 1981, 246.

assumption that there is no vacuum: if void existed, the retreat of the blood would not need to have been followed by the inhalation of aether, since the space in the λίφαιμοι could be occupied by void. The *aether* only follows the movement of the blood because of the lack of void. When somebody wonders why inhalation occurs, the analogy with the clepsydra can facilitate understanding, precisely because its workings are also dependent on the premise that vacuum does not exist. If void existed, the clepsydra could not work as it does. During stage 1a the clepsydra would be filled with both air and void, which means that the air could be compressed and the water would be able to enter the vessel. During stage 2 there would be no reason for the liquid inside the clepsydra not to fall out of the lifted vessel, since the liquid remains inside the clepsydra partly by the lack of a substance to replace the space left by the falling water and partly by the air pressure at the strainer. The fact that the latter reason cannot be sufficient on its own can be seen in stage 3: as soon as air can enter through the newly opened top vent and thus fill the space, the air pressure alone fails to keep the liquid inside. Both the clepsydra and respiration, then, require the absence of void, although unlike Anaxagoras, Empedocles leaves this implicit. The analogy in B100 is helpful for some parts of his audience to comprehend why the movement of one substance is immediately followed by the movement of the other substance: there is no vacuum. Hence, the analogy facilitates comprehension of *how* respiration takes place, but a careful reader can also extract the reason *why* it takes place as it does. This is admittedly a subtle effect of Empedocles' analogy, but some intellectuals among his audience might actively have reflected on such questions, and the explanatory effect of the absence of vacuum could also happen subconsciously in a somewhat wider section of the audience.

To conclude, the analogy with a girl playing with a clepsydra forms a significant part of Empedocles' argumentation on respiration. Could it have been left out? Yes, in theory lines 1–8 could have sufficed, but that does not mean that the clepsydra does not play a crucial role in Empedocles' reasoning or in his efforts to communicate his understanding to his audience. As I argued, the discovery of his respiratory theory likely depended on his observations of a clepsydra. The poetic description in largely Homeric vocabulary adds an aesthetic dimension to his theory. The analogy provides a mnemonic aid to his audience, and to an attentive reader even an explanation of the cause of breathing.[52]

52 Theophrastus used an analogy with the clepsydra in his explanation of why people sweat more when they exhale (Theophrastus, *On Sweat* 25). This is probably an intertextual allusion to Empedocles' analogy, as they both use several stages of the clepsydra's

4 Conclusion

In this article, I argued that the references to the clepsydra in Anaxagoras, Aristotle's *De Caelo*, and Empedocles are significant parts of their respective argumentations. Because (a) the outdated comparison theory of analogies has remained influential in the study of Graeco-Roman science, because (b) scholars have often treated different kinds of comparisons as a homogeneous group, and maybe because (c) we as modern scholars are less familiar with the functioning of the clepsydra, meaning that we have to work harder to understand these passages than their contemporary audiences, scholarship tends to focus on establishing the point of comparison, without asking the further question what the clepsydra adds to the theory.

The indispensability of the clepsydra can most clearly be seen in Anaxagoras, for whom the liquid transferring device likely played a heuristic role. His interest in describing and explaining the phenomena occurring around a clepsydra suggests that he reached his conclusion about void because of his observations of the clepsydra, which means that his theory might not have existed were it not for the clepsydra. In the subsequent expository stage Anaxagoras, like the other thinkers, could have left the reference to the clepsydra out, but only at quite a high cost. The persuasive power of being able to confirm certain characteristics of air by employing a clepsydra at home should not be underestimated, such as the possibility to verify that air can carry other substances in the *De Caelo*. Moreover, the household device can aid an audience to remember different phases of the target domain, and even implicitly point to the explanation of why inhalation works according to Empedocles. In short, the clepsydra makes a significant epistemological contribution for both the thinkers and their audiences that could not have easily been replaced.

The comparisons with the clepsydra, an everyday household artefact, show that these thinkers were not only interested in abstract (meta)physical and physiological questions, but were also rooted in a material and cultural context. As I intend to demonstrate in future work, a thorough examination of

functioning in order to explain a human physiological process between air and a liquid, which share the same bodily vessels. Another instance of the reception of Empedocles' analogy has largely been ignored by ancient philosophers, and only been noted by historians of medicine (e.g., Lonie 1981, 367, who states that 'the parent of this [in the *On Diseases IV*] and similar pneumatic demonstrations seems to be Empedocles' famous passage on the clepsydra'). When explaining the cause of dropsy, the Hippocratic treatise *On Diseases* IV.57.4–5, dating to the last quarter of the fifth century BCE (Lonie 1981, 71), includes an analogy with a narrow-necked vessel containing a hole in its base, which effectively renders the vessel similar to a clepsydra.

ancient Greek philosophical and scientific references to artefacts and of the different epistemological practices in which these artefact comparisons are embedded improves our understanding of the heuristic methods these thinkers used, of the ways they communicated their theories with their audiences, and ultimately of these theories themselves.[53]

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CHAPTER 6

The Metaphysics of the Coin-Image

Richard Seaford

In this paper I extend arguments made previously for the importance of coined money as a factor in the emergence and content of presocratic philosophy, and for the strikingly similar intellectual revolution occurring at about the same time in India. Here I extend the argument to the metaphysical dimension of imitation.

I begin here by briefly indicating the three pillars of my earlier argument. Firstly, presocratic philosophy began in the same place (Ionia, in its commercial capital Miletos), and at the same time (the early sixth century BCE), as the rapid pervasion of the city-states by the recent invention of coinage. Secondly, in societies without advanced technology cosmic power was generally imagined in terms of societal power (e.g., Zeus is a patriarchal monarch). This process, which I call cosmisation,[1] did not cease with the advent of the *impersonal* quasi-omnipotence of coined money in a society in which, in contrast to the theocratic monarchies of the Near East, monarchy had been replaced by the polis. Thirdly, the presocratic universe is remarkably similar to money: in the idea that the universe is a single entity that is transformed from and into everything else, in the increasingly greater abstraction of the single entity, and in numerous details. None of this means that I ignore the importance of other factors in presocratic thought, such as mystery-cult[2] and human intelligence.

In this paper I investigate the emergence of the *idea of imitation* (*and image*) from Homer and Hesiod (§1) to texts of the sixth and fifth centuries (§2) and eventually, after adducing the coin-image (§3), in Plato (§4). I argue for the importance of the (generally completely ignored) factor of monetisation in the complex matrix from which Greek philosophy emerged. This implies rejection of the widespread practice of reducing presocratic thought to the autonomous, ahistorical intellect. Like any other hypothesis, mine stands or falls by the amount that it can account for, by the extent to which it can explain what is otherwise inexplicable.

1 For cosmisation (or cosmic projection) see Berger 1967; Seaford 2020a, 67–9.

2 See e.g., Seaford 2004, index s. Mystery cult.

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1 Image and Imitation in the Earliest Literature: Homer and Hesiod

We must first clarify the terminology of representation, both English and Greek. By 'image' I mean unmoving visual representation (e.g., figural painting). I use 'imitate' more broadly to include also imitative *enactment* (e.g., drama). By 'mere image' and 'mere imitation' I mean representation in which what is represented (the 'model') is clearly distinct from what represents it (painting, drama, etc.), so that for instance the 'mere image' of god is an image which reproduces only the appearance of the deity and nothing of its presence or power.

The verb εἰκάζειν (and its compounds) can mean to make an image, as well as to liken, compare, conjecture, and imagine, and the related noun εἴκων can be translated as copy, image, comparison, mental image, or phantom.[3] The verb μιμεῖσθαι (from μῖμος, a kind of performer) refers basically to imitative *enactment*. But enactment has a visual component, and the μιμ- word-group (μιμεῖσθαι, μίμημα, μίμησις, and compounds) could eventually refer to making an image.[4] We will see that these are not the only relevant Greek terms. The notions of image and imitation do not emerge clean cut into the world.

In Homer and Hesiod none of these words occur. Images and imitation are rare, and the *ideas* of image and of imitation are barely present. There is much *observation* of likeness, as in the similes, but very little of its *creation*. Let us deal with what seem to be exceptions.[5]

There are two Homeric instances of a deity making an εἴδωλον that is exactly like a mortal (*Il.* 5.449–551; *Od.* 4.796). However, in both cases there is no human consciousness of the difference between the εἴδωλον and the person that the εἴδωλον reproduces. The εἴδωλα are not so much images as *doubles*.[6] The distinction will be made by Plato (*Cratylus* 432bc): were a god to create a being with all the qualities of Cratylus (inner and outer), we would have not an image (εἰκών) of Cratylus but 'two Cratyluses'. The word εἴδωλον could much later

3 This last meaning may be felt even when an obvious translation is 'image': Euripides. *Medea*. 1162 ἄψυχον εἰκὼ προγελῶσα σώματος.

4 Almost all the voluminous scholarship on *mimesis* has been devoted to its complex and unprecedented variety of meaning in Plato and Aristotle. Exceptionally, Koller 1954, Else 1958, and Sörbom 1966 did also exhaustively collect (between them) and extensively discuss the pre-platonic occurrences of the μιμ- group. But even they do not raise the *historical* question of explaining the remarkable development of the terminology.

5 Poseidon's transformation of the Phaecaian ship onto a rock (*Od.*13.1623) had been urged by Zeus as transforming the ship into a 'rock like a ship' (156–7): but this is not imitation.

6 On this distinction see Vernant 1991.

mean a mere image,[7] but that is not what it means in Homer. In the Homeric underworld εἴδωλα are people, albeit attenuated by death, phantoms.[8]

Other possible exceptions are the miraculous artefacts made by Hephaistos. On either side of the door of Alkinoos' house are immortal dogs of gold and silver, created by Hephaistos to 'guard' it (*Od.* 7.91–4). But they are not 'images' of dogs, which would be useless as guards. Homeric (and Hesiodic) artefacts are not produced merely to give visual pleasure.[9] Hephaistos' working attendants, made of gold and 'like living young women', move, and are said to have mind, voice, and strength (*Il.* 18.417–21), just like the first women made (out of earth) by Hephaistos in the *Works and Days* and *Theogony* of Hesiod. True, these first woman are each said to be 'like a modest maiden' (572), and the one in *Works and Days* (Pandora) is also praised as 'like the immoral goddesses in aspect' (62). But neither of them are imitations of existing females: rather, as Vernant puts it, "Pandora is fashioned to resemble a human maiden who does not yet exist and whose exact prototype she will be."[10]

Even for the extensive scenes on the shield of Achilles (*Il.* 18.478–673) there is no word suggesting image or imitation: Hephaistos 'made' them 'in'[11] or 'put' them 'in'.[12] Any sense of these scenes as mere images is further diminished by details that could not have been visually represented, including sounds and complex movements.[13] As with Hephaistos' other artefacts – the dogs and the attendants – the lack of the idea of a mere image belongs to (what we call) the confusion of the lifelike with the living. So too Daidalos is imagined both as the first realistic sculptor and as a magician who created statues that move.

In *Iliad* Book 6 the Trojan women lay a robe on the knees 'of Athena' (303), not of her 'image'; and her rejection of their request is described with a verb (311 ἀνένευε) that means to throw back the head (a gesture still used by Greeks to mean 'no'). What we regard as an image or representation of Athena is here imagined as (partially or entirely) *identified* with Athena. The closest possible

7 Herodotus uses εἴδωλον to mean phantom (5.92g), but also of statues (1.51; 6.58).

8 Cf. *Il.* 23.66. One of the εἴδωλα made by a deity (*Od.* 4.796) appeared to Penelope in a dream: for us the dream is a mental image, but in Homer it exists independently of the sleeper, over whose head it stands: *Il.* 2.22, 10.496, 23.65–8 (the phantom of the dead Patroklos).

9 An exception as an artefact within an artefact: Hephaistos adorns the first woman of *Theogony* with a diadem into which he 'put' many creatures 'like animals with voices' (581–4).

10 Vernant 2011, 407.

11 483 ἐν … ἐτεύξε; 490, 573, 587 ἐν … ποίησε; 590 'he decorated (ποίκιλλε)'.

12 ἐν … ἐτίθει: 541, 550, 561, 607. Cf. *Il.* 3.125–8.

13 See e.g., Edwards 1991, 207–8.

contact with the deity excludes the idea of a mere image,[14] just as the offering of an image of an animal to a deity may be best imagined as an actual animal.

As for imitative *enactment*, Homer comes close to it in the numerous passages in which a deity assumes the voice and appearance of a mortal (though occasionally of a bird), generally as disguise required for divine intervention. But this 'being like' (ἔοικα) or 'seeming to be' (εἴδομαι)[15] looks like miraculous transformation rather than imitation. Both verbs occur in other contexts with no suggestion of imitation.

Not miraculous, by contrast, and so clearly imitative, are the two instances of *mortals* imitating mortals. Odysseus made himself like Dektes (*Od.* 4.247), and Helen made her voice like the wives of the Greeks in the wooden horse (*Od.* 4.279). They are both in the same narrative, and it is significant that Stephanie West in the Oxford Commentary[16] argues (without even noting the unusual meaning) that they are both later additions to the Homeric text. In both passages the verb is ἐΐσκειν or ἴσκειν, which elsewhere in Homer means *liken* in the sense of *compare* or *conjecture* but in these (probably late) passages has come by a small shift to mean *make like*, as it does in two further Homeric passages. At *Od.* 19.203 (ἴσκε ψεύδεα πολλὰ λέγων ἐτύμοισιν ὁμοῖα) its meaning has been since antiquity disputed. Russo in the Oxford Commentary, comparing Hesiod *Theogony* 27 (ἴδμεν ψεύδεα πολλὰ λέγειν ἐτύμοισιν ὁμοῖα), concludes that 'by adding ἴσκε Homer has rendered the syntax ambiguous'. Here again we have a (clumsy) addition, perhaps to express the notion of *making like* implied in the other words. Finally, ἐΐσκειν is used of the miraculous ability of Athena to transform herself into 'everything' (*Od.* 13.393).

2 Imitation and Image after Homer and Hesiod

Of the μιμ- word-group there is before the fifth century BCE only one instance, probably from the last third of the sixth:[17] in the *Homeric Hymn to Apollo* the

14 Such attitudes to divine images persisted long after the notion of copying became available (e.g., Plato *Laws* 931a). In general, Greek deities seemed invisibly absent from their statues, in which they may nevertheless sometimes – especially with human action such as invocation – seem powerfully present: Scheer 2000, 115–29; Steiner 2001; Hölscher 2017. Cross-cultural treatments of these issues are Gell 1998 (esp. 40, 114) and Freedberg 1989.

15 *Iliad* 2.22, 2.280, 2.791–5, 3.122, 3.386–9, 5.462, 13.69, 16.720, 17.326, 17.585, 19.350–1. 20.81–2, 21.285, 21.600, 22.227; *Odyssey* 1.105, 2.268, 2.383, 2.401, 3.372, 5.337, 5.353, 6.22–4, 7.20, 8.8, 8.194, 13.222, 13.288, 16.157, 20.31, 22.206, 24.503, 24.548.

16 Heubeck, West, and Hainsworth 1998.

17 *Homeric Hymn to Apollo*. 163–4. For the likely date see Burkert 1979, 62; West 1999, 369; Richardson 2010, 13–15.

girls of Delos 'know how to imitate (μιμεῖσθαι) the voices of all men and their rattling' (163–4).[18] In the first half of the fifth century there are seven further instances.

In Pindar μιμεῖσθαι refers to pipes imitating the wail of a Gorgon (*Pythian* 12.19–27), to imitating in songs accompanied by pipes the sound of the Siren (*fr*. 94b.13–15), and to imitating 'the Pelasgian horse or Amyklaian dog as you shake with your foot in the contest pursuing the curved song' (*fr*.107a 1–3).

The remaining four instances are from Aeschylus. In *Choephoroi* (564) μιμεῖσθαι refers to the imitation of Phokian speech as disguise. In a description of orgiastic Dionysiac ritual, '… bull-voiced fearful μῖμοι bellow from somewhere invisible …' (fr. 57, from *Edonians*): whether by an instrument (presumably the ῥόμβος) or by the voice, this is imitative enactment of the voice of a bull. In the satyric *Theoroi or Isthmiasti* (fr. 78a) μίμημα is used (along with εἴκων and εἴδωλον) of satyric masks, and in an unknown drama (fr. 364) it referred to a tunic (χιτών) as imitating a Liburnian cloak (μανδύη).

Of these eight instances, six refer to imitative enactment, and the other two (of the noun μίμημα) to artefacts that were used in imitative enactment (certainly the satyr-masks, probably the foreign cloaks[19]). In most cases the model is very different in kind from the imitator: an animal (horse, dog, bull) or a *Mischwesen* (Gorgon, Siren, satyr). It is unsurprising that four of the eight instances are from the earliest extant *dramatist*, inasmuch as the world's first ever drama (in the full sense) makes the idea and fact of imitation manifest.

However, we should not suppose that drama is the ultimate cause of the advent and currency of the idea of imitation. Rather, the idea of imitation – with its concomitant metaphysics – was promoted by the same socio-economic process that favored the emergence of drama. But to develop this suggestion would go well beyond my present concern.[20] Here I confine myself to a single concrete illustration of the transition from embodiment to imitation, drawn from Aristotle's location of the origin of tragedy in what he calls the σατυρικόν, some kind of performance by men dressed as satyrs.

When men were dressed as satyrs so as to become part of the eternal *thiasos* of Dionysos (especially in the rite of passage of mystic initiation), they were not

18 It is argued by Peponi 2009 that μιμεῖσθαι here should be translated not 'mimick' but 'represent', 'involving the evocation of the essence of an entity but not necessarily exact reproduction of its formal details'.

19 Exotic foreign Exotic tunics (χιτῶνες) were mentioned in Aeschylus' Dionysiac *Edonians* (fr. 59), surely as worn by adherents of Dionysos. The Liburnians lived on the north-eastern Adriatic coast.

20 For the underlying socio-economic connection between the emergence of drama and the emergence of metaphysics see Seaford 2012.

imagined as *imitating* but as *becoming* satyrs.[21] I put the distinction crudely: there is of course between the extremes a spectrum accommodating the various kinds of Dionysiac ritual and performance in various times and places. But this does not diminish the importance of the distinction. The transition from satyric ritual to satyric drama[22] is the transition from *becoming* satyrs to a *mere imitation* of them. The consciousness of mere imitation was perhaps helped to emerge by the striking difference between humans and satyrs (or Gorgons, Sirens, animals), which would tend to diminish the traditional unconscious habit of assuming identity between imitators and imitated. In cultic enactment the mask tends to identify its wearers with satyrs, but in the drama it may be detached from any wearer, as an artefact, a *mere image* (εἴκων, εἴδωλον) admired by the satyrs for its likeness to themselves as an 'μίμημα (imitation, image) by Daidalos, it lacks only a voice' (*Theoroi fr*. 78c.7).

The Homeric ἐΐσκειν (or ἴσκειν) is after Homer largely replaced[23] by εἰκάζειν, which – like ἐΐσκειν – could mean *compare*, *conjecture* or *make like*. It belongs to a word group (εἴκων, εἴκασμα, εἰκάζειν, and their compounds) of which there are before the fifth century only two instances, both of them posthomeric, and both of εἰκάζειν meaning *compare*.[24] Then, in the first half of the fifth century, Aeschylus is for the εικ- word-group even more prominent than he is for the μιμ- word-group. He uses the verb εἰκάζειν and its compounds sixteen times, always meaning compare or conjecture, including twice of the same image on a shield in *Seven Against Thebes*.[25] Of his four extant uses of the noun εἴκων, all meaning image, one refers to the satyr-mask, another to the image on a shield in *Seven Against Thebes* (559); and of another shield-image he uses εἴκασμα (523, with much the same meaning as εἴκων). The description of the shield-images in *Seven* is the earliest sustained treatment of the idea of the mere image.

Shield-images were intended to frighten the enemy:[26] for instance Terror, Fear, and the Gorgon with her 'terrible stare' (δεινὸν δερκομένη) on the shield of Agamemnon in the *Iliad* (11.36–7). Each of the first five named mythical besiegers in *Seven* has on his shield a distinctive aggressive or 'arrogant'[27] image

21 Seaford 1994, 265–9. Cf. e.g., the mystic formula 'ram, you fell into milk (κρίος ἐς γάλα ἔπεσες)' (Graf and Iles Johnston 2007, 36).

22 For the traces of satyric initiation rituals in satyric drama see Seaford 1984, 41–4.

23 ἐΐσκειν does occur after Homer rarely, in the sense of compare or conjecture.

24 Sappho fr. 115; Theognis 127 (see below).

25 Aeschylus, *Agamemnon* 163, 1131, 1244; *Choephori* 12, 14, 518, 567, 633, 976; *Eumenides* 49; *Seven Against Thebes* 356, 431, 445; *Suppliants* 244, 288, fr. 451f12.

26 For anthropological reflection on precisely this phenomenon see Gell 1998, 31 (cf. 69–71).

27 E.g., 387 ὑπέρφρον σῆμα.

consonant with his threatening and boastful utterances. Each image is imagined as having traditional *agency*, as embodying the *reality* of its model, as contributing to the violence inflicted by the warrior who carries it.[28] However, in a remarkable reversal, the images are imagined, by the defending king Eteokles, as turning *against* the besieging warrior: *night* as descending on the eyes of Tydeus (403), a *firebearing* thunderbolt as striking Kapaneus (444–5), a *man and a city* as captured along with Eteoklos (478–9), *Typhon* on Hippomedon's shield as defeated by *Zeus* on his opponent's (512–20,); the *Sphinx* as blaming Parthenopaios for her battering (560–1).

This reversal of the shield-images' traditional agency co-exists with the new idea that the shield-image is a mere *image* (εἴκων, εἴκασμα). The σήματα (signs) on the shield of Tydeus 'cannot wound' (398).

The resulting ambivalence, or opposition between old and new, is aligned with another opposition – or rather transition – between old and new: the transition, from the self-destruction of the powerful family to communal benefit for the polis, that informs the *Seven* and many other Attic tragedies.[29] Shield-images might refer to the divine ancestry of their mythical bearers.[30] The highly individual shield-images of the attackers in *Seven* express an anachronistic individualism that ends in the killing of them all, the mutual fratricide of the royal brothers, and the communal salvation of the polis (793–821). But this does not mean that in reality shield-images necessarily threatened the coherence of the polis: we also hear in the classical period of the soldiers of a polis bearing the same shield-device (e.g., the initial letter of the polis),[31] a fitting expression of the famous group solidarity of hoplites.

Three of the shields in *Seven* deserve further scrutiny.

(1) Kapaneus expresses defiance of Zeus, whose lightnings and thunderbolts he likens (431 προσήικασεν) to midday heats. His shield-image is a 'fire-bearing (πυρφόρος)' naked man carrying a torch and crying in gold letters 'I will burn the city'. All this implies a claim to have more fire-power than Zeus. But Kapaneus' likenings, of thunderbolts to midday heats and of the πυρφόρος to himself, are both deluded. Eteokles' response is that he will be justly struck by the πυρφόρος thunderbolt that is 'not at all likened (ἐξηικασμένον) to the midday heats of the sun' (444–6). The repetition of πυρφόρος deploys the *reality* represented on the shield against its arrogant bearer.

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28 It is from this same broad perspective that in Aeschylus the contents of dream, omen, curse, and (what we call) metaphor are all embedded in reality, as channels of divine power over mortals in conflict: Seaford 2012, 23–7.

29 Seaford 1994.

30 Euripides *Meleager fr.* 530; Pausanias 5.25.9.

31 Spier 1990, 125; Eupolis fr. 359; Xenophon *Hellenica*. 4.4.10, 7.5.20; Bacchylides *fr*. 2.1.

(2) Hippomedon's shield has Typhon, whereas his opponent's has Typhon's conqueror Zeus, who accordingly might 'πρὸς λόγον τοῦ σήματος become saviour' (519–20): the mention of λόγος (here something like 'meaning') betrays the need to explain that the sign (σῆμα) is a *reality* (Zeus in real action). The ambivalence between image and reality continues into the descriptions – immediately of Typhon as 'a likeness hostile to mortals and gods' (523 ἐχθρὸν εἴκασμα …), and then of the Sphinx on the next shield (Parthenopaios'):

(3) Parthenopaios' Theban opponent 'will not allow the man bearing an image (εἴκω) of a most hateful monster (the Sphinx) to enter the wall from outside: she will blame her bearer when she gets a battering beneath the city walls'.[32]

We have so far mentioned only five of the seven besiegers' shields. The seventh is Polyneikes', whose shield-image of being led back to Thebes by Justice will not be enacted. Of special interest is the sixth shield, of the wise seer Amphiaraos, who eloquently condemns the attempt to destroy the Theban polis (582–3 πόλιν … πορθεῖν) despite himself belonging to the besieging Argive army. His *shield bears no sign* 'because he wants not to *seem* but to *be* the best (οὐ γὰρ δοκεῖν ἄριστος ἀλλ' εἶναι θέλει), harvesting a deep furrow in his mind from which good counsels grow' (591–4). Here the imagined embodiment of reality by the shield-images is definitively reduced to mere seeming. The transition from the destructive and self-destructive individualism (expressed in the shield-images) to the polis' survival desired by Amphiaraos is aligned with transition to the *wisdom of preferring Being to Seeming*. In another Aeschylean tragedy, *Agamemnon*, Kassandra describes 'mortal affairs' (when successful) as the easily erased three-dimensionality represented by σκιαγραφία ('the painting of shadows').[33] Σκιαγραφία will also be often used by Plato as an expression of mere Seeming.[34]

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32 556–61. The deletion of line 559 (εἰκὼ φέροντα πολεμίας ἐπ' ἀσπίδος) is unconvincing: Hutchinson 1985, 130 claims that (a) what we have identified as ambivalence (elsewhere as well as here) makes the line suspect!; (b) 'τῶι φέροντι should not be anticipated by φέροντα', when in fact the repetition has point, emphasising μέμψεται; (c) 'πολεμίας is in this context a pointless and displeasing epithet': but it is paralleled by the need (indeed for us slightly odd) to specify the hostility of the 'likeness' at 523. Further, the feminine τυγχάνουσα (561) goes best with εἴκω.

33 Aeschylus *Agamemnon* 1327–9. Page in his Commentary oddly fails to understand the idea ('it seems an absurd thing to say … and yet it is said here'), and Fraenkel in his Commentary equally oddly attempts to defend the manifestly indefensible τρέψειεν. The meaning is explained in his Commentary by George Thomson, who adduces numerous illuminating passages not mentioned by the other commentators.

34 Plato *Phaedo* 69b, *Critias* 107b, *Parmenides* 165c, *Theaetetus* 208e8, *Republic* 365c, 523b, 583b, 586b, 602d, *Laws* 663c.

The *Agamemnon* also says, about Menelaos' loss of Helen, 'of beautiful κολοσσοί the χάρις (charm, beauty) is hateful to the man. In the emptiness of eyes all Aphrodite is lost (416–19).' Κολοσσοί are closer to 'doubles' than to 'images'.[35] The startling oxymoron 'χάρις is hateful' expresses the gap between the double and the mere image: it is the lack the ocular interaction, typical of erotic love (and of divine statues), that enforces the bitter realisation that the statues of the lost Helen are not doubles but mere images.[36] The same ambivalence was present in Euripides' lost *Protesilaos*, and (minimally) in his *Alcestis* (348–54). On the other hand, in the first woman made by Hephaistos in Hesiod, a 'beautiful evil' (*Theogony* 585), there was no antithesis between *seeming* (beauty) and *real* (evil).

The Amphiaraos passage of *Seven* (467 BCE) is not in fact the earliest extant passage to express a general distinction between Being and Seeming. That honor belongs to a poetic fragment of Xenophanes of Colophon:[37]

> δόκος δ' (seeming, appearance) ἐπὶ πᾶσι (over all things) τέτυκται (has been created).[38]

He is explaining why we do not have clear knowledge 'about the gods and what I say about all things'. The verb he uses for 'created' (τεύχειν) is in archaic poetry used of the creation of the scenes on the shields of Achilles (*Il.* 18.483, 449) and of Herakles (*Aspis* 154, 208); and of the creatures created on the diadem of the first woman (Hesiod *Theogony* 581–3), where we also find ἐπὶ πᾶσι (just as in the Xenophanes): χάρις – beauty or grace – was breathed 'over them all'. Xenophanes uses the language of craftsmanship to express his distinction

35 Vernant 1983.

36 A warning: Fraenkel's interpretation of this passage in his Commentary on the play is manifestly nonsensical. Much better, though inadequate, is Thomson's.

37 Xenophanes was born on the second quarter of the sixth century and lived on well into the fifth. The most recent discussion of the dates is Thibodeau 2019.

38 B34.4 D-K. Δόκος here is sometimes wrongly translated 'opinion'. It is a very rare word, for which – in lieu of a translation – LSJ gives '= δόκησις', for which it gives the meanings (a) opinion, fancy, and (b) apparition, phantom, appearance as opposed to reality, repute. (a) and (b) can be signified by the same word because they are, roughly speaking, subjective and objective aspects of the same thing. In Xenophanes (b) is to the fore, given that (1) for τεύχειν cf. e.g., *Il.* 5.449 (phantom), 18.483, 449 (images); (2) ἐπὶ πᾶσιν (by itself) more often refers to things than to people, and anyway here surely picks up πάντα (all *things*) from two lines earlier; (3) this allows ἐπὶ its common meaning 'over', as at Hesiod *Theogony* 583; (4) for universalising philosophy cf. the Pythagorean μέτρον δ' ἐπὶ πᾶσιν ἄριστον (and Plato *Sophist* 240a5).

between Seeming and Being, with Seeming replacing χάρις. Mere Seeming is as if created by the maker of images.

Xenophanes also says that if animals could draw, they would draw gods that looked like themselves (B15), that mortals believe that gods are born and have clothes and voice and form like their own (B14), and that the Ethiopians say that their gods are snub-nosed and black, the Thracians that theirs are blue-eyed and red-haired (B16). Images of gods do not tell us what god is really like, because they are in fact images of their creators. Implicit in this revolutionary insight is the new idea that images of gods are mere images, mere Seeming. For Xenophanes the general distinction between Being and Seeming is associated – as it will be later for Aeschylus and Plato – with the insubstantiality or deceptiveness of images.

According to Xenophanes the reality is that there is one god who, without moving from where he is, consists entirely of thought and perception, exercises universal power by thought alone, is 'similar to mortals neither in body nor in thought', and is in some sense identical with the universe.[39] So too Aeschylus's Zeus carries out his will while not moving from his place, is in some sense identical with the universe, and has a mind which is unlimited:[40] and so he cannot be likened (προσεικάζειν) to anything except himself.[41] In *Seven* Kapaneus ignorantly likens (προσεικάζειν) the power of Zeus to what it does not in fact in resemble while trying to outdo it in his shield-image.

And so in both Xenophanes and Aeschylus we find the following combination of ideas: something approximating to[42] monotheism, the redefinition of god in terms of thought that extends everywhere, the uniqueness of god expressed as unlikeness to anything else, the general distinction between Being and Seeming, and the delusiveness of the visual image. Xenophanes also denies that athletics benefits the polis, valuing – somewhat like Aeschylus' Amphiaraos – intelligence above physical strength (B2.13–22). Similarly, their

39 DK 21A4, A29–31, A34–6; B23–6.

40 *Suppliant Women* 100–3, 1049, 1058; *fr.* 70.

41 *Agamemnon* 163–5: it evokes the traditional cosmic *scales* (an instrument of equivalence) traditionally controlled by Zeus, who is here imagined in terms of (the new omnipotence over equivalence of) reified abstract value. Here and at *Choephori* 518–21 the phrase οὐκ ἔχω (προσ)εικάσαι refers specifically to the impossibility of the *likening* (even of 'all things') that is required for *equivalence of value*. Εἰκάζειν came to refer to the quantitative *estimation* of goods (*PSI* 5.522; *Papyri Gorab* 8.14: both 3rd cent. BCE), probably from its basic meaning of 'likening' via equating an observed quantity with (the idea of) a specific quantity. For further detail see Seaford 2010.

42 They both mention other gods.

contemporary Herakleitos expresses allegiance to the polis,[43] redefines Zeus in terms of 'one thing, the only wise' (B32), and is aware of the delusiveness of images (he ridicules praying to divine statues: B5).

I have also argued in detail that the cosmologies of Xenophanes, Herakleitos, and Aeschylus (as of early Greek cosmology in general) were influenced by the impersonal abstract quasi-omnipotence of money.[44] How does this relate to my current theme? The pervasion of the polis by coined money, the idea of the mere image, and the distinction between Being and Seeming emerge together in the sixth century polis: what is the relation between them?

The first instances of the idea of the mere image and of its delusiveness occur along with a radically new metaphysics. To what extent was this new complex of ideas confined to a small intellectual elite? Its presence in the plays of Aeschylus, performed before thousands, suggests a wider currency. But in general the images of deity, regarded though they were by Xenophanes as mere images (of humans), continued to be regarded by many as (at least in some respects) embodying the deity.[45] For them the presence of (or at least access to) deity was a practical and emotional necessity. What then were the circumstances that allowed some people to become relatively free of such necessity? Why and how could the revolutionary concept of the mere image (and of mere imitation) emerge?

Revolutionary conceptual transformations do not occur by themselves. An obvious explanation for the emergence of the Greek concept of the mere image is the development of the capacity to create visual art realistic enough to be seen as a mere image.[46] There is no doubt some truth in this. But it is surely not the whole story. Firstly, in the early texts it is not just the idea of the image that is largely absent but also the idea of imitative enactment. Secondly, in Homer the content of (what we call) visual art is in fact described in a manner that

43 Herakleitos DK 22B2, B43, B44, B89, B113, B114.

44 Seaford 2004; Seaford 2010; Seaford 2020a. For the convergence between the monetary abstraction and the abstraction of the subject see Seaford 2020a, 265–70. Both Xenophanes of Colophon and Aeschylus of Athens are *poets*, for whom the influence of the impersonal abstract power of money merges with the traditional conception of Zeus as personal, whereas for the pioneering Ionian prose-writers it produces a world pervaded and controlled an entity that may have been identified as divine but was impersonal (water, the unlimited, air, fire).

45 See footnote 12 above.

46 Another relevant development is the transition in Greek vase-painting from (a) themes that reinforce the rituals in which the vases were used (as well as expressing power, glory, status, etc.), such as numerous mourners at a funeral depicted on Geometric funerary vases, to (b) themes that seem to be prized more for their purely aesthetic appeal. See esp. Langdon 2008. But I cannot extend the discussion to Greek visual art here.

implies that it is *very* real:[47] the art is assumed to be (what we call) realistic, but this does not engender the concept of the visual image. Thirdly, in the ancient Near East realistic images of deities were not envisaged as mere images. It has for instance been observed of the Akkadian word *ṣalmu* (often translated 'statue') that rather than being a copy of something in reality, the image itself was seen as a real thing. It was not considered to resemble an original reality that was present elsewhere but to contain that reality in itself.[48]

But I cannot here enter the rich magic of the ancient Near East, except to note that the identification of deity or king with image was favoured by its role at the centre of the political, economic, and military processes of theocratic monarchies. In Greek society, on the other hand, monarchy was replaced by a self-governing community of citizens (the polis), and the image/deity in the temple did not have the political, economic, and military roles of Near-eastern deities with their attendant priests. This helped to open a new space in the polis for an intellectual elite. While the presence of deity in the Greek temple remained a practical and emotional necessity for the many, the elite had access to new forms of power, especially the new power of large amounts of *money* to answer almost all needs, to create not only individual well-being but also the individual autonomy and leisure needed for philosophy.

All the produce of Pericles' land was regularly sold, everything needed was bought from the market, 'with the result that every expense and receipt involved number and measure', and the whole process was in the hands of a trained servant.[49] Wealthy citizens of the monetised polis lived off abstract substance. Οὐσία can mean both Being and property, and οὐσία ἀφανής with the meaning 'invisible property' referred especially to money, which is easily concealable even in high values. Essential both for Plato's metaphysics and for his autonomous leisure was unchanging abstract value-substance:[50] and so was slavery,[51] the idea of which informs Plato's description of the domination of matter by the abstract.[52]

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47 Consider the sounds and complex movements we have noted in the scenes on Achilles' shield; also e.g., *Od.* 19.228–31.

48 Bahrani 2003, 127.

49 Plutarch *Pericles* 16; cf. e.g., Aristotle *Politics* 1255bc.

50 For more on the relationship of Plato's metaphysics to the economy (including the *circulation* of money) see Seaford 2020a and 2020b. On the role of money in Plato's *Republic* see Noutsopoulos 2015.

51 In his will Plato bequeathed two estates (one of which he had bought), four male household slaves, and a considerable amount of silver and gold; he also freed a female slave and declared that he owed nobody anything (Diogenes Laertius 3.41–3, the veracity of which there is no reason to doubt).

52 Seaford 2020a, 296–8.

3 The Coin-Image

We have seen that the only two instances before the fifth century of the εικ- word-group, to which belongs the main word for a visual image (εἴκων), are of the verb **εἰκάζειν**, the basic meaning of which is to liken one thing to another, to find a resemblance; and that furthermore εἰκάζειν was also much more common in the first half of the fifth century than εἴκων. It seems that the idea of finding resemblance was initially more common than – or even preceded – the idea of a visual image.

Of the two pre-fifth century instances of εἰκάζειν one is in Theognis.[53] Gold and silver that is κίβδηλος (false, adulterated) is easier to detect than a false mind concealed in a breast (119–24). It is believed by some that this refers merely to adulterated metal, whereas Kurke argued that it refers to *coinage*.[54] I once preferred the former alternative,[55] but now think that Kurke was right. For I ignored (as did Kurke) line 127, in which Theognis states – as a reason for the difficulty of detecting the false mind – 'nor would you liken (**εἰκάσσαις**) as if going to a sale'.[56] This surely continues the analogy with precious metal. Given that εἰκάζειν here means 'liken' or 'compare',[57] what in a sale is likened or compared to what? The offered gold or silver to pure gold or silver? Or the coin-image to other such coin-images? The latter is much more likely, given (a) the association of εἰκάζειν with *image* (εἴκων, εἴκασμα), (b) the point given to the comparison: a coin-image guarantees internal quality, whereas there is no external sign of a false mind; (c) the same *topos* at Euripides *Medea* 516–9: the relative difficulty of detecting a bad man is because men do not have on their bodies a χαρακτήρ, the standard term for the mark on a coin; (d) Euripides *Electra* 558–9, where Orestes asks of the recently arrived old man:

> Why is he staring at me as if looking at a bright mark (χαρακτήρ) on silver? Is he likening (προσεικάζει) me to someone/something (τῶι)?

53 It must be admitted that the passage, like much attributed to Thegonis, may not be by Theognis himself, and is impossible to date with certainty. It probably belongs to the sixth century BCE: West 1974, 40–71; Lane-Fox 2000, 37–40.

54 Kurke 1999, 53–5.

55 Seaford 2002, 145–65.

56 οὐδέ κεν εἰκάσσαις ὥσπερ ποτ᾽ ἐς ὤνιον ἐλθών, The emendation ὤνιον (Camerarius) introduces sense by merely changing mss. σ to ν. To ὥσπερ ποτ᾽ ἐς West would prefer ὥστ᾽ ἔμπορος, 'like a merchant'.

57 As generally in its earliest occurrences. It retains this basic sense, even when it is (with accusative and dative merely understood, as here, or in the phrase ὡς εἴκασαι) vaguely but idiomatically translated 'guess'. This also applies to its compounds.

Examining whether the mark (χαρακτήρ) on a coin was *like other such marks* (to ensure authenticity)[58] might be expressed – it is here implied – by the verb προσεικάζειν. I conclude that εἰκάζειν in Theognis 127 refers to likening or comparing the coin-image to other coin-images.

After Theognis the next instances of the word εικ- word-group (still mostly εἰκάζειν) are – we have seen – in Aeschylus, especially of the shield-images in *Seven*. Deborah Steiner[59] has argued that the shields in *Seven* 'emerge as value-bearing tokens, or stamped and inscribed metal pieces signalling the content of the man behind'. She refers to (a) the language of commerce in the passage, as well as language suggestive of coinage;[60] (b) the combination on coins, as on the *Seven* shields, of images with writing;[61] (c) images that appear on both coins and shields,[62] including the Sphinx on Parthenopaios' shield in *Seven*;[63] (d) the thick linear borders that surround Athenian coins in the sixth century in the manner of shields.[64] To this argument we may two further similarities of shields with coins: (e) the *circularity* of (many) shields, which is emphasised in *Seven* (489, 496, 540, 591, 642); (f) the evidence for shield-images of the classical polis being *standardised*.[65]

But why then was coinage not *explicitly* evoked in *Seven* (in say a metaphor for a shield)? Perhaps because coinage was manifestly absent from the heroic era: it was absent from Homeric epic, and arrived in Attica not long before Aeschylus' birthdate of 525 BCE. Moreover, the advent of coinage does not necessarily create its own vocabulary. The two words closest to our 'coin' are ἀργύριον, the diminutive of 'silver' (ἄργυρος), and νόμισμα, which means coinage by virtue of referring to νόμος (law or custom): neither occurs in the lifetime of Aeschylus (i.e. before the middle of the fifth century), except for two instances

58 See also 550 ἐν κιβδήλωι, 572 χαρακτῆρα. The examining might be done by sellers or by the testers called ἀργυροσκόποι (*IG* V.1390.47–8; Phryn. *Praep. Soph.* 30.10 (de Borries) or ἀργυρογνώμονες (e.g., [Plat.] *Virt.* 378e).

59 Steiner 1994, 53–9.

60 *Seven* 477, 488, 521, 545, 547–8, 558–60, 561, 659.

61 Writing on the shields: *Seven* 434, 468, 646–8.

62 She cites Kraay 1976, 58; see also subsequently Spier 1990 (with images shared by coins and shields, and coin-images depicted as if on shields).

63 Kraay 1976, 242.

64 Kraay 1976, 58.

65 Note also that in Euripides' *Elektra* the unique mythical shield image is implicitly opposed to the standard coin-image: Orestes, examined – we saw – as if by one who examines the χαρακτήρ on a coin (to ensure its likeness to every other one), is then identified in the opposite way – by a χαρακτήρ (scar) that marks his *uniqueness* (571–2), evoking the 'signs in the circle' (ἐν κύκλῳ … σήματα) of the shield of Achilles in the preceding ode (455).

of νόμισμα meaning custom.[66] Nevertheless, early fifth-century Athens was already pervaded by money (coinage and bullion), whose influence on tragedy (including Aeschylus) was considerable,[67] even where money was not explicitly mentioned. The influence of coinage on *Seven* is an example of such inexplicit influence. For us coinage possesses a distinct identity, but may initially have appeared as stamped circular pieces of silver that were sometimes seen in terms of what was familiar and most resembled them: circular shields, with which they shared some images.

The standardisation of shield-images and of coin-images favoured the identity and unity of the polis. But the coin-image has the further crucial function of guaranteeing the acceptability of the coin (i.e. its conventional value). The guarantee, which becomes essential to the economy, depends on the *likeness* of the image to the same image on other coins. Testing for purity and weighing are no longer necessary, but one must compare (εἰκάζειν or προσεικάζειν) the image, through memory or in reality, to the same image on other coins.

Coinage was invented in western Asia Minor, probably – the latest research suggests – 'around the middle of the seventh century BCE'.[68] It subsequently became widely used in the Ionian city-states, and thereafter in other Greek city-states.[69] The value of a coin is endowed by its image with a standard (conventional) value that from the beginning was generally higher than its intrinsic (metallic) value.[70] This innovation had various historically unprecedented consequences. Firstly, the easy acceptability of coins facilitated exchange, with the result that they came to be used for everyday transactions. They were produced in their hundreds of thousands or even millions already in the sixth century BCE.[71] Secondly, coins were not normally melted down for their metal: unlike Mesopotamian silver, their *only* purpose was to be money.

The third consequence concerns *abstraction*. Where there is a single measure of value, value tends to be imagined as abstract (numerical). But coinage raises the abstraction into a new sphere. A coin has two values: its value as metal, and a conventional (ideal) value created by its image. This produces what I call a dual ontology: the coin seems to be simultaneously a metal entity and another (abstract) entity with a higher value than its metallic value. This ideal abstract entity or value-substance must be (in contrast to the slight variability

66 Seaford 2004, 142–3.

67 Seaford 1998.

68 Kirscher and Konuk in the latest major contribution to the ever-changing study of the earliest (electrum) coinage, van Alfen and Wartenberg 2020.

69 Seaford 2004, 129–31.

70 Seaford 2004, 136–46; van Alfen and Wartenberg 2020, 61, 312, 320, 442, 513, 550.

71 References in Seaford 2004, 135.

and changeability of the metal entity) imagined as unitary and identical in all such coins everywhere and in the future. The general use of coinage *requires*, and so generates, the general acceptance of the idea of a powerful value-entity that is – though embedded in material – abstract, universal, unchanging, and transformed from and into everything else. Unlike the commodity, the only function of the coin is to embody its standard value reified as an *abstract entity* that seems to participate in a *universal* abstract entity.

The pervasion of the advanced city-states by coinage meant that for the first time in history *exact copies were all-pervasive because socio-economically essential*. If there had been anything anywhere earlier deserving the name of mass production,[72] the production of coins took it to a new level, not simply by virtue of the vast number of artefacts rapidly produced but also because their *effectiveness depended on their exact resemblance to each other*. The mass-produced coin-image was an exact image that – to be accepted – *had to* be an exact image. The economy came to depend on the creation and distribution of generally accepted small portions of abstract value, which in turn depended on the standardisation of images that was (with inevitable exceptions) as exact as technology allowed. Standardised coin-images, each expressing the identity of the whole polis, passed through the hands of most people. Aristotle in the *Nicomachean Ethics* 1133a17–21) notes that νόμισμα (currency, coinage) equalises the parties to exchange. Inherent in every coin was a quasi-democratic universality. Whereas the arrogant shield-images in *Seven* express the *uniqueness-in-action* of each polis-endangering mythical individual, the coin-images evoked by the shields depended for their polis-wide circulation on universal *likeness* to other coin-images.[73] This is, I suggest, an instance of the synthesis (or creative tension) – noted[74] as characteristic of Attic tragedy – between the individual autonomy of mythical heroes and the communal institutions of the democratic polis. It is worth observing in this connection that the transformation promoted by coined money was political as well as economic and intellectual: for instance, it is not coincidental that democracy was created in Athens, as was drama, a generation or two after the introduction of coinage.

The conventional abstract value embodied in the metal of the coin depended on its image. Let us look more closely at how this worked. What was required

72 Notably figurines and roof-tiles (Seaford 2004, 66–7) and indeed the iron spits that endured the equal distribution of sacrificial meat and were a stage in the emergence of coined money: Seaford 2004, index s. spits.

73 Plato *Republic* 371b, *Laws* 918a.

74 E.g., Vernant and Vidal-Naquet 1988, 23–8.

in a coin-image, whatever it represented, was confidence-creating *resemblance* to other coin-images. An image of Athena in a temple provides interpersonal access between mortals and goddess, and so is imagined to embody her powerful presence. But such presence would be detrimental to the function of the image of her head on an Athenian coin. Like many other images in the archaic period, the coin-image had a function, but its function had – uniquely – nothing to do with embodying its model (Athena cannot anyway be imagined to be wherever there is a coin). It is the essence of the coin, in contrast to the seal or the amulet, to have no relationship with any person other than temporary ownership, no connection with the deity or anything else stamped on it other than being a mere image (or the mere image of an image), and no connection with any commodity other than for the purpose of exchange. This is because in order to function, coins must be easily transferred, must circulate. The power of the coin must be *impersonal*, must consist entirely of its conventional abstract value. What it embodies must be this power alone, which depends on the resemblance of its image to all other such coin-images, be they of deities or significant animals or anything else. For it to (through its image) *embody any other power* would complicate and undermine its function as a coin. The head of Athena on a coin could provide aesthetic pleasure, or a happy reminder of her power, but it had to do so without *embodying* her power or presence.

Coinage is unique in interconnecting within itself real (abstract) power-substance with mere (material) image, in order to perform an essential, universal socio-economic function. This was, I suggest, an especially effective factor in promoting the idea of the mere image. The suggestion is of course speculative, and *certainly does not exclude other factors*. But the coin-image is, besides its unusually widespread use and central socio-political importance, the only artefact that *requires* that separation of model from image that is a precondition for the emergence of the idea of the mere image.

4 Plato

The predominance of abstract value-substance (apprehended by the mind) over matter (apprehended by the senses) within the coin, whose only function is to embody abstract value, was a special case of the same predominance within the commodity. This brings us to the central role, in Plato's metaphysics, first of money and then of the mere image.

Abstract value-substance, unitary, unchanging, and *separated from circulation* is cosmised as the Parmenidean One, which is all that is real: perceptibles

(plural and changing) are illusory. Plato, by contrast, while cosmising abstract value-substance as the Form of the good,[75] attempts to give an account of its relation to perceptibles. He does so by means of intermediaries, the unchanging abstract *Forms* (I use capitalised 'Form' for Platonic Forms). The ontological difference between Being and Seeming is implicit in earlier philosophy, and explicit in Xenophanes and Aeschylus, but Plato is the first to systematically problematise the relationship between the two.

The Form of perceptibles, e.g., the Form of a bed, is an abstract reification of its imagined ideal form. Why did Plato believe that there is a single abstract Form of a bed more real than actual beds? And why did he do so against the arguments that he himself produces in *Parmenides*, arguments strong enough to make some modern interpreters believe (even if mistakenly) that they mark Plato's abandonment of transcendent Forms altogether?[76] The answer cannot ignore the *ideology* of Plato. He is in the grip of a predisposition to privilege ontologically the abstract over the material.

Whence the predisposition? Neither users nor sellers of beds have in mind a single abstract Form of a bed (and even constructors of beds tend to follow a procedure or another real bed). What people more frequently have in mind is (apart from its use) its monetary value. Like coins and all commodities, the bed combines materiality with abstract value, and so participates in universal abstract value. What motivates the idea that the abstract Form of a bed is more real than a material bed is the universal abstract reality in which the material bed participates, namely its monetary value.

In reality (a) a material bed has (b) an abstract value (while still being a bed), which is constituted as abstract value by (c) abstract value in general – as is the abstract value of each commodity or service.

Correspondingly, according to Plato, (a) a material bed depends in some way (see below) on (b) the abstract Form of a bed (abstract, but nevertheless somehow a bed), and this and other abstract Forms depend in some way on (c) the universal Form of the good, 'by which just things and the other things become useful and beneficial' (*Rep*. 505a2–4), and by which what can be known (Forms) exists and is knowable (*Rep*. 507b–509b).

In the Form of the bed the abstract value of the bed is *reified*, as an abstract entity that replaces the matter of the bed while somehow retaining its bedness. The Form of a bed is the bed imagined from the perspective of the abstract (monetary) value in which beds participate, a synthesis of the bed with abstract value-substance. This metaphysical projection (or cosmisation)

75 *Republic* 505a, 508a–e, 532b1, *Laws* 965b–966b; as 'beyond Being': *Republic*. 509b.
76 E.g., Ackrill in Allen 1965, 206; see further Guthrie 1978, 58–9.

of commodities helps Plato (in contrast to Parmenides) to account for plural, changeable, perceptibles, while partly respecting the Parmenidean logic that reserves reality for unchanging abstraction.

But there are of course Platonic Forms of more than just commodities. The comprehensive social power of money is (as is the comprehensive social power of the monarch) cosmised as universal. Parmenides cosmises it as the abstract One that is all that exists (excluding multiplicity), the Pythagoreans as *numbers*, Plato as the abstract Form of the good from which the multiple Forms derive. Given the universality of what is cosmised, there should be Forms for all things: and accordingly Socrates confesses that he thinks the doctrine of the Forms should apply to *everything* (Plato. *Parmenides* 130cd). But on the other hand the Form of the good retains the *value* inherent in money, and so Socrates in the same passage has to admit that the idea that there are Forms of *valueless* things such as hair, mud, and dirt is absurd.

At any rate both the material bed and the Form of a bed are – on the ontological spectrum of value – between abstract value-substance in general at one extreme (separately cosmised as the unitary Form of the good) and useless, formless mud and dirt at the other. But the unchanging abstract Form of the bed is closer to abstract value-substance and the Form of the good, and so more real, than is the material bed.[77]

The Forms are in a broad sense causes of the perceptibles. But how does the causation work? The numerous words that Plato uses to describe the relation of perceptibles to Forms have been conveniently listed by Ross.[78] Almost all of them[79] refer to either (1) the *participation* of the perceptibles in the Forms,[80] or (2) the *presence* of the Forms in the perceptibles,[81] or (3) the *likeness* of the

77 The movement of the soul from mere seeming to reality has 'measuring, counting, and weighing' as 'aids': *Rep*. 602d.

78 Ross 1951, 228–30.

79 An exception is the inferiority (φαυλότερον) and aspiration of perceptibles to the Forms (*Phaedo* 74de, 75b; cf. *Timaeus*.52c2, *Lysis* 219d3–5; Poetsch 2019, 114, 217, 258–65) which is consonant with the higher *value* of the latter.

80 Plato *Gorgias* 467e7, *Symposium* 211b2, *Phaedo* 100c5, 101c3–5, 102b2, *Republic* 476d1–2, *Parmenides* 158b6–c4, 160a2, *Sophist* 228c1. The words are μετέχειν, μετάσχεσις, μέθεξις, μεταλαμβάνειν, κοινὸν, κοινῇ, κοινωνεῖν.

81 *Laches* 191–2, *Gorgias* 506d, *Hippias Major* 293–4, *Lysis* 217, *Euthydemos* 280b, 301a. *Meno* 72e, *Cratylus* 390ab, 413c, *Phaedo* 100d, *Republic* 402c, 434–5, *Parmenides* 150a, *Sophist* 247a, *Philebos* 16d. The words are ἐν, ἐνεῖναι, ἐγγίγνεσθαι, κεῖσθαι ἐν, παραγίγνεσθαι, παρεῖναι, παρουσία.

perceptibles to the Forms (including *created* likeness, imitation).[82] According to Aristotle Plato maintained that the perceptibles participate in the Forms,

> merely changing the name: for the Pythagoreans said that entities exist by *imitation* (μίμησις) of numbers, whereas Plato said by *participation* (μέθεξις), changing the name.

This metaphysical importance of numbers derives, I have argued elsewhere, from the numerical nature of monetary value.[83] 'Merely changing the name' indicates the lack of clear differentiation in Plato's theory between likeness and participation, which are indeed at *Parmenides* 132d combined: Socrates describes perceptibles as likenesses (ὁμοιώματα) of the Forms, and describes their participation (μέθεξις) in the Forms as assimilation (εἰκασθῆναι).

The (1) *participation* of the perceptibles in the Forms is much the same[84] as the (2) *presence* of the Forms in the perceptibles, and they are both based on (3) *likeness*. Material beds with monetary value *participate* in monetary value: in other words monetary value is *present* in them. As for the *likeness* of the material bed to the Form of the bed, it is overdetermined: its abstract *value* is like the abstract value reified in the Form, and its *form* is like the bed-form retained in the Form (stripped of its materiality). There is (a) the materiality of the bed, (b) the bed-form, (c) abstract value, and (d) reified abstract value. The material bed combines (a), (b) and (c). The Form of the bed combines (b) and (d). And (d) on its own is sublimated as the Form of the good.

Along with these relations between (material) perceptibles and Forms, perceptibles are also ontologically inferior (less real) than Forms. I will shortly describe how this inferiority is *imagined*. But first I must briefly emphasise the basic explanation of this ontological inferiority of the material, in other words of the ontological superiority of the abstract. Ultimately it is practical. Abstract Being sublimates monetary (abstract) value-substance, through the possession of which Plato and others acquire and control material goods and services.

Plato is of course no more conscious of the psychological process of sublimating monetary value-substance as abstract Being than a believer in Zeus is of the psychological process of sublimating a patriarchal monarch as a god.

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82 *Euthyphro* 6e4; *Phaedo* 74e3, *Republic* 510b4, 8, d7, e3, 511 a6, *Phaedrus* 250a6, b3–5, *Timaeus* 29b2–3, c1–2, 50d1, 51a2, 52c2, 92c7, *Philebus* 16d2, *Timaeus* 39e2, 48e6, 50c5, 50d1, 51d2. The words are ἐοικέναι, προσεοικέναι, εἰκών, εἰκάζεσθαι, ἀπεικάζεσθαι, ὁμοίωμα, ἀφομοίωμα, ἀφομοιοῦσθαι, παράδειγμα, μιμεῖσθαι, μίμησις, μίμημα, ἀπομιμεῖσθαι.

83 Seaford 2004, 266–83.

84 The Platonic words for participation (footnote 74 above) mean having a share or part of something.

However, a patriarchal monarch is essentially powerful and superior, and on Olympos can be equipped with a thunderbolt. It is not the same with money: it exercises power only in *circulation*, but monetary value is reified and cosmised by Parmenides and Plato as *possessed*, in *separation from circulation.*[85] The guardians of Plato's ideal polis are told that they *possess* always divine gold and silver coinage in their souls while being forbidden contact with the polluting *circulation* of human coinage (*Republic* 416e). Coins with their mass-produced material images are vulgar, whereas their (invisible) abstract value may be internalized as divine. In general Plato sustains the superiority of abstract Being by a persuasive ethical and organisational privileging of the mind (and its abstract objects) over the senses (and their material objects and sensations). But how is he to express its *ontological* superiority?

Platonic Forms are reified abstractions, like the Form of the good, from which they derive. But perceptibles, because their thingness is *material*, cannot be simply derived from what is abstract. How then does Plato's account of their relation to the Forms imply their ontological inferiority?[86] (1) *participation* and (2) *presence* do not imply ontological inferiority. (3) *Likeness* on the other hand may do so, but only if it is the form of likeness known as an image, and moreover only if 'image' is limited or defined in a certain way that is much harder to do to *participation* and *presence*.

The first extant text to limit or define the image in the required way is Plato's *Sophist*. In his discussion of the sophist as 'image-maker', he defines the image (εἴδωλον), which includes reflections, paintings, and suchlike (239d), as 'another such thing made in the likeness of (ἀφωμοιωμένον) the true one' (240a).[87] The image (εἴδωλον), it is then agreed, is not true but only *like* the true, and so – because the true is what really exists (ὄντως ὂν) – what is *like* (τὸ ἐοικός) does not really exist.[88] The ambivalence we have described (notably in Aeschylus), between image as mere image and as containing the reality of its model, is here implicitly rejected by Plato: he has entirely separated the image from the reality of its model, to which therefore it relates by similarity alone. For Plato a figure with all the qualities of Cratylus would be, we saw earlier (§1), not an image of Cratylus but a second Cratylus. But in contrast to the Homeric εἴδωλον, the Platonic εἴδωλον is a mere image. In contrast to Hephaistos 'putting' things into

85 On the extensive philosophical importance of the dual essence of money, as necessarily possessed but necessarily circulating, see Seaford 2020a.

86 For their ontological inferiority see e.g., *Republic* 477a, 478d, 515d; *Timaeus*. 27d–28a.

87 See also esp. *Timaeus*. 52c; Poetsch 2019, 214–6.

88 For Plato the mere image may also be *verbal*: this allows him the earliest sustained explicit recognition of what we call metaphor.

the shield of Achilles, Plato insists that the painter is concerned with mere appearance.[89] Moreover, just as the painting of a bed is less real than the bed itself, so the bed itself is less real than the abstract Form of the bed, which the craftsman has in mind as he constructs a material bed, which is an image of the Form of a bed.[90]

This does not mean however that images have no existence at all (any more than perceptibles have no existence at all). The mere image does exist in a way (πῶς), because it really is an image (εἴκων): and so Being and non-Being are entangled.[91] The perplexing ambivalence of the image was in Aeschylus with the reality of its model, in Plato (more abstractly) with its reality as an image.

An image represents only some of the features of its model (were it to exactly represent all of them, it would – we have seen – be not an image but a double). Accordingly, its ontological inferiority is a matter of *absence*. And the inferiority will be unequivocal when what is absent from the image is the model's power-substance, the substance that gives the model its capacity, use, or power (be it a bed, a tree, a person, or a god). A thunderbolt depicted on a shield is (for Plato if not for Kapaneus) powerless. You cannot sleep comfortably on a painting of a bed. This ontological distinction between image and model corresponds to the material-abstract distinction between perceptibles and Forms in the following way: what is imagined to be absent from the image of the Form of the bed (i.e. from the material bed) is the power-*substance* of the Form of the bed, namely *reified* abstract value, which in the Form of the bed is the entity that replaces matter.

However, there also seems to be a lack of correspondence between the image-model distinction and the material-abstract distinction. The model for visual images was (at least in the ancient world) on the whole not abstract but itself material. However, in this respect the visual depiction of deities is a special case, because deities are supremely powerful, potentially present everywhere, and generally invisible. True, they are – in almost all early Greek texts – imagined as material enough to be identified with mortals.[92] But Olympian deities were in fact usually invisible (because remote), while being made accessible or even present through material images. In the sixth century the invisibility of their power could, under the influence of monetisation, begin to be imagined as part of their *nature*.

89 E.g., *Republic* 597e2–598e3; *Sophist* 236b.

90 *Republic* 597a, 596b.

91 *Sophist* 260, 264d: Plato is here concerned primarily with the existence of (false) *discourse* (λόγος). See also *Republic* 478d5–10.

92 For this phenomenon in the living polytheism of Hinduism see Gell 1998, 67, 116.

For Xenophanes, as for Aeschylus, Zeus redefined in terms of ubiquitous thought merges with the universal abstract power of money (§2). This makes it possible for Xenophanes to regard the material images of deities as in fact nothing more than mere (material) images (of their creators). The images were in the temples, but also on coins (and so as images of images), where they *had to be* (material) mere images, so as make present abstract value (§3). In coinage abstract value, material, and mere image were intimately interconnected. The coin prefigures within itself the Platonic close antithetical interconnection between material mere image and unchanging invisible (abstract) Being. Because the head of Athena on a coin had to be a mere image, it is not the goddess or her invisible power that is made present but the invisible (abstract) power-substance of money: there is a mismatch between what is copied and what is made present. Athena may travel to visit her cult places (e.g., *Odyssey* 7.81), but cannot be simultaneously present in thousands of coins.

In both Xenophanes and Aeschylus mere material (perceptible) images are aligned with mere Seeming (§1), as in Plato, who also takes the next step of making explicit the idea of a mere image, which he uses to express the ontological inferiority of perceptibles in a way that participation and presence cannot. It is significant that in his only substantial discussion of the nature of matter, in the *Timaeus*, Plato explicitly rejects participation and presence as expressing the relation of matter (perceptibles) to Forms.[93] Instead, he imagines matter as gold being moulded into different shapes, and as a substance *stamped with images* of eternal figures (50c: τῶν ὄντων ἀεὶ μιμήματα τυπωθέντα ἀπ᾽ αὐτων). Fantasy, as often, resolves contradiction: the stamped gold resembles coinage, but without the aforementioned mismatch between what is copied and what is made present.

What do I mean here by the image *expressing* the ontological inferiority of perceptibles? It seems natural to assume that it functions as a *metaphor* designed to illustrate or clarify another relationship (other than the relationship of resemblance) between perceptibles and Forms. According to Guthrie, 'through the metaphors of participation and imitation, or by the simple dative, what he is saying is that [perceptibles] are dependent on the Forms for such being as they have'.[94]

But whatever exactly is meant by the broad term 'dependent', 'imitation' is not *simply* a metaphor for it, any more than calling the cosmos an image

93 52a: 'neither receiving anything from elsewhere into itself nor itself going anywhere into anything else'.

94 Guthrie 1975, 497. Aristotle disparages the Platonic forms (in being called paradigms, and things in which other things participate) as 'poetic metaphors' (*Metaphysics*. 991a22).

(εἰκών) of the intelligible (*Timaeus* 92c) is simply a metaphor for some other relation (what relation?) between the cosmos and the intelligible. If we want to retain the term 'metaphor' in such contexts, we should avoid confusion by calling it 'constitutive metaphor'. That the image was in Plato *constitutive of* ontological difference emerges clearly from the recent collection and discussion, over four hundred pages, of all the relevant Platonic passages by Christoph Poetsch.[95] His first sentence is 'Platon's Philosophie ist eine Metaphysik des Bildes'. What I have added is that the emergence of the idea of a (material) mere image emerged in conjunction with the universal power of abstraction (especially on coins), as part of a broad societal transformation that included much else – including, I have argued elsewhere,[96] the genesis of the *mere imitation* that we call drama.

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95 Poetsch 2019, e.g., 313: '… die Gleichnisbilder selbst auf spezifische Weise Teil des Seins sind. Sie stehen nicht also extraontisches Beispiel gänzlich getrennt von den Dingen … Denn insofern sich das eidetische Sein im Sinnlich-Physischen veranschaulicht, ist die Wirklichkeit bereits in sich selbst ikonisch, gleichnishaft verfasst. Das Sein ist – wenn man auf den aristotelischen Teminus vorgreifen möchte – in sich selbst metaphorisch und die Metapher so Teil des Seins'.

96 Seaford 2012.

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CHAPTER 7

Anaximenes and the Millstone

Dirk L. Couprie

1 Introduction: Theodoretus' Text

In Diels' *Doxographi Graeci*, Aëtius' *Placita* 2.2 is entitled "on the shape of the cosmos" (Περὶ σχήματου κόσμου). In a footnote, Diels adds a text from Theodoretus (fourth century AD) on two anonymous groups, the former of which Diels links to Anaximenes, the second to Anaximander.[1] Theodoretus' text, labeled "Aët. 2.4", has found a place as an A-fragment on Anaximenes in Diels' *Fragmente der Vorsokratiker*. In their *Aëtiana*, Mansfeld and Runia first put it in a postulated missing chapter "Aëtius *Placita* 2.2a",[2] but later they decided not to take it in their reconstruction of Aëtius' *Placita*.[3] Yet Theodoretus' text about two anonymous groups who are said to have used two different images of the motion of the cosmos remains one of the most intriguing texts in the doxography on ancient Greek cosmology. It reads as follows:

> καὶ οἱ μὲν μυλοειδῶς, οἱ δὲ τροχοῦ δίκην περιδινεῖσθαι ⟨τὸν κόσμον⟩.[4]
>
> And some (say that) (the cosmos) whirls around like a millstone, others (say) that it (whirls around) in the manner of a wheel.

The words ⟨τὸν κόσμον⟩ were added by Diels, because the context of the text is about the cosmos. It should be noted, however, that the content of Theodoretus' text is not about the shape of the cosmos, but "about the displacement and the movement of the heavenly bodies" (Περὶ τῆς τῶν ἀστέρων φορᾶς κινήσεως), which is the title of Aëtius' chapter 2.16. The generally accepted attribution to

1 See Diels 1879, 329, see also ibidem 46. Cf. Mansfeld and Runia 2009, 324: "[this text] refers to motion rather than shape (…). It seems out of place in the present chapter."

2 See Mansfeld and Runia 2009, 331–336 (hereafter MR, followed by the publication of the volume being cited.).

3 See MR 2020, 777–779 (*Appendix*).

4 Theodoretus, *Graecarum affectionum curatio* 4.16 = DK 13A12 = Wöhrle 2012, As112 (with the misprint "die Erde" instead of "der Kosmos"); not in Laks and Most 2016, hereafter 'LM', Graham 2010, and Kirk, Raven and Schofield 1983; hereafter KRS.

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Anaximander of the part of the text that says that the cosmos turns around like a wheel, is probably correct. According to Anaximander, the sun and moon can be compared with wheels.[5] The also generally accepted implication of this is that the sun and moon (and other heavenly bodies as well) also pass under the earth. Therefore, I read "the cosmos" in this text as a kind of shorthand for "the heavenly bodies". In the *Fragmente der Vorsokratiker*, Diels did not put this doxa under the caption of Anaximander, but only under that of Anaximenes (DK 13A12). At first sight it seems reasonable to suppose that in the first part of Theodoretus' text, where it is said that the cosmos turns like a millstone, Anaximenes, who was Anaximander's apprentice, must be meant.[6] However, in their discussion of Aëtius' chapter 2.2, Mansfeld and Runia rightly write: "It is very difficult (…) to determine how the contrast between the two kinds of motion can be explained".[7] In this essay, I will examine whether Diels was right in attributing to Anaximenes the image of a millstone for the motion of the heavens, and if so, what it might have meant. More specifically, given that at least Anaximander was one of the "others" (οἱ δὲ), since he compared the sun and moon with wheels, I will try to find out who were the "some" (οἱ μὲν) and what they could have meant by the image of a millstone. The present essay is a renewed attempt to tackle the interpretive difficulties, building on my earlier work on this in *Heaven and Earth*.[8] To this end, I will make extensive reference to archeological evidence as to what a millstone might have been in Anaximenes' time and place.

As far as I know, the image expressed by the word μυλοειδῶς has always been understood to refer to horizontally placed millstones as we still know them, and more specifically to the rotating upper one, while the lower one remains stationary.[9] The cosmological idea that seems to be expressed by the image of

5 Cf. DK 12A21 and 12A22.

6 The only place where the sun according to Anaximenes seems to be compared to a stone or brick is in a book attributed to al-Ǧāḥiẓ, who has, in Daiber's translation, which I am not able to check: "[die Gestalt der Sonne] ist wie eine breite Platte" (Daiber 1980, 399, sub 8; not in DK or in other handbooks). However, this has to do with the shape and the substance of the sun, not with its movement. More familiar is the comparison of the heavenly bodies to nails or leaves (DK 13A14; see also DK 13A15: "the sun is flat like a leaf"). The authorship of al-Ǧāḥiẓ is a matter of discussion among scholars, see Plessner 1975, 103, n. 255.

7 MR 2020, 778.

8 Couprie 2018, chapter 7.

9 So, e.g., MR 2009, 334: "circular motion in a horizontal plane". But in MR 2020, 778, they correctly write: "that in the archaic period the millstone was not horizontal as it became later, but stood vertically".

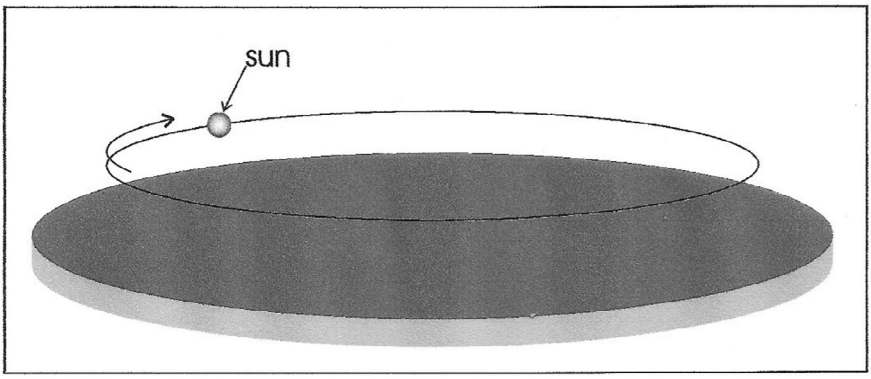


FIGURE 7.1 The sun, allegedly moving like a horizontally turning millstone above the earth
DRAWING BY THE AUTHOR

the millstone, understood this way, can be visualized for the sun as in Fig. 7.1, where the flat earth can be compared to the lower, immobile millstone, while the sun moves like the upper, rotating millstone above the earth.

Since Moritz' *Grain-Mills and Flour in Classical Antiquity*,[10] in which also several Greek texts are discussed, the awareness has dawned that rotary mills with a horizontally rotating millstone were not used in Greece until the first century BCE. Especially in the last decades, many articles by archeologists have been published, in which this insight is confirmed. Nevertheless, many scholars, when they read the words "mill" and "millstone" in ancient Greek texts, will still think that such rotary mills were meant.

In my previous book, I already made the suggestion of a vertically placed millstone.[11] In the present essay I will argue that in Anaximenes' time and place the vertical millstone of an oil mill was the only possible option. This still leaves open the question as to whether Theodoretus meant it that way, and thus, whether he was alluding to Anaximenes when he used the image of the millstone to describe the movements of the heavenly bodies. Before presenting the archaeological evidence, I will address the rather complicated interpretive problems related to other textual material describing the movements of the heavenly bodies according to Anaximenes.

10 Moritz 1958.
11 Couprie 2018, 123.

2 Other Texts on Anaximenes and the Movements of the Heavenly Bodies

Anaximenes is usually thought to have been active about the middle of the sixth century BCE.[12] In chapter 7 of my book *When the Earth Was Flat*, I argued that according to Anaximenes, the heavenly bodies revolve around the flat earth, which means that they also pass under the earth.[13] Fig. 7.2 illustrates my interpretation of the cosmology of Anaximenes, showing how the heavenly bodies turn aslant the earth's surface, around the tilted celestial axis.[14]

I based this interpretation on Ps.-Plutarch's version of a doxa in Aëtius:

> Ἀναξιμένης ὁμοίως [sc. Ἀναξίμανδρῳ] **ὑπὸ τὴν γῆν καὶ περὶ αὐτὴν** στρέφεσθαι τοὺς ἀστέρας.[15]
>
> Anaximenes likewise (sc. like Anaximander), (said that) the heavenly bodies revolve under the earth and around it.

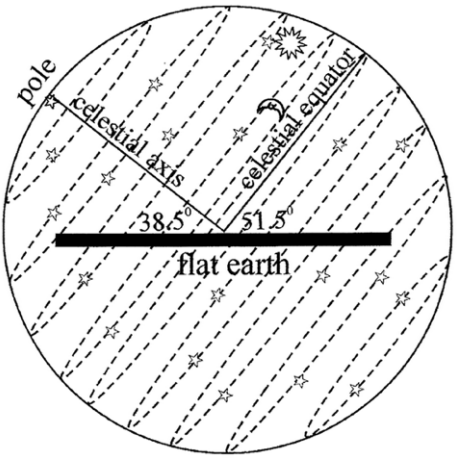


FIGURE 7.2
The paths of the heavenly bodies according to Anaximenes
DRAWING BY THE AUTHOR

12 See, e.g., Guthrie 1962, 115; KRS 1983, 143–144. Recently, Thibodeau 2019, 240–261, has argued for a much later date: he places Anaximenes' birth in the 520's BCE. This, however, does not influence the argument in my paper.

13 Couprie 2018, 99–130.

14 Drawing from Couprie 2019, 126, Fig. 7.14.

15 This version not in DK, LM 2016, Graham 2010, and KRS 1983. But see MR 2009, 487 sub P2.16.4; Mansfeld and Runia 2020, 944–945, §5. Curiously, Wöhrle 2012, As 38 deletes ὁμοίως and καὶ but adds οὐχ.

Here the word περί is used to emphasize that, according to both Anaximander and Anaximenes, the heavenly bodies revolve around the earth: above the earth when they have risen and under the earth when they have set. This was also how Qusṭā Ibn Lūqā understood it. His rendition of Aëtius' text is, in my translation of Daiber's German translation of the Arabic original:

> Anaximenes believed that the heavenly bodies move *above and under the earth*.[16]

This sounds as if the text Qusṭā Ibn Lūqā translated in Arabic had ὑπὲρ γῆν (above the earth) instead of περὶ γῆν (around the earth). In contrast, Eusebius' and Stobaeus' versions of the same Aëtius' text say just the opposite:

> Ἀναξιμένης οὐχ ὑπὸ τὴν γῆν, περὶ αὐτὴν δὲ στρέφεσθαι τοὺς ἀστέρας.[17]
>
> Anaximenes (says that) the heavenly bodies do not revolve under but around the earth.
>
> Ἀναξιμένης οὐχ ὑπὸ τὴν γῆν δὲ ἀλλὰ περὶ αὐτὴν στρέφεσθαι τοὺς ἀστέρας.[18]
>
> Anaximenes (says that) the heavenly bodies do not revolve under but around the earth.

Theodoretus' simile of the millstone is commonly thought to express the same idea as Eusebius' and Stobaeus' versions of Aëtius. Both in the *Doxographi Graeci* and the *Fragmente der Vorsokratiker*, Diels puts forward Stobaeus' version as the right one,[19] and this is almost always the only one quoted by other scholars in handbooks and commentaries. Diels even amended Ps-Plutarch's version as if it would say the same as Eusebius' and Stobaeus' version. In *When the Earth Was Flat*, I argued at length why Ps.-Plutarch's version should be preferred.[20] Since they reacted at that, I feel obliged to insert a short discussion

16 Daiber 1980, 153. I am not able to read the Arabic original. In German, it reads: "Anaximenes glaubte, daß die Sterne sich oberhalb und unterhalb der Erde bewegen". See also Wöhrle 2012, As205; MR 2009, 488, and MR 2020, 938, note at 2.16.5.

17 Eusebius, *Praeparatio Evangelica* 15.47.

18 Stobaeus, *Eclogae* 1.24.1 = DK 13A14 = Graham 2010 Axs 19 = Wöhrle 2012, As 124; not in LM 2016 and in KRS 1983. In MR 2009, 488 and 495 it is read δὲ ἀλλὰ, in MR 2020, 944 ἀλλὰ δὲ.

19 See Diels 1879, 136 and 346; DK 13A14.

20 Couprie 2018, 114–128.

of Mansfeld and Runia's remarks on this question. They put forward several arguments for their favoring Stobaeus' and Eusebius' reading and they conclude: "There can be little doubt that E[usebius] and S[tobaeus] preserve the right reading".[21] For this statement they provide arguments, that deserve to be considered more closely.

In 2009 (MR 2.2), Mansfeld and Runia defended their choice for Eusebius' and Stobaeus' version by stating that the versions of PQ [Ps.-Plutarch and Qusṭā ibn Lūqā] "are most likely the result of textual corruption, e.g., in response to the word οὐχ falling out".[22] This would imply that a copyist of Ps.-Plutarch's manuscript, abusively having deleted οὐχ, should have decided not only to delete the word δὲ (or even the words δὲ ἀλλὰ) as well, but also to add the word ὁμοίως. This argument no longer appears in Mansfeld and Runia's recent book (2020, MR 5.2) supposedly because they no longer consider it to be valid. In 2020, it seems to be replaced by the argument that "in fact the evidence in E[usebius] and S[tobaeus] is older than that of the Byzantine mss. of P[s-Plutarch]."[23] To me, this argument as such is not convincing, because it appears to exclude beforehand the possibility that these manuscripts go back to a tradition in which the original wordings were better preserved than in those of Eusebius and Stobaeus. Moreover, Mansfeld and Runia do not comment to the fact that Qusṭā ibn Lūqā (820–912 AD) confirms the reading of Ps.-Plutarch, which seems to prove that he had before his eyes the same text as in the Byzantine manuscripts of Ps.-Plutarch. The main argument of Mansfeld and Runia by which they underpin their conviction that Eusebius and Stobaeus preserve the right reading, is that "the same doxa is already anonymously reported in almost exact the same formulation in Aristotle's *Meteorology*".[24] To me, it is a strange way of arguing that Eusebius' and Stobaeus' version of the movements of the heavenly bodies must be the right one because Aristotle uses the same words in describing the movements of the sun according to some anonymi. In *Heaven and Earth*, I already argued that Aristotle does not refer here to Anaximenes, but to an archaic world-picture, in which the sun is above the earth (ὑπὸ γῆν) when it is day and moves around the rim of the earth (περὶ τὴν γῆν) – and behind mountains – at night.[25]

21 MR 2020, 944.

22 MR 2009, 488.

23 MR 2020, 945.

24 MR 2009, 488; MR 2020, 944. For a quotation and discussion of Aristotle, *Meteorology* 354a28–32, see the next section.

25 Couprie 2018, 119.

Given that two contradicting versions of this doxa exist (Eusebius/Stobaeus, versus Ps.-Plutarch/Qusṭā Ibn Lūqā), the most obvious assumption is that one must be the original and the other the distorted version. In *Heaven and Earth* I argued that Ps.-Plutarch must have offered the right version, contrary to the dominant opinion among scholars. Whether I was right or wrong in preferring Ps.-Plutarch's version, it remains interesting to examine what Eusebius and Stobaeus could have meant by saying that the heavenly bodies do not go under but around (περί) the earth.

3 Texts That Seem to Confirm Stobaeus' Version

Three other texts seem to confirm Eusebius' and Stobaeus' reading of Aëtius' above quoted doxa. A text in Diogenes Laërtius is similar to that of Stobaeus and apparently draws from the same source with key words in bold:

> Ἀναξιμένης (…) κινεῖσθαι δὲ τὰ ἄστρα **οὐχ ὑπὸ γῆν, ἀλλὰ περὶ γῆν.**[26]
>
> Anaximenes says that the heavenly bodies do not move under the earth but around the earth.

Hippolytus, too, uses similar expressions:

> Ἀναξιμένης (…) **οὐ κινεῖσθαι δὲ ὑπὸ γῆν** τὰ ἄστρα λέγει, καθὼς ἕτεροι ὑπειλήφασιν, **ἀλλὰ περὶ γῆν**, ὡσπερεὶ περὶ τὴν ἡμετέραν κεφαλὴν στρέφεται τὸ πιλίον. κρύπτεσθαι τε τὸν ἥλιον οὐχ ὑπὸ γῆν γενόμενον, ἀλλ᾽ ὑπὸ τῶν ὑψηλοτέρων τῆς γῆς μερῶν σκεπόμενον καὶ διὰ τὴν πλείονα ἡμῶν αὐτοῦ γενομένην ἀπόστασιν.[27]
>
> (Anaximenes) denies that the heavenly bodies move under the earth, as some others suppose, but he says that they move around the earth like a felt cap turns around our head. The sun is hidden not by going under the earth, but by being covered by the higher parts of the earth and by being a greater distance away from us.

---

26 Diogenes Laërtius, *Lives of Eminent Philosophers* 2.3 = DK 13A1 = Wöhrle 2012 As 72; not in LM 2016, Graham 2019, and KRS 1983.

27 Hippolytus, *Against All Heresies* 1.7.6 = DK 13A7(6) = LM 2016, D5(7) = Wöhrle 2012 As 56(7.6) = Graham, 2010, Axs 12(6) = KRS 1983, 156.

The words "as some others suppose" obviously are an addition by Hippolytus. More interestingly, Hippolytus adds three new elements: the simile of the felt cap (τὸ πιλίον), the higher parts of the earth that hide the sun at night, and the greater distance of the sun. The same words for the motions of the heavenly bodies that Eusebius and the others applied to Anaximenes, were used by Aristotle to describe the opinion of some anonymi:

> τὸ πολλοὺς πεισθῆναι τῶν ἀρχαίων μετεωρολόγων τὸν ἥλιον μὴ φέρεσθαι ὑπὸ γῆν ἀλλὰ περὶ τὴν γῆν καὶ τὸν τόπον τοῦτον, ἀφανίζεσθαι δὲ καὶ ποιεῖν νύκτα διὰ τὸ ὑψηλὴν εἶναι πρὸς ἄρκτον τὴν γῆν.[28]
>
> Many of the ancient meteorologists are convinced that the sun does not travel under the earth but around the earth and that (northern) region, and that it disappears and causes night because the earth is high towards the north.

In the above mentioned chapter of my *Heaven and Earth*, I argued that it is rather the other way around than Mansfeld and Runia suggest: not only Eusebius and Stobaeus, but also Diogenes Laërtius and Hippolytus copied what they had read in Aristotle, thinking that Aristotle's anonymous "many of the ancient meteorologists" should be applied to Anaximenes, and they altered Aëtius' words in conformity with what they had read there. That their wordings go back to Aristotle is most apparent in Hippolytus' version, for he also repeats the notion of the higher parts of the earth in the northern region, behind which the sun at night is hidden. Perhaps they had Theophrastus as a common source for this misguided interpretation of Aristotle's words.

4 Recent Interpretations of the Movement of the Celestial Bodies According to Anaximenes

Recently, several scholars, mainly referring to Hippolytus' text, have argued that Anaximenes, in contrast with Anaximander, said that the heavenly bodies circle *always above the earth*, parallel to the surface of his flat earth. Moreover, they combined this interpretation with Hippolytus' image of a felt cap. The combination of these ideas is illustrated for the sun in a picture in Graham's book, showing the firmament as a hemisphere that stands upon the rim of

28 Aristotle, *Meteorology* 354a28–32 = DK 13 A14 = LM 2016, D16 = Wöhrle 2012 As 4 = Graham 2010, Axs 18 = KRS 1983, 157.

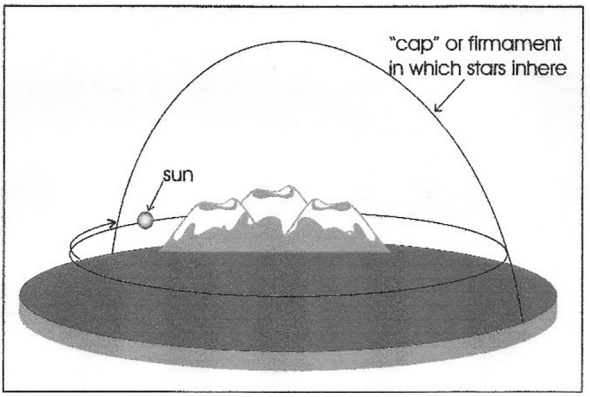


FIGURE 7.3
The heavens as a felt cap and the sun at night hiding behind the northern mountains, after Graham
DRAWING BY THE AUTHOR

the earth as a kind of cap (see Fig. 7.3). The picture also shows the mountains, behind which the sun is supposed to hide at night: the "higher parts of the earth", mentioned by Aristotle and Hippolytus.[29] Graham's picture is probably derived from a picture in Bowen and Todd.[30] However, that picture represents the situation of an observer on one of the poles on a spherical earth, when the sun is half a year above and half a year below the horizon. The circle around the central observer is the circle of his horizon, while in Graham's picture it is the rim of Anaximenes' flat earth. This is the source of the absurdities Graham's picture leads to. For the sake of clarity, I will repeat my main arguments of my refutation of the combination of the image of the felt cap and the idea that the heavenly bodies always circle above the earth.

Panchenko and Kočandrle also seem to accept this image as reflecting Anaximenes' ideas, understanding it essentially as expressed in Fig. 7.3.[31] Appealing to ancient Chinese cosmology, both authors suggest that the curvature of the heaven is just an optical illusion. It is, however, not easy to understand how these authors combine the two ideas that, on the one hand, the curvature of the heaven (and thus the setting sun) is an illusion, and that, on the other hand, the heaven is actually shaped like a cap.[32] Moreover, especially Panchenko makes

29 Graham 2013, 62–65. Drawing by the author, after Graham, Fig. 2.2.

30 Figure 9(a) in Bowen and Todd 2004, 177.

31 See Panchenko 2015, 416, quoting with consent KRS 1983, 157: "The cap-image must illustrate the hemispherical shape of the sky, not its obliquity." Kočandrle 2019, 116, writes: "The turning of a felt cap would then reflect the movement of the Heavens as a whole." See also Kočandrle 2021a, 255–256 and 2021b, 198–199.

32 See Panchenko 2015, 416: "It follows that the slant of Heaven in this system is illusory"; Kočandrle 2019, 109: "it (sc. the sun) seems to follow a semicircular path". Kočandrle (2019, 106) rightly remarks, that in the Chinese *gai tian* system "both heaven and earth are

a big point of the last words of Hippolytus' text ("[The sun is hidden] … and by being a greater distance away from us"), as though the setting sun would behave like those things we can no longer see because they are out of the reach of our range of visibility.[33] In my opinion it would be strange if Hippolytus would have said that according to Anaximenes the sun sets both because it appears behind a mountain and because it disappears out of sight just like all objects that are far away. These two options seem to mutually exclude. It has been suggested that this last clause might be a doxographical addition.[34] I think that the text can remain as it is and that Hippolytus, when he speaks of the great distance, wants to say that the mountains behind which the setting sun hides are as far away as possible on a flat earth and thus are situated at its periphery. If the sun disappears behind a nearby object, be it a house, a hill, or a mountain, it does not become night; only when the sun disappears behind mountains far away, night is falling. In other words, the Greek word "καί" at the end of Hippolytus' text is used as an *explicativum*: "namely", "and … at that".

As we saw, Mansfeld and Runia consider Aristotle's text as, although anonymously, containing the same doxa as that in Eusebius and Stobaeus on Anaximenes.[35] They also seem to consider Aristotle's text as the source of Aëtius' doxa on Anaximenes, since they quote it under the heading "Sources and Other Parallel texts."[36] Unfortunately, however, they concoct a strange mixture of the interpretation of Graham and the above explained archaic world-picture. They write: "the preposition περί cannot mean 'around' in the usual sense of the cosmic revolutions (…), but rather 'around' *more or less* in a plane parallel to the flat earth, *dipping* below the horizon but not going all the way below the earth."[37] What can be meant by a plane that is more or less parallel to the flat earth and that is also supposed to dip below the horizon is not clear to me. A plane is parallel or it is not, and a plane dipping below the horizon is certainly not parallel to the flat earth.

Since the sun is at different heights in the sky during the seasons, we may ask which sun is depicted in Graham's drawing. Given the supposed notion that the sun is always above the earth's surface, the intention probably is that the sun of Fig. 7.3, which is rather low above the horizon, is the winter sun.

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two fully separate, parallel planes", but he does not tell how this relates to the supposed cap-shaped heaven of Anaximenes. Similarly in Kočandrle 2021a, 257 and 2021b, 204.

33 See Panchenko 2015, 414.

34 KRS 1983, 156.

35 MR 2020, 944: "the same doxa is already anonymously reported in almost exactly the same formulation in Aristotle's *Meteorology*."

36 MR 2020, 948, referring to DK 13A14.

37 MR 2020, 943 (my italics).

Then we must add the sun in spring and autumn as well as the sun in summer, rotating somewhere higher in the sky. In this conception, the orbit of the winter sun is wider than that of the spring/autumn sun, which in its turn is wider than the orbit of the summer sun. This is also Panchenko's interpretation of the supposed movement of the sun during the seasons above the surface of the flat earth: "I propose that not only the track of the sun is alternatively expanding and contracting, but also that the sun goes half a year down and half a year up; from solstice to solstice, it describes a truncated cone."[38] This is visualized in Fig. 7.4.[39] Lest the mountains behind which the sun is supposed to hide would reach beyond the heavens, I had to stretch the 'cap' of the firmament making it look more like an ancient Greek πιλίον.[40]

This picture shows that, given a diameter of the earth's surface of about 5000 kilometers (which is the extent of the earth as known in Anaximenes' days), the inevitable consequence is that the mountains behind which the sun is supposed to hide at night would reach the absurd height of several thousands of *kilometers* instead of a normal height of, say, 4,000 *meters*. The source of this strange consequence is the attempt to make sense of Hippolytus' words, "the heavenly bodies move around the earth like a felt cap turns around our

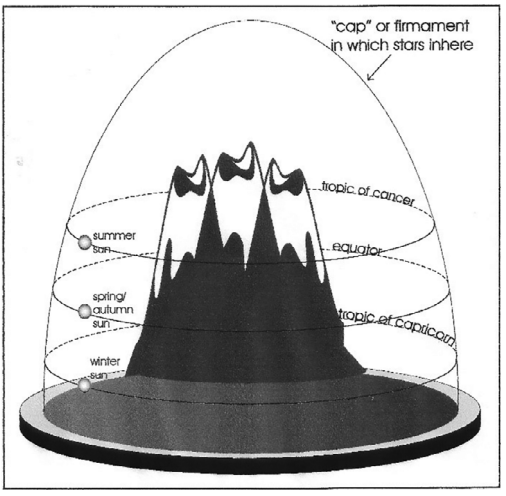


FIGURE 7.4
The sun during the seasons, supposedly circling above the flat earth
DRAWING BY THE AUTHOR

38 Panchenko 2015, 423.

39 In Couprie 2018, 103, Fig. 7.2, I followed Boll's suggestion of the heaven as a top hat (Boll 1914, 361, n.1). Now I think it does more right to the interpretation of Graham, Panchenko, and Kočandrle to keep the image of a curved πιλίον, as in the present Fig. 7.3.

40 For an image of the ancient Greek πῖλος, see *Wikipedia*, article "Pileus (hat)".

head". In this interpretation, the words περὶ γῆν ("around the earth"), not only in Hippolytus' text, but also in those of Eusebius, Stobaeus, and Diogenes Laërtius, are read as ὑπὲρ γῆν ("above the earth"). Kočandrle writes: "In reports on Anaximenes, we thus find explicit descriptions (…) of the movement of heavenly bodies *only above the earth*"; and Panchenko: "Ancient doxography emphasizes that Anaximenes made celestial bodies *rotate above the earth*".[41] These alleged 'reports with explicit descriptions' or 'emphasis in the doxography' simply do not exist.

There is no need for the absurdities this interpretation of Anaximenes' cosmology leads to. In an earlier investigation of the interpretive difficulties of the cap simile, I concluded that it must have been an invention on the part of Hippolytus in a failed attempt to elucidate Anaximenes' intentions.[42] After all, no other source mentions this image. Guthrie already wrote: "Hippolytus' taste for homely human similes cannot be said to be very helpful."[43] My suspicion is that Hippolytus was misguided by Anaximenes' use of the verb πιλέω ("make into felt", "compress") as a synonym of πυκνόω ("contract", "condense", DK 13B1). Hippolytus had read: πιλουμένου δὲ τοῦ ἀέρος "(as the air had compressed", DK 13A6), and then he fabricated his simile of the πιλίον ("felt hat") for the heavens.

Aristotle, on the other hand, after discussing why most rivers flow from north to south, only mentioned a cosmological afterthought about an archaic world-picture, in which the heavenly bodies take a daily bath in the Ocean, out of which they rise again.[44] As Panchenko already remarked, these mountains at the rim of the earth should not be in the northern region only, since in Greece the summer sun rises and sets in southern regions.[45] Aristotle certainly did not have in mind such ridiculously high mountains as in Fig. 7.4, but mountains of a normal size. The archaic world-picture that Aristotle was hinting at can, e.g., be found in Homer and in Hesiod and is illustrated in Fig. 7.5.

The simple explanation of the word περί in the texts of Eusebius, Stobaeus, Diogenes Laërtius, and Hippolytus, too, is that the heavenly bodies, when they have set, turn around (περί) the rim of the earth, or more precisely: around the

41 Kočandrle 2019, 109 (my italics); Panchenko 2015, 413: (my italics).

42 See Couprie 2018, 99–129.

43 Cf. KRS 1983, 157: "his context, which is concerned with showing that the greatest rivers flow from the greatest mountains, in the north, makes it quite clear that he understands 'the earth being high in the north' to refer to its northern mountain regions." See also Guthrie 1962, 138.

44 Cf., e.g., Guthrie 1962, 138.

45 Cf. Panchenko 2015, 420.

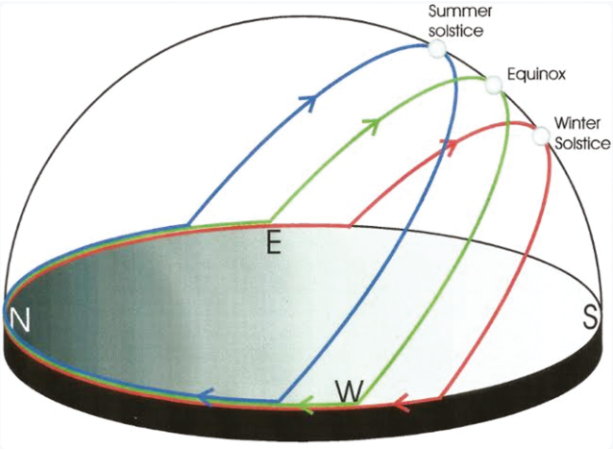


FIGURE 7.5
In the archaic Greek conception, the sun at night moves around the rim of the earth (περὶ γῆν)
DRAWING BY THE AUTHOR

periphery (περιφέρεια) of the circular surface of the flat earth. The preposition περί and the prefix περι- do not necessarily indicate a full circle (although for the most southern stars the course around the rim of the earth would be almost a full circle).

5 A Papyrus Text

Before we can properly address Theodoretus' text with which this essay started, we need to look at yet another text. Although it does not mention a name, a papyrus text from Epicurus should, according to Graham, quoting Perilli, express Anaximenes' idea of celestial bodies moving above the earth in circles parallel to the earth's flat surface. Since the interpretive problems of this text are of a different nature than those discussed above, I postponed its discussion in order to pay separate attention to it. The slightly different reading and a new translation I will propose now, I only discovered after I had mentioned this text already in *When the Earth Was Flat*. In that book, I still followed Arrighetti's reading of this text and Graham's translation (except for the word "and", which Graham puts before "for all those", but which is not in the Greek text).[46] I will first quote it here from Arrighetti and in Graham's translation:

46 Cf. Couprie 2018, 121.

τοίχους ἐν [κύκλ]ωι ποιήσαντες ἵ[να φρά]ξωσιν ἡμᾶς πρ[ὸς τ]ὴν δῖναν, ὡς ἔξωθεν αὐτῆς περιφερομέ[ν]ης, πᾶ[σ]ιν(?) [ὕ]π[ὲρ κε]φά[λ]ης τὰ ἄστρα περιάγου[σι]ν.[47]

They construct walls in a circle [around the earth] so that they may screen us against the vortex, as it whirls around outside the earth, for all those (?) who drive the heavenly bodies around in a circle overhead.[48]

This looks like a free paraphrase of Aristotle's above quoted text, with the significant difference that walls *all around the earth* protect us against the cosmic whirl instead of mountains in the north behind which the sun would hide at night. The intention of the verbs ποιεῖν (to make) and περιάγειν (to drive around) is obviously not that the ancients literally drove the heavenly bodies around, nor that they literally built walls against the celestial whirl (let alone that they built walls of several thousands of kilometers high), but that they – whoever they were – imagined a certain elevation of the rim of the earth, probably in the form of mountains of a normal height.[49]

At first sight, the final clause "for all those who drive the heavenly bodies around in a circle overhead", seems to confirm the interpretation of the heavenly bodies moving in circles parallel to the surface of the flat earth, as in the interpretations of Graham, Panchenko, and Kočandrle,[50] especially because of the combination of the preposition ὑπέρ and the prefix περι-. Let us therefore take a closer look at Epicurus' text. The meaning of the clause beginning with "for all those" is not clear. If we are supposed to think of people, who adhere to the idea, put forward by Graham and others, of celestial bodies moving in circles parallel to the earth's flat surface, it is not obvious why they would need walls *around* the earth to save us from the vortex, since the heavenly bodies

47 Epicurus, *On Nature*, in Arrighetti 1960, 233–234: 33, from Herculaneum Papyri 1042.8.vi. See Graham 2010, Axs20 and p. 92; Perilli 1992, 16–17.

48 Arrighetti (1960, 232) translates ποιήσαντες as "pensarono": "… che pensarono ai baluardi in cerchio affinchè ci protegessero dal vortice che gira intorno ad essa (la terra), per tutti questi che fanno girare gli astri sopra la testa….". This looks like a slip of the pen; he probably had still in mind that a few lines earlier a similar text (Arrighetti 1960, 228, 8.ii) has ἐπενόησαν instead of ποιήσαντες: οἳ μ[ὲν γὰρ οἰο]ν[ε]ὶ [τοί]χους το[ὺς κύκλ]ω[ι ἐπε]νόησαν ὑ[πάρχον[τας τῆ]ι γῆι [τοι]αύτης [δίνης] (for they believe that there exist walls, as it were, in a circle, (to protect) the earth against that vortex).

49 Cf. Perilli 1992, 16: "Epicuro polemizza, in sostanza, contro una concezione della terra τυμπανοειδής, circondata di monti (ὄρη), raffigurati quali mura (τοῖχοι)…." See also the previous note, in which it is shown that elsewhere [ἐπε]νόησαν is used instead of ποιήσαντες.

50 Of these three, only Graham refers to this text, although tucked away in a section on Anaxagoras; see Graham 2013, 127.

are supposed to be *above* the earth only. How can these walls at the rim of the flat earth protect them (or us) from the whirl above our heads? Moreover, Anaximenes would be a bit of a small number for "all those."

My suggestion is that the interpretive problems of Epicurus' text can be solved by another translation and a slightly different reading of the text.[51] Arrighetti, Perelli, and Graham read πᾶ[σ]ιν.....περίαγουσιν as a dative adjective (used substantively) with a dative present participle. I would suggest that we should read λ instead of σ in the distorted and illegible space between πα and ιν, so that we get πά[λ]ιν instead of πᾶ[σ]ιν.[52] That is why I put question marks behind πᾶ[σ]ιν and "all those". Accordingly, I would read περιάγουσιν as the third person plural of a verb in the present tense and take the same subject for the verbal forms ποιήσαντες (an aorist participle) and περιάγουσιν, so that the text reads and can be translated as follows:

> τοίχους ἐν[κύκλ]ῳ ποιήσαντες ἵ[να φρά]ξωσιν ἡμᾶς πρ[ὸς τ]ὴν δῖναν, ὡς ἔξωθεν αὐτῆς περιφερομέ[ν]ης, πά[λ]ιν [ὕ]π[ὲρ κε]φά[λ]ης τὰ ἄ[σ]τ[ρα] περιάγου[σι]ν.
>
> Having constructed walls in a circle [around the earth] so that they (sc. these walls) may protect us from the vortex when it goes around outside the earth, they drive the heavenly bodies around above our heads again.

The image that the restored text of Epicurus evokes is the same as the archaic idea discussed above and drawn in Fig. 7.5 of heavenly bodies that make a part of a circle in the heavens from their rising to their setting, and after they have set go around the earth from west via north to east, where they rise again. We may imagine that at the rim of the earth the celestial vortex is dangerously close by, so that some protection in the form of mountains (or walls, or an elevated rim) would not seem a superfluous idea. This is especially the case when the celestial bodies are imagined not to go under the earth, but to circle around the rim of the earth and thus might be feared to intrude the earth or in their vortical motion to drag along some of it and its inhabitants.

I think the reading of πά[λ]ιν ("again") instead of πᾶ[σ]ιν is confirmed by the words νῦν ("now") and πρότερον ("earlier") in another fragment from the same papyrus:

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51 In Couprie 2018, 121, I still accepted Arrighetti's reading πᾶσιν because I had not yet figured out that πάλιν makes more sense.

52 The word πάλιν has an acute where πᾶσιν has a circumflex, but the papyrus is written in capitals without diacritics.

> ποσὶν αὐτῷ φαινομένου κατωτέρῳ τ[οῦ]το οὐ νοήσει, δ νῦν ἀναβὰς ὑπὸ ποσὶν ἔλαβεν, πρότερον ὕπὲρ κεφάλης ἔχ[ο]ν [ἔ]δυ.[53]
>
> that which appeared to be below his feet, he cannot believe this, that what he now sees rising from below his feet (was the same as what) earlier, being above his head, has set.

I suppose that the single letter δ in Arrighetti's transcription stands for δὲ. It should be noted that this text is not polemical against the ancients who "built walls around the earth", but against those who, like Xenophanes, thought that every day a new sun arises. Epicurus here uses ὑπὲρ κεφαλῆς as an antithesis to ὑπὸ ποσὶν (see also elsewhere in the same papyrus).[54] Epicurus does not use the words ὑπὲρ κεφαλῆς to indicate that the heavenly bodies are *always* above our heads, but only when we see them.

Thus far I have discussed several texts about the movements of the celestial bodies, all of which are or have been related to Anaximenes. My conclusion is that they are all about the archaic world-picture, visualized in Fig. 7.5, but not about heavenly bodies always orbiting above the flat earth, as in the interpretation of recent authors. The above discussion was intended to pave the way for the rest of this essay, in which I will focus on the interpretation of Theodoretus' use of the image of the millstone in explaining the movements of the celestial bodies. Drawing on archeological research, I will explore what a millstone could have been in Anaximander's time, in order to understand what the image of a millstone, used for the movements of the heavenly bodies, might have meant.

6 Grain Milling in Ancient Greece

The raw cereal grains are not digestible to humans, but must be cooked or roasted, or crushed by means of a grinding device. Milling with horizontally lying millstones can be done in windmills, where the vertical rotation of the sails by means of gears is transferred to a horizontal rotation of the upper

53 Arrighetti 1960, 232, Pap. 1042, 8.v.

54 Arrighetti 1960, 230–231, Pap. 154, 8.iv: νο]μί[ζοιμ]εν, ἐν ταῖς μεταβάσε[σ]ιν, ὅμ[ο]ιον εἰπεῖν, ταῖ[ς ἐ]πὶ τὸ ἄν[ω, καὶ] δ᾽ ὑπ[ὲ]ρ κεφαλῆς ἀρτίως εἶχε το[ῦτ᾽ ἄ]ν ὑπὸ π[οσ]ὶν ἰσχάνοι[μ]εν κα[τὰ] τὴν μ[ε]τάβασιν φα[ί]νε[σθ]α[ι κάτ]ω , … (we would believe by analogy, as said, that the bodies that go up and above our head proceed in exactly the same way when they are under our feet). Arrighetti 1960, 232, Pap. 154, iii. 3 has only a few decipherable words: ὑπ[ὲ]ρ κεφ[αλῆς and ὑπὸ ποσ[ὶ]ν.

millstone (the so-called runner stone), or in watermills, when the rotation is transferred from a vertical waterwheel. These mills must also have the necessary equipment to lift the upper millstone a little above the lower one (the bedstone). The first reason is that otherwise its weight, which can amount to several hundreds of kilograms, would prevent the rotation of the upper millstone, or else, if it were possible at all to make it rotate, it would produce gravel. The second reason is that there should be just enough space between the two stones for the grain to be milled.[55] The suspension of the upper millstone is made by an iron support called 'rynd' (or 'rind'), which is usually four-armed or cross-shaped and eventually can be adjusted according to the speed of the wind or when the grinding surface becomes worn.[56] The runner stone is slightly concave and the bedstone slightly convex, which helps the centrifugal flow of the flour. The underside of the runner stone and the upper surface of the bedstone are divided into 'furrows' (for cutting and distribution of the grain and flour, and for ventilation) and 'land' (between the furrows).

The windmill was invented in the Middle Ages, while the use of a waterwheel not just for raising water to a higher level for irrigation or to supply water to a town, but as a power source for driving a millstone was a Roman invention in the second century BCE and described by Vitruvius (first century BCE), or perhaps it was invented in the ancient Near East, in the third century BCE.[57] It is mentioned in an ode by the poet Antipater of Thessalonica (first half of the first century BCE), in which he praised an overshot watermill as a relief for the hard work of milling with hand-mills:

> ἴσχετε χεῖρα μυλαῖον, ἀλετρίδες: εὕδετε μακρά,
> κἢν ὄρθρον προλέγῃ γῆρυς ἀλεκτρυόνων:
> Δηὼ γὰρ Νύμφαισι χερῶν ἐπετείλατο μόχθους:
> αἱ δὲ κατ᾽ ἀκροτάτην ἀλλόμεναι τροχιήν,
> ἄξονα δινεύουσιν ὁ δ᾽ ἀκτίνεσσιν ἑλικταῖς
> στρωφᾷ Νισυρίων κοῖλα βάρη μυλάκων.[58]
>
> Cease from grinding, you women who toil at the mill; sleep late, even if the crowing cocks announce the dawn. For Demeter has ordered the

55 This is still the case in modern mills; cf. Hockensmith 2009, 7: "the distance between the stones was carefully regulated to prevent them from touching but keep them running close enough together to grind."

56 Cf. Storck and Teague 1952, 82.

57 Cf. Watts 2002, 47; Moritz 1958, 131 and 220; Vitruvius, *De architectura* 10.5.2.

58 Antipater of Thessalonica, *Epigrams* 9.418 (http://www.attalus.org/poetry/antipater2.html; for the Greek text, press G). Nisyros is an island in the Aegean Sea.

> Nymphs to perform the work of your hands, and they, leaping down on the top of the wheel, turn its axle which, with its revolving spokes, turns the heavy concave Nisyrian millstones. We taste again the joys of the primitive life, learning to feast on the products of Demeter without labor.

As to the question of whether Anaximenes could have known such rather complicated mills with two horizontal stones, the upper of which rotates over the lower, immobile stone, the answer must undoubtedly be in the negative. Therefore, it is worthwhile to investigate what 'mills' and 'millstones' looked like in Anaximenes' time.

7 Non-rotary Grain Mills

We are used to understand the word 'milling' as referring to a rotary motion, but this is a special kind of what in a broader sense is called 'milling', or 'grinding', or 'crushing'. The Greek word μύλη originally meant no more than 'apparatus for crushing'.[59] The principle of all mills of whatever kind, and even of mortar and pestle, is that grain corns (or other substances) are crushed between two stones, the lower one of which is immobile and the upper one movable.[60] In Greek literature from before the first century AD, however, there is no verb for 'turning' a mill, such as στρέφειν, περιάγειν, περιφέρειν, περιελαύνειν.[61] The verb ἀλετρεύειν in Homer simply means 'to grind', and not 'to turn the mill'.[62] That the normal Greek grain mill was non-rotary is confirmed by the archaeological findings, as we will see. Grinding was and still is employed for several purposes, the most obvious of which is the preparation of food and especially grain. The oldest way of crushing the grain was by pounding it with a wooden pestle (ὕπερος) in a mortar-like tub (ὄλμος or ὅλμος);[63] see Fig. 7.6.[64]

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59 See Moritz 1958, 2.

60 Cf. Blümner 1875, 25; Blümner, however, still thought that all Greek mills were rotary.

61 Cf. Moritz 1958, 3 and Lindet 1899, 15. The verb περιδινεῖσθαι in text A dates from the fifth century A.D. and is primarily said of the sun (or the cosmos) and only secondarily of the millstone.

62 Cf. Lindet 1899, 14.

63 Cf. Hesiod, *Works and Days* 423; Herodotus, *Histories* 1.200. Later words used for mortar were θυεία (according to Liddell, Scott, and Jones 2011., also used in the sense of oil-press), ἴγδις or ἴγδη, and τρίβιον (in Cyprus); later words for pestle were δοῖδυξ and ἀλετρίβανος; see Villing and Pemberton 2010, 557–558.

64 Picture freely available on the internet: http://www.mlahanas.de/Greeks/images/WomenGrain.jpg.



FIGURE 7.6
Greek women pounding, 6th century BCE. Photography from the mid-20th century
PUBLIC DOMAIN

A more advanced, but also very old device was the so-called saddle-quern, on which the grain was not pounded but rubbed, and which has been used for millennia in Greece and the surrounding countries. It consisted of a lower slab and a smaller stone, the grain-rubber or rider that was rubbed back and forth on the slab's surface. Both mortars and saddle-querns have been excavated in great numbers, for example in Troy, and they were still in use in Anaximenes' time and much later. The word μύλη (mill) in Homer refers to a kind of saddle-quern, just like the word μυλήφατος ('crushed in a mill').[65] The addition "*turned* by women", after the translation "handmill" in the dictionary is certainly wrong for these simple devices.[66] Fig. 7.7a shows that there was a certain degree of overlap between the mortar-and-pestle and the saddle-quern.[67] Fig. 7.7b shows the more common type of saddle-quern with larger rubbing stones and sloping table-stones.[68]

A further development of the saddle-quern was the hopper-rubber, also called the 'Olynthus mill', after one of the sites in the southern Peloponnesus where it was found. Another site was, for example, Priene, near Miletus.[69] In

65 Homer, *Odyssey* vii, 104; xx, 106, 111; ii, 355. See the discussion of these texts in Moritz 1958, 4–6.

66 See Liddell, Scott, and Jones 2011, s.v. μύλη. In a separate publication, I intend to deliver an elaborate discussion of the ancient Greek words for mills and millstones.

67 Tell Balata, Palestine, 1550–500 BCE, Allard Pierson Museum voor Oudheden, Leiden. Photo by the author.

68 Sakkara, ca. 1350 BCE, Allard Pierson Museum voor Oudheden, Leiden. Photo by the author.

69 Cf. Moritz 1958, 43 n2, 50 n. 2.



FIGURE 7.7A
Saddle-quern with charned grain
PHOTO BY THE AUTHOR



FIGURE 7.7B
Egyptian statuettes (18th dynasty, about 1350 BCE) of two women grinding grain with saddle-querns
PHOTO BY THE AUTHOR

this device, the upper stone was no longer cylindrical but flat and rectangular and provided with a slit that served as a hopper from which the grain could be fed into the mill. It was probably invented in the sixth century BCE and spread throughout Greece.[70] An early specimen of this mill, still in use in Egypt in the first century AD, is shown in Fig. 7.8.[71] In contemporary papyri it was called a Theban mill.[72] It looks like a square saddle-quern with a hopper in the upper stone and two handles to push and pull it over the table-stone. On the photograph only the furrows on top of the table-stone are visible, but the underside of the upper stone with the hopper also had a pattern of furrows.[73]

The mills of Fig. 7.7a, 7.7b, and 7.8 were the simple mills that were used in households and the milling could be done by women because, although tiring, it did not require excessive strength. As soon as the need arose for larger amounts of flour for several households or whole villages, milling had to be done in bakeries with larger mills. For this purpose, the Greeks developed the big hopper-rubber of Fig. 7.9 and Fig. 7.10, where the upper stone was heavier

70 Cf. Moritz 1958, 42–52.

71 Photo kindly provided by the Kelsey Museum of Archaeology, University of Michigan. On the website of the museum it is said that it "follows an ancient Egyptian design". Pestman 1990, 123, using the same photo, identifies the Theban mill with the Olynythian mill, but the former is clearly a more primitive hopper-rubber than the latter.

72 See, e.g., *BGU* (*Berliner Griechische Urkunden*) I.251.17 and III. 719.10.

73 Cf. Frankel 2003, 9, Fig. 7 (patterns of striations on lower stones) and 10 Fig.8 (patterns of striations on upper stones). See also Moritz 1958, 46, Fig. 5 and 48, Fig. 6; Lepareux-Couturier 2014, 150, Fig. 1.

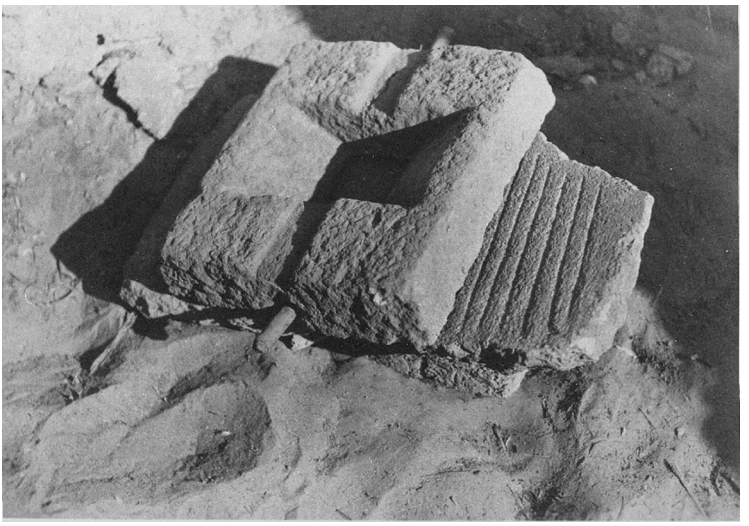


FIGURE 7.8 A simple hopper-rubber (Theban Mill), found in Karanis
PHOTO KINDLY PROVIDED BY THE KELSEY MUSEUM OF ARCHAEOLOGY, UNIVERSITY OF MICHIGAN

and fixed to a post on one side. Operating this kind of mills required much more strength, and thus the milling was done by manpower. Such a hopper-rubber is depicted two times on a Megarian bowl (third or second century BCE, see Fig. 7.9).[74] The figures in the frieze appear to perform a comic act of a group of intruders who break into a mill and disturb the millers at their work.[75] The people handling the mill are referred to as ΜΥΛΩΘΡΟΙ (millers) and their boss is called ΜΥΛΩΝΑΡΧΗΣ (master of the mill). The two mills are depicted (as is the sieve) at right angles.

In Fig. 7.10, a little boy tries (in vain) to operate a reconstruction of an Olynthian mill, pulling and pushing the hopper-rubber over a stone platform that is put on a table.[76] The beam he handles is attached to the top of upper stone and fixed to a vertical peg at the other end.

74 Drawing from: https://books.openedition.org/pufr/8575. Megarian bowl, Louvre CA 936. See also: Frankel 2003, Fig. 2; Moritz 1958, 13, Fig. 1; Storck and Teague 1952, Chapter. 7. The pictures of the bowl on the website of the Louvre are too vague to reproduce here, and for our purpose taken from the wrong side. The photos in Rostovtzeff 1937 are better, but he also has the same drawing.

75 Cf. Moritz 1958, 15–16. I intend to discuss more aspects of this bowl and its inscriptions elsewhere.

76 From Wefers and Mangartz 2014, 87, Fig. 4; reconstruction by Kuno Menchen, Römisch-Germanisches Zentralmuseum, photo by Fritz Mangarz. See also Frankel 2003, Fig. 5 and 6.

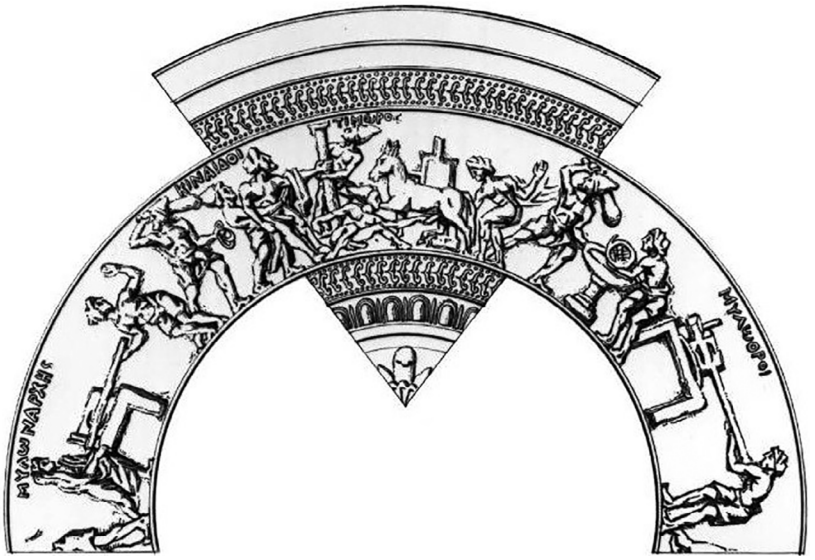


FIGURE 7.9 Two hopper-rubbers on a Megarian bowl, fourth century BCE
PUBLIC DOMAIN



FIGURE 7.10
A reconstruction of an Olynthian mill
PHOTO BY FRITZ MANGARTZ

The μύλη in one of Aristophanes' plays, where a person says he will "buy a good mill to crush my anger", should be understood either as a hopper-rubber or as a saddle-quern, and not as the lower stone of a mill, as the dictionary suggests.[77] Both the saddle-quern and the hopper-rubber are called "mill" (μυλή), which shows that milling does not necessary imply a rotary movement. The

77 Liddell, Scott, and Jones 2011, s.v. μυλή; Aristophanes, *Wasps* 648.

lower stone of the saddle-quern and the hopper-rubber was called τράπεζα.[78] The mortar and pestle, the saddle-quern, and the hopper-rubber were the mills or grinding devices used in Anaximenes' time and region. Of these primitive mills, neither the pestle, nor any part of the saddle-quern and the hopper-rubber seems suitable as an image of the movement of the sun (or the cosmos).

8 Rotary Grain Mills

We already saw that the watermill, in which the vertical rotation of the water-wheel was transferred to the horizontal rotation of the upper millstone, was a Roman invention. However, other kinds of rotary mills existed in the ancient Mediterranean world, of which we must investigate whether they were known in Anaximenes' time and region. The simplest *rotary* tool was the hand-mill with the upper stone turned by a handle. According to Moritz, the oldest rotary hand-mills were conical, (the lower stone was convex and the upper stone concave), to keep the stones concentric. In a later development, a rynd-and-spindle arrangement with two circular stones of about equal diameter proved to be more efficient (see Fig. 7.11).[79]



FIGURE 7.11
A rotary hand-quern still in use in northern Jordan
PHOTO BY DIA'A MAZARI GHARAIBEH

78 Cf. Moritz 1958, 45 n. 1; Foxhall 2007, 205. See also LSJ s.v. τράπεζα III.5.
79 Ebeling 2019, 83, Figure 2. Photo by Dia'a Mazari Gharaibeh.

After a thorough investigation of ancient rotary hand-mills, Moritz drew the conclusion that the origin of the rotary hand-mill is to find farther west and much later than is generally assumed.[80] The rotary hand-mill was used in the western Mediterranean territory and probably invented in Spain, but arrived in Greece only in the first century BCE.[81] Moritz' book still is the standard work on the history of grain-mills in antiquity, but recent authors tend to date the oldest rotary hand-mills further back Jaccottey, for instance, writes: "La meule rotative à main apparaîtrait vers le milieu du V^e^ siècle a.C. au nord-est de la péninsule Ibérique", which is still after Anaximenes' lifetime and far from his country.[82] Most important for the subject of this essay is, however, that recent authors agree that rotary hand-mills only much later spread eastwards and reached Greece centuries after Anaximenes' lifetime, at the end of the Hellenistic period (in the first century BCE). For example, from the 105 fragments of milling devices found in a recent excavation site at the Acropolis in Athens, only 6 were from rotary querns, dated as Late Hellenistic, Roman, Byzantine and Medieval; the others were from saddle-querns and hopper-rubbers, dated as Prehistoric, Late Helladic, Geometric, Mycenaean, Archaic, Classical, Hellenistic, Roman, and early Byzantine.[83] Frankel and Syon recently concluded: "The rotary hand-mill was brought to the east much later, probably by roman soldiers".[84] They offer a diagram of the diffusion of different types of mills over the Mediterranean territory, very similar to that of Alonso Martinez, who compares the ancient Iberian and Greek traditions of milling, and which is reproduced here as Fig. 7.12a.[85] The red line indicates the diffusion of the rotary quern from Spain ("Oeste") in the 5th century BCE via Italy ("Centro") to Greece (and the Levant; "Este") at the beginning of the Christian era. See the timeline on the left of the diagram. Greek testament texts on papyri from Ptolemaic Egypt, dating from the first century AD demonstrate that at that time hopper-rubbers still were preferred above or at least used next to rotary querns.

One of the reasons of the surprisingly long absence of rotary hand-mills in Greece could have been that "with the hand-mill the advantage of rotary over oscillatory motion is slight".[86] Or, as Moritz writes elsewhere, "a reasonably fine

80 Cf. Moritz 1958, 61.
81 Cf. Moritz 1958, 105. See also Runnels and Murray 1983, 62.
82 Jaccottey et al. 2013, 405.
83 See Poupaki 2014–15.
84 Frankel and Syon 2016, 93–94.
85 Alonso Martinez 2015, 31, Figura 3. See also Wefers 2012, 16, Abb. 2 (spread of rotary mills in Europe).
86 Moritz 1958, 114–115.

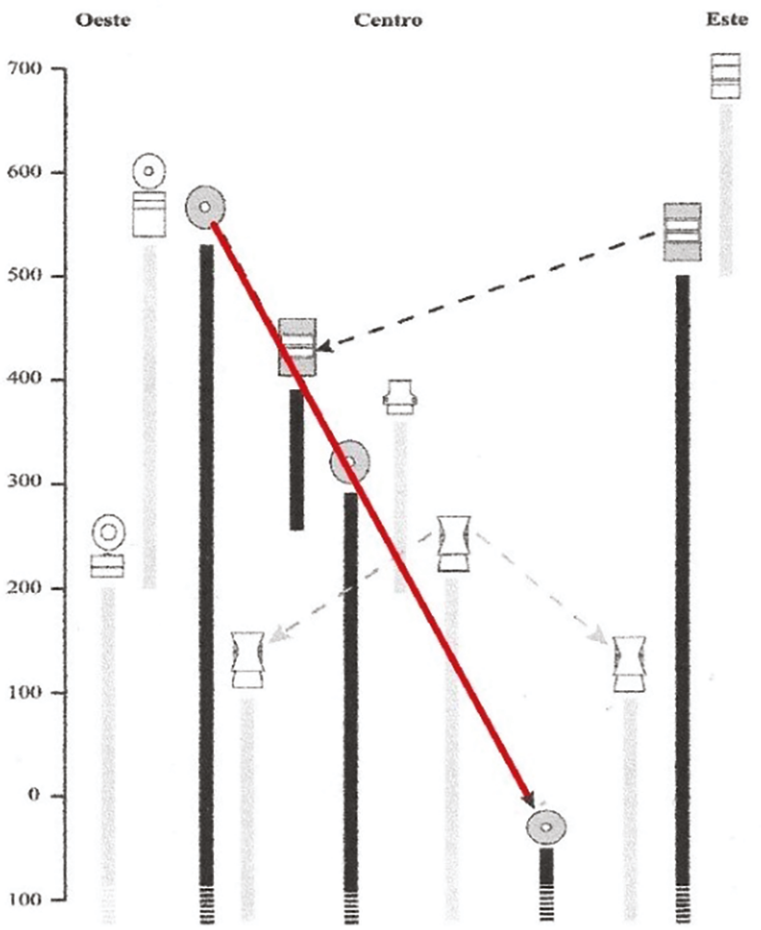


FIGURE 7.12A Development and diffusion of different types of mills over the Mediterranean territory, after Martinez 2015

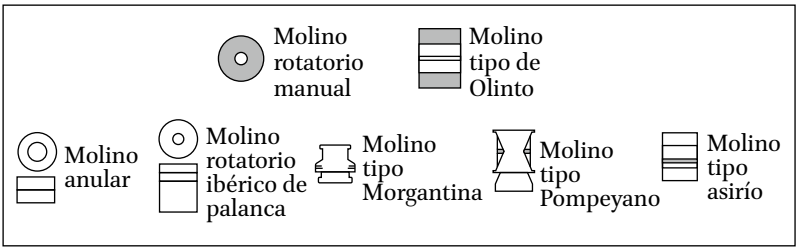


FIGURE 7.12B Legenda for Fig. 7.8a, after Martinez 2015

flour can be produced even by primitive milling methods, and an improvement of these methods does not necessarily mean that the flour is any finer, but that it is produced with less human effort".[87] I think we can be more precise about the reason why the Greeks stuck to the rubbing mills for such a long time. Saddle-querns and hopper-rubbers made it possible to produce a flour as fine as desired by rubbing it with upper stone as often as needed. In the rotary hand-mill, on the other hand, the upper stone, touching with its entire surface the bedstone, has to be lifted up a little by means of a rynd to make some space between them, because otherwise the upper stone could not be turned or would produce gravel. This means that the resulting flour was less fine than could be achieved with the saddle-quern or the hopper-rubber. In the western Mediterranean, people opted for less human effort, whereas the Greeks opted for finer flour. Only after a tool had been developed that enabled the millers to regulate the distance between the stones (as is still used in modern mills), it became possible to produce flour of any desired quality with rotary mills.

Two claims of earlier rotary hand-mills are questionable. Foxhall mentions the discovery of a rotary mill from the end of the sixth century in Carthago, reported by Morel.[88] Jaccottey, however, dates it at the end of the fourth century BCE and writes about this claim: "Interprétés comme des parties de meules rotatives, ces fragments sont difficiles à caractériser à cause de leur petite taille."[89] The picture of Morel's found (Fig. 7.13) shows, how justified such reservation is. Moreover, Morel does not deny the fact that is crucial for our



FIGURE 7.13
Fragment of a rotary hand-mill (?)
PHOTO BY J-.P. MOREL

87 Moritz 1958, xxv–xxvi.
88 Foxhall 2013, 171; Morel 2001, 240–251.
89 Jaccottey 2013, 407.

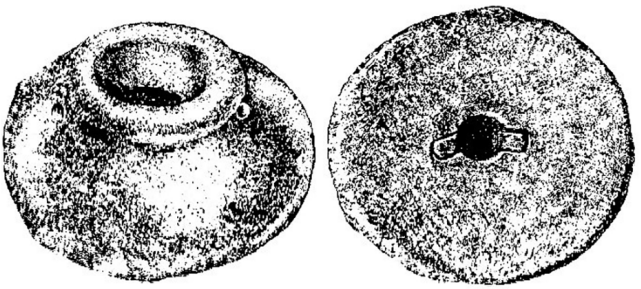


FIGURE 7.14 Drawing of the upper and lower side of the upper part of a rotary hand-quern found near Lake Van (dating questionable)
PUBLIC DOMAIN

enquiry, namely that in the Greek world the rotary hand-mill only appeared at the end of the Hellenistic period.[90]

Storck and Teague mention the find of "the upper quern stone of a manually rotated circular stone, dating from about the eight century BCE, complete with not only hopper but rynd" from Urartu at the Lake Van region in the far eastern part of present-day Turkey, described by Tseretheli (see Fig. 7.14).[91] I was unable to consult Tseretheli's publication, but his early dating seems very questionable.

If this really concerns a rotary hand-mill from the Urartu period (860 to 585 BCE), "it appears to stand entirely outside the line of western milling development" as Storck and Teague remark.[92] The find must have been misdated by Tseretheli, who was not an archaeologist but a philologist. His publication was not considered worth mentioning in a recent review of the archeology of Urartu.[93] From the western Mediterranean world, the rotary hand-mill was introduced in the Levant during the Roman occupation of Palestine.

90 Morel 2001, 241. Photo from Morel 2001, 242, Fig. 1.

91 Storck and Teague 1952, 77 and Figure 39; Tseretheli 1939, Plate 32.

92 Storck and Teague 1952, 77.

93 Cf. Bobadilla 2014. Barnett and Watson (1952, 136, 139, and 142) mention several "stone rubbers", "stone querns" and "querns" from Urartu, found in excavations of a citadel in Karmir-Blur (near Yerevan, the present capital of Armenia), without further descriptions and without pictures. In these cases, we probably have to do with saddle-querns, not with rotary hand-mills. Piotrovski (1969, Plate 25, caption on p. 210) has one picture of a "basalt quern" from the same excavation, apparently showing the best-preserved item, without further description. The photo is too bad to reproduce but shows a round bedstone with what seems to be the roller or upper stone of a saddle-quern.



FIGURE 7.15A
Two 'hour-glass' mills found in Pompei
PHOTO COURTESY OF RICK BAUER

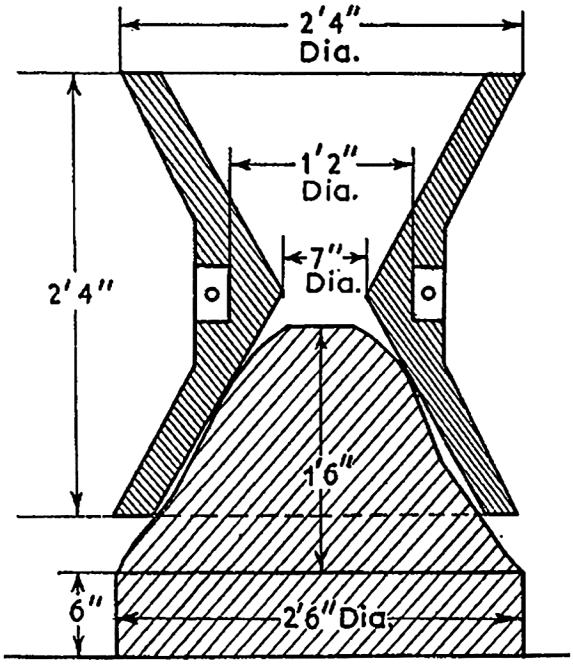


FIGURE 7.15B
Cross-section of an 'hour-glass' mill
PUBLIC DOMAIN

The earliest published example of a rotary quern in the region is from the first century AD in Masada, Israel.[94]

Another Roman invention was the rotary mill called 'hour-glass' mill after its shape, several of which were found in a bakery in Pompei, which were driven by manpower or by donkeys (see Fig. 7.15a and 7.15b).[95] Earlier types go

94 Ebeling 2019, 81.

95 Photo of Fig. 14a, courtesy of Rick Bauer, from Dr George Fay's slides collection. https://www.pompeiiinpictures.com/pompeiiinpictures/R6/6%2006%2017.htm; VI.6.17 Pompeii.

back to 185 BCE.[96] The rotating part was called *catillus*, the conical bedstone was called *meta*. This type of mill was replaced in the fourth and fifth century AD by the watermill with millstones, because the flow of water could produce much more power than a donkey.[97]

We may conclude that, in all probability, such things as rotary mills with a horizontally turning millstone did not exist in Anaximenes' time and environment. Still, the problem remains what could be meant in Theodoretus' text, quoted at the beginning of this essay, by saying that the cosmos whirls around like a millstone.

9 Millstones in Ancient Greek Olive Crushing

So far, we have only dealt with grain-mills. An authority on grain-mills in classical antiquity, however, tells us that "the rotary olive-grinder may well be older than the rotary grain-mill."[98] And an authority on olive cultivation in ancient Greece, discussing the Roman rotary olive crusher called *trapetum* (on which more below, see Fig. 7.19), writes: "it is possible that rotary mills per se are much earlier than has previously been thought."[99] Let us therefore look at the production of olive oil and see what these rotary mills could have done for olive crushing.

In ancient Greece, olives were harvested every two years. The olives could not (and still cannot) be pressed into oil immediately; they had to be crushed first, producing a kind of pulp. In ancient times, this initial crushing was done with mortar and pestle.[100] Another, more developed olive-crusher was the roller-and-bed type, which looks like a saddle-quern, of which it was obviously a derivative. This crushing device had a much bigger cylindrical roller that was moved back and forth over the olives on the lower grinding stone, called τράπεζα.[101] It is important to note that in this device the cylindrical roller does not rotate while lying on its flat surface, as we are used to from a millstone in a mill, but is rolled back and forth on its side. This method was still in use in Palestine at

August 1976. Looking through doorway to bakery in north wall of entrance room. Fig. 14b from Moritz 1958, 75, Fig. 8.

96 See Moritz 1958, 74.

97 Cf. Blümner 1875, 48.

98 Moritz 1958, 104.

99 Foxhall 2007, 166.

100 Cf. Foxhall 2007, 179.

101 Cf. Foxhall 2007, 205.

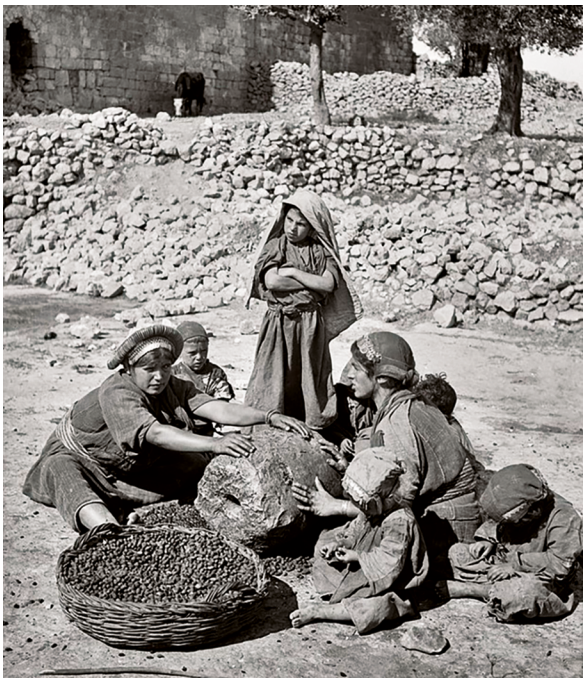


FIGURE 7.16
Palestinian women crushing olives with a roller-crusher
PUBLIC DOMAIN

the beginning of the twentieth century (see Fig. 7.16).[102] A well-preserved olive press facility, also including what seems to be a roller-crusher has been excavated in Azoria in eastern Crete in the Greek Aegean, dating from the Archaic period.[103]

In a further development, the arduous labor of rolling back and forth a cylindrical stone was replaced by the circular motion of a vertically placed disk-like millstone that was made to roll both over and around the platform of a circular basin. This mill was driven by manpower or by a donkey. The mechanism was quite simple: the millstone had a hole in the center, through which a horizontal handle was inserted that was connected to a vertical axle on the center of the platform (see Fig. 7.17a[104] and 7.17b).[105] The roller was either cylindrical or somewhat tapered like a truncated cone. When found alone and outside a

102 Photograph freely available on the internet: Palestinian women crushing olives – Google zoeken. See also: Frankel, Avitsur and Ayalon 1994, 30, Fig.19, and Foxhall 2007, 189, Fig. 6.27.

103 Ca. 700–500 BCE. See Haggis 2006, 4. D300.

104 Source: https://www.oliveoil.com/history-of-olive-oil/.

105 Source: Piazzasalento, https://www.piazzasalento.it/importare-via-obbligata-per-andare-avanti-73932.



FIGURE 7.17A
Manually operated olive crusher
PHOTO FROM HTTPS://WWW.OLIVEOIL.COM/HISTORY-OF-OLIVE-OIL



FIGURE 7.17B
Horse-driven olive crusher
PHOTO FROM PIAZZASALENTO, HTTPS://WWW.PIAZZASALENTO.IT/IMPORTARE-VIA-OBBLIGATA-PER-ANDARE-AVANTI-73932

mill, it can easily be distinguished from a bedstone or runner stone of a horizontally rotating mill, because a roller stone has no furrows and no traces of a rynd. The oldest devices appear to have had only one single millstone.[106] Lynch and Rowland date this invention at about 600 to 500 BCE, which was during Anaximenes' lifetime.[107] Later olive mills have two opposite stones, or sometimes three, placed in a circle.

The photos of mills on Fig. 7.17a and 17b show two of still functioning olive-mills of this type. The mill in Fig. 7.17a has a rather small crushing cylinder and can be driven by hand force. The mill in Fig. 7.17b is bigger and is driven by a horse; in ancient times this would have been a donkey. It is important to note that these vertical millstones have two motions: one around its own axis and another rolling in a circle on top of the platform. A vertically rolling millstone has only a relatively slight contact with the platform on which it rolls and

106 Cf. Foxhall 2007, 171.
107 Lynch and Rowland 2003, 9 and 33 ("2500 BCE" on p. 3 is obviously a misprint).

is therefore much easier to make it turn than a millstone that is horizontally placed with its flat surface on the flat surface of a bedstone. This explains why vertically rolling millstones were developed and used much earlier than horizontally rotating millstones. The construction with the stick through the hole in the center of the millstone and attached to the vertical spindle is not only a means to make the stone roll, but also prevents it from toppling over. Note also the disk-like elevation in the center of the platform in Fig. 7.17a.

Most interesting is the recent excavation in 1992–2004 and the reconstruction in 2004–2005 of an archaic olive oil plant, in Klazomenai, about 100 kilometers north of Miletus, where Anaximenes lived. Its first phase dates from 600/580–546 BCE, which was during (or even before) Anaximenes' lifetime (see Fig. 7.18a,[108] 7.18b,[109] and 7.18c[110]). The big basin in Fig. 7.18b is colored half blue and half orange, which means that it was in use both in the first and in the second phase.

The combination of the roller stone with the central piercing and the big basin in which it lies, both visible on the photograph of the excavation site looks like the remnants of two essential parts of a roller mill. However, the reconstruction of the crushing mill on the right side leaves open several questions.[111] For example, the rather complicated construction of a platform on which the operator of the mills stands, which is obviously done because the basin of the mill is so close to the wall. Although the reconstruction is said to represent the first phase, the excavators remark that "in the first phase the olives might have been crushed on the bedrock with the aid of a cylinder".[112] If their reconstruction is right, the mechanism must have been already a further development from the simple roller-crusher described above.

This equipment evolved into a mill with two opposite stones and much later into what Cato described as the *trapetum*,[113] a rotary mill with two hemispherical stones in a large stone basin (Fig. 7.19).[114] The earliest evidence for mills that

108 Koparal 2010, 327, fig. 2. Photo courtesy of E. Koparal.

109 http://www.klazomeniaka.com/300-ZEYTINYAGI-ISLIGI-2.htm, Resim 3; see also: Koparal 2010, 328, fig. 3a. Drawing courtesy E. Koparal.

110 Koparal 2010, 328, fig. 3b; courtesy of E. Koparal. The man hanging on the lever of the oil press is a pastiche of a picture on an Attic *skyphos* (sixth century BV), Boston Museum of Fine Arts (nr. 99.525); cf. Foxhall 2007, 135, Fig. 6.2.

111 See the critical notes in Foxhall 2007, 140–143, and Frankel 2020, 556.

112 Koparal 2010, 323.

113 Cato, *De Agri Cultura* 20.2.

114 Photo History St Ursula's College Kingsgrove, History Classes, 12 Ancient History, Pompeii 1A. https://sites.google.com/a/syd.catholic.edu.au/boudica/12-ancient-history/12-ah-vesuvius/pompeii-1a.



FIGURE 7.18A
The excavation site of the olive oil plant in Klazomenai
COURTESY OF E. KOPARAL

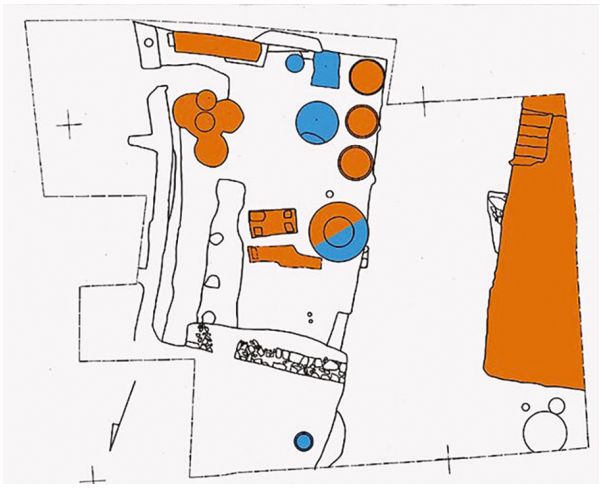


FIGURE 7.18B
The first (blue) and the second (orange) phases of the olive oil plant in Klazomenai
COURTESY OF E. KOPARAL

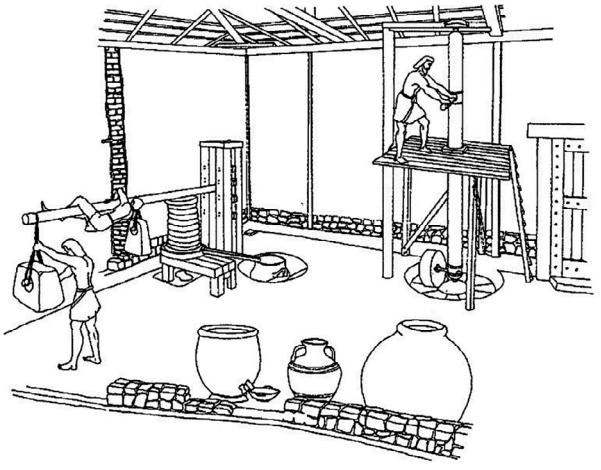


FIGURE 7.18C
Reconstruction of the first phase with a hand-driven rotary mill
COURTESY OF E. KOPARAL



FIGURE 7.19 A *trapetum* in the Antiquarium at Boscoreale, Pompei
PUBLIC DOMAIN

looked like the *trapetum* has been found in Olynthus and can be dated fifth to the fourth century BCE.[115] The construction as a whole and especially the hemispherical stones are indications of a high degree of craftsmanship. This implies that previously more primitive roller mills, as shown above, must have been in use.

For our purposes in this essay, the simple mill with one rolling stone (as in Fig. 7.17a and Fig. 7.17b) is the most appealing. Even apart from the excavation in Klazomenae, there are several reasons why it could have existed already in Anaximenes' times. The crushing of olives was a necessary operation before the resulting pulp could be pressed to produce the oil. Crushing the olives with a cylindrical roller (as in Fig. 7.16), moved back and forth by hand, was a strenuous job to do. To develop the rather simple device of the millstone rolling in a circle and attached to a pole in the base stone was not beyond the technological capacities of the time. It would have made the crushing of the olives much easier and could also have resulted in a better product.

It has been remarked that there are several reasons, why this kind of equipment is so hard to find or to identify in excavations.[116] First, while primitive mills for grinding grain like the saddle-quern were available in every ancient household and used on a daily basis by the housewife or a slave, oil pressing

115 Cf. Foxhall 2007, 169; Moritz 1958, 57.
116 Cf. Foxhall 2007, 131–132.

installations were scarcer, used only every second year after the harvest and situated close to the olive gardens outside the usual excavation sites, which are villages or cities. Second, primitive olive crushers had wooden parts, which have been worn in the course of time. Third, the remaining stones, the roller and the basin, could later have been removed from their original places and used for other purposes.

Both Aristotle and Diogenes Laërtius tell the story that Thales purchased all ἐλαιουργεῖα in the vicinity of Miletus.[117] The Greek word is usually translated as 'olive-presses', but these facilities must certainly have included the necessary equipment to crush the olives before they could have been pressed. A better translation would be 'workshop for processing olives into oil'. Since this equipment was relatively scarce, as said above, Thales would probably not have had to buy more than five to ten of them.

Anyway, there is ample reason to believe that, if such a thing as a 'millstone' that could be used as an image for the movement of the cosmos existed at all in Anaximenes' time and environment, it must have been the vertical roller of a primitive olive-crushing mill. If you seriously want to attribute the word μυλοειδῶς in Theodoretus' text to Anaximenes himself, he can only have meant such a vertical millstone. The above-described twofold movement (around its own axis and rolling in a circle over the platform) of the vertical millstone used for crushing olives is a reasonably fair image of an archaic conception of the movement of the heavenly bodies (compare Fig. 7.5 with Fig. 7.20). When we imagine, for example, a red dot representing the sun at noon on top of the side of the rolling cylindrical millstone, we will see it go lower and lower, being all day above the earth (ὑπὲρ γῆν), until it disappears at sunset behind the elevated disk-like part in the center of the basin, which may represent the earth (see Fig. 7.20). After that, the point representing the sun moves around the rim of the central disk representing the earth (περὶ γῆν), until it appears again at sunrise above the earth's surface and goes up towards its former position on top, never coming under the earth (οὐχ ὑπὸ τὴν γῆν).

The image of the sun moving like a millstone will function most effectively on two conditions: 1) when the circumference of the millstone is as large as the circle it describes rolling over the platform, so that the sun (the red dot on the millstone) always culminates at the same point (the south); 2) when the elevated disk-like part in the center of the basin, representing the earth, is not

117 See Aristotle, *Politica* 1259a6 = DK 11A10 = LM 2016 THALES P15 = Graham 2010, Ths 8 = Wöhlre 2009 Th 28 = KRS 1983, 73; Diogenes Laërtius. *Lives of Eminent Philosophers* 1.26 = DK 11A1(26) = Wöhrle 2009, Th 237(26); not in LM 2016, Graham 2010, and KRS 1983.



FIGURE 7.20 The sun symbolized by a red dot on a vertically rolling millstone, after Martinez 2015

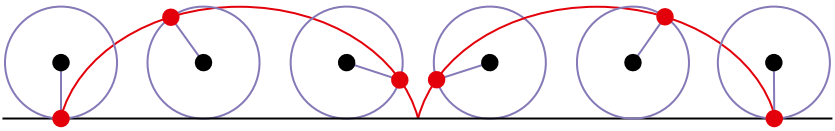


FIGURE 7.21 A cycloid. Drawing after Cycloid – from Wolfram MathWorld [https://mathworld.wolfram.com/Cycloid.html]

too low, so that the red dot actually "takes a bath" in the basin, in which the millstone is rolling around.

As with all similes, there are also elements that are not accurate. For example, the figure described by the red dot when the millstone is rolling, is a cycloid (or more precisely in the case of a millstone rolling in a circle: a cycloid projected on an imaginary cylinder). The cycloid is also referred to as "the Helen of geometry". In Fig. 7.21, it is shown how a point on the rim of a rolling circle generates a cycloid. Of course, Anaximenes did not know that this figure was a cycloid.

The point of comparison is, though, that the sun at night turns behind the rim of the earth in a similar way as the point on the millstone turns behind the central disk on the platform. This is as far as the image of a millstone can get in representing an archaic conception of the movements of the heavenly bodies.

10 A New Interpretation of Theodoretus' Text

The result of the foregoing investigation into the archeological evidence is that *if* the simile of the millstone as an image of an archaic conception of the movements of the heavenly bodies goes back to Anaximenes himself, it can only have been in reference to the vertical millstone of an olive mill. It is tempting to stop here and conclude that Theodoretus' simile of the millstone should be understood as the vertically rolling millstone of an olive oil mill and that Diels was right when he stated that this simile relates to the cosmology of Anaximenes. This would imply that Theodoretus, just like Stobaeus, Diogenes Laërtius, and Hippolytus, understood the cosmology of Anaximenes as a return to an archaic world-picture, in which the heavenly bodies, once risen, circle from east to west above the surface of the flat earth and, when set, take a bath in the Ocean and move around the rim of the earth from west to east, behind mountains. Yet, there are reasons why I do not draw that conclusion. Although the rotation of the vertical millstone of an olive-mill can offer a reasonably fair representation of an archaic conception of the movement of the heavenly bodies, as shown above, the crucial question is whether Theodoretus used it that way. Theodoretus lived in the first half of the fourth century AD, when mills with a horizontally rotating millstone had become more common. Another interpretation of the above text would come about when considering how the words μύλος ("millstone") and μυλοειδής ("like a millstone") are used in three other texts, dating from the Christian era, in which the likeness of a millstone is associated with the movement of the heavenly bodies.

Cleomedes' birth and death dates are unknown and a matter of discussion among scholars. Bowen and Todd contend that his book "may belong chronologically to some time around AD 200".[118] Referring to Posidonius, Cleomedes uses the image of a millstone (μύλος) to explain the movements of the heavenly bodies as seen by someone on one of the poles of the spherical earth:

> κύκλον οὖν περιγράφουσαι παρ᾽ αὐτοῖς αἱ σκιαὶ περίσκιους αὐτοὺς ποιοῦσι, παραπλασίως τοῖς μύλοις ἐν τοῖς ὑπὸ τοὺς πόλους κλίμασι στρεφομένου τοῦ κόσμου.[119]

118 Bowen and Todd 2004, xi.

119 Cleomedes, *Caelestia* 1.4.136–139. See Todd 1990, 23. Bowen and Todd 2004, 58. This text is also mentioned in the discussion of Theodoretus' text in MR 2009, 334.

> Shadows there accordingly describe a circle, and make people "encircled with shadows", since in the regions below the poles the cosmos revolve like a millstone.

Cleomedes is describing how shadows behave at different latitudes (κλίματα) of the spherical earth. Since in the polar zones the sun half of the year is above the horizon, making each day a full circle around an observer, one would see his shadow turning all around him (περίσκιος) there. Strictly speaking only at the poles themselves, where an observer's horizon is the celestial equator, is the cosmos seen "rotating like a millstone".

Even more instructive is a text in the *Treatise on the Astrolabe* by Joannes Philoponus (*c.*490–*c.*570 AD), in which he compares certain crown-like (parts of) circles on the astrolabe with the parallel circles of latitude on the celestial sphere (see Fig. 7.22a[120] and 7.22b):

> ὥστε τέμνεσθαι ὑπ᾽ αὐτῶν τὸ ὑπὲρ γῆν ἡμισφαίριον στεφανοειδῶς, οἵαν ἔχουσι θέσιν οἱ παράλληλοι κύκλοι ἐν τῇ μυλοειδεῖ τοῦ παντὸς θέσει.[121]

> so that the hemisphere above the earth is cut by them after the fashion of a crown, in a placing similar to that occupied by the parallel circles in the millstone-like arrangement of the whole.

In Fig. 7.22a, the lines of the "crown" are drawn for an observer at 30 °22′ N. The horizontal diameter indicates his horizon, the vertical diameter his meridian. The stars and configurations stay on the lines of the "crown" during their daily rotation. This is not the place to elaborate on the astrolabe and its functioning. In the context of this essay, the image of the millstone is the only thing relevant. "The whole" (τὸ πᾶν) in the above text apparently refers to the celestial sphere. In Fig. 7.22b, the lines indicate parallels of latitude on the celestial sphere. During the rotation of the celestial sphere, the stars and constellations always remain at the same circle of latitude. On the celestial sphere, millstone-like parts are cut off by the parallel circles of latitude, of which in Fig. 7.22b only those on the northern hemisphere are drawn. These circles of latitude are, as

120 Drawing from Drecker 1928, 7, Abb.2. See also Jarry 2015, XLIII.

121 See Jarry 2015, 6, line 13–14 (section 2). I am obliged to Jaap Mansfeld, who brought this text to my attention. It is also mentioned in MR 2009, 334. I take the commentary "these texts suggest that the image of the millstone properly refers to the heaven rather than the cosmos" to mean that the words "cosmos", "hemisphere" and "the whole" in the texts of Cleomedes and Philoponus are shorthand for "the celestial bodies", just as I suggested at the beginning of this essay about the word "cosmos" in Theodoretus' text.

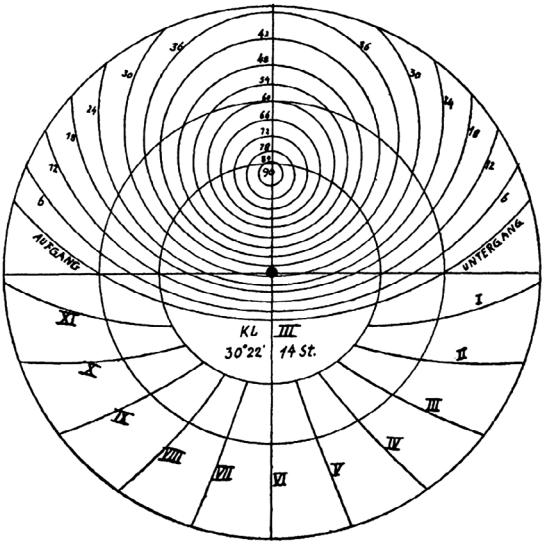


FIGURE 7.22A
Crown-like circles of latitude in a stereographic projection on an astrolabe for an observer at a latitude of 30 degrees north
PUBLIC DOMAIN

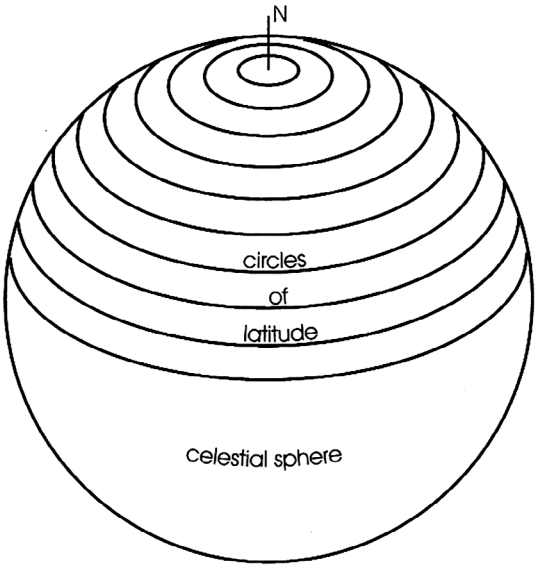


FIGURE 7.22B
Circles of latitude cutting off millstone-like parts of northern half of the celestial sphere
DRAWING BY THE AUTHOR

it were, the translation of the "crown" on the astrolabe. Philoponus obviously has in mind *horizontally* rotating millstones, which implies that the meaning of the word μυλοειδής had evolved from indicating the shape of a stone suitable not only for rubbing back and forth as with the saddle quern but also for throwing as in Homer, into the shape and motion we still associate with a horizontally turning millstone.

The same image is also used in a Scholium on a text of Autolycus of Pitane (*c.*360–*c.*290 BCE), in which the rotation of the celestial sphere around its north-south axis is described:

> Ὅ ἐστν ἐπὶ τῆς μυλοειδοῦς κινήσεως·[122]
>
> This is about the millstone-like motion.

This is a Scholium of unknown date in the Christian era, preserved in a manuscript from the 14th century.[123] According to Drecker, the quotation is from Autolycus himself, but it is not included in Aujac's edition.[124]

These three texts demonstrate that in later times it had become customary to compare the movement of the heavens to a horizontally turning millstone. The millstones in these three texts could have been those which Vitruvius had already described, using water as their driving force, or the rotating upper stones of rotary hand mills. It is a fair guess that Theodoretus, too, had in mind such a horizontally turning millstone. In that case, Theodoretus probably used it as a conventional image of the contemporary, Ptolemaic, cosmology of a *spherical* earth in the center of a spherical cosmos. This would also provide an answer to the question, who Theodoretus could have meant with "some" (οἱ μὲν), namely not Anaximenes, as Diels suggested, but the astronomers of his time, who worked within the context of a Ptolemaic cosmology. After all, I think the most plausible interpretation is that with his simile of the millstone, Theodoretus meant a horizontally turning millstone, not referring to allegedly horizontally above the earth's surface rotating heavenly bodies (as in Fig. 7.1), nor to an archaic world-picture (as in Fig. 7.5), but to the movements of the heavenly bodies as described in contemporary spherical earth cosmologies (as in Fig. 7.22b).

One question remains, namely: who are the people Theodoretus had in mind by "others" (οἱ δὲ), who had the celestial bodies move like a wheel (τρόχος)? As we saw above, by "some" (οἱ μὲν), he was referring to contemporary astronomers who held the opinion that the earth is spherical and at the center of a spherical cosmos. It lies at hand, then, to suppose that by "others" (οἱ δὲ) and with the image of the wheel he meant those who thought that the earth was flat and yet had the heavenly bodies make full circles, above the earth when

122 Hultsch 1885, 12, note at ιγ.

123 See Hultsch 1885, LV, *Adnotatio in Scholia*, referring to footnote on 12, lines 23–25; see also XXIII for the date of the manuscript, and 214 s.v. μυλοειδὴς κίνησις sphaerae.

124 Drecker 1928, 23, n. 9; Aujac 2002, 48–49.

they had risen, under the earth when they had set. On a flat earth, these circles necessarily must lie aslant the flat earth's surface, according to the latitude of Greece. Theodoretus must have thought in the first place of Anaximander, who had used the image of wheels lying aslant the earth's flat surface.[125]

Using the plural (οἱ δὲ), Theodoretus apparently thought, and rightly so, that the image of the wheel did not only fit Anaximander's cosmology, but was apt to illustrate the movements of the heavenly bodies in any flat earth cosmology. In other words, the image of the wheel lying aslant applies also to other ancient cosmologists who believed that the earth was flat and yet believed that the heavenly bodies make full circles around the flat earth, above its surface when they had risen and under the earth when they had set (see Fig. 7.2). Anaximenes was one of these flat earth cosmologists, and I believe that Theodoretus counted him among the "others". So, it was not the image of the millstone that Theodoretus connected with Anaximenes, as Diels supposed, but the image of the wheel. My interpretation fits well with Pseudo-Plutarch's above-discussed version of Aëtius, according to which Anaximenes had the same ideas about the movements of the heavenly bodies as Anaximander. Theodoretus had direct access to Aëtius as his source of the opinions of the ancient Greek philosophers.[126] I suppose he had before his eyes Ps.-Plutarch's version of the doxa on the movements of the heavenly bodies.

11 Conclusions

The aim of this essay was to investigate whether Diels' attribution to Anaximenes of the image of the millstone for the movement of the celestial bodies in Theodoretus' text was right. It became an exercise in excluding an interpretation of a text on ancient Greek cosmology with the help of relevant archeological data. A survey of the archeological evidence showed that rotary mills with a horizontally rotating millstone did not yet exist in Anaximenes' time and place. This means that Theodoretus' text cannot be invoked as supporting the idea that the celestial bodies always orbit above the surface of the flat earth, as in the interpretation of Anaximenes' cosmology by some recent scholars. Only a vertically placed millstone rolling around on its base as in an oil mill appears

125 Aëtius, *Placita* 2.20.1 = DK 12A18 = LM ANAXIMAND. D20 = MR 2020, 2.20.1 = Graham 2010, Axr 22 = Wöhrle 2012, Ar 148; Aëtius, *Placita* 2.25.1 = DK 12A22 = LM ANAXIMAND. D26 = Gr Axr 25 = MR 2020, 2.25.1.

126 See MR 1997, 328, Figure 2: "the tradition of the Aëtian Placita". See also 284: "He certainly has direct access to the original work".

to provide a reasonably fair image of the movement of the celestial bodies, and especially of the sun, in which they, after having set, were supposed to travel around the rim of the earth (see Fig. 7.5). This would be consistent with texts of Aëtius and others, provided they are interpreted according to a text in Aristotle that was shown to refer to an archaic world-picture.

However, a closer look at Theodoretus' text compared with other texts dating from after the introduction into Greece of mills with a horizontally rotating millstone, revealed that Theodoretus himself in all probability not had meant to refer to a vertically rolling millstone of an oil mill, but to a horizontally rotating millstone, and that he must have intended it as an image of the movement of the celestial bodies in contemporary (Ptolemaic) spherical earth cosmologies. Theodoretus contrasted this with the representation of the movement of the celestial bodies in ancient flat earth cosmologies, for which he used the image of a wheel. This image appears in Anaximander's cosmology, but is applicable to other Presocratic cosmologies as well, including that of Anaximenes, in which the celestial bodies, when set, go under the earth (see Fig. 7.2). My interpretation of Theodoretus' words would be in agreement with Pseudo-Plutarch's and Qusṭā Ibn Lūqā's versions of a text of Aëtius, which states that according to Anaximenes, as with Anaximander, the celestial bodies continue their orbits under the earth.

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CHAPTER 8

Weaving the Double Square

An (Im-)Material Contribution to Early Greek Mathematics

Ellen Harlizius-Klück and Giovanni Fanfani

1 Introduction

The geometrical figure demonstrating the doubling of a square can be found in the Mediterranean on depictions of fabrics as early as the 9th century BCE, and all along into the Classical era.[1] However, doubled squares cannot be generated in weaving by geometrical construction. Despite the repeated claim that weaving only allows for geometric patterns,[2] weavers do not shape them by using lines/threads in a geometric manner. Although they indeed use instruments bearing the same name as the tools for geometrical construction

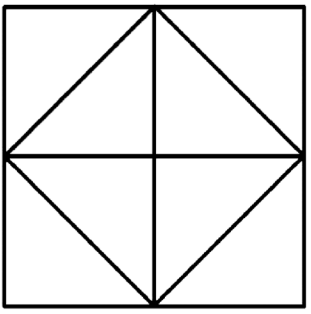


FIGURE 8.1
Gemetrical representation of the doubled square
GRAPHICS ELLEN HARLIZIUS-KLÜCK

1 One of the earliest depictions of a warp-weighted loom on a plate from Cyprus shows several rows of geometrical motifs, among them a series of double squares. See Harlizius-Klück 2017, 262. Diane Carroll, who collected fabric patterns from ancient sources like fabrics remains and fabric depictions, detected several patterns including the double square geometry. See Carroll 1965, plates 32–34 on pp. 476–478.

2 For example Oliver Simons: "Between warp and weft of a carpet there is little room for visionary forms; the grid of the weave only allows for the clear lines of a geometric ornament." (Simons 2007, 145, transl. Harlizius-Klück). There is a grain of truth in this statement; however, to generalize it for all weaving techniques and especially tapestry is misleading. As Holzman makes clear, the rectilinear geometry only imposes itself on small tapestry motifs (Holzman 2019, 545).

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(Lat. *regula* and *radius*, which denote the heddle rod and the shuttle in weaving respectively, as well as ruler and compass in geometry), weavers construct the plane (the fabric) and the figure (the geometrical shaped pattern) at the same time, whereas in geometry the plane is there (be it as sand or wax on a tablet), and construction can proceed deliberately. The grid-like structure of a weave on one hand indeed imposes constraints on the pattern shape, but it also leads to patterns that always consist of countable relations of numbers and thus are always commensurable.

From this follows that weaving a doubled square, namely the figure with the diagonal being incommensurable to the side of the square, should be impossible. So, how did weavers produce the pattern we see on the depictions? Did the ancient philosophers who discussed the topic of incommensurability along this figure ever look at the woven pattern? What would they have learned from it?[3]

Ancient weaving technology, as a technical mode to generate patterns and geometrical shapes, implements a logic that, deeply embedded in the material, engages arithmetic and its relation to geometry. This essay traces the nature of such engagement in the context of the emergence of mathematics within Greek philosophy, exploring in particular the case of the double square as both a prominent fabric pattern and a central piece of early mathematics that encompasses the notion of the incommensurability of side and diagonal of the square.

The structure of this contribution falls into three main parts. The first section sets up to describe and explicate a) how a loom is set up and how this setup includes ideas and elements classified as mathematical; b) the way how threads are ordered by generalizing properties of numbers rather than by absolute number or measure; c) the way how weavers calculate for arranging patterns. In the second section, a close reading of the slave-boy mathematical lesson in Plato's *Meno* paves the way for discussing how the problem of doubling a square, and the connected question of linear and quadratic incommensurability (including the 'archaizing' proof in Euclid X app. 27), somewhat shape the complex relation between arithmetic and geometry in pre-Euclidean mathematics. The third and final part stages an imaginary follow-up dialogue

3 In the time span discussed here, mathematics was often not a topic of its own, but part of a wider range of interests in thinkers like Thales, Pythagoras, Hippocrates of Chios, Archytas, Plato. The case of Theodorus of Cyrene and his student Theaetetus is partly different, as they are essentially associated with their achievements in the field of geometry.

to the slave-boy lesson in the *Meno*, demonstrating how a weaver would argue along a 'woven' diagram of a double square and how this relates to the problem of commensurability.

2 Mathematics at the Warp-Weighted Loom? On Setting Up the Geometry and Counter-System of a Warp-Weighted Loom

Hesiod, in his *Works and Days*, tells us that there is a 'right time' (*kairos*) to begin weaving: on the twelfth day of the month, "a woman should set up her loom and carry forward her work".[4] Different from handlooms today, the warp-weighted loom in use in ancient Greece was not a permanent equipment belonging to a specific room or studio, but a device only temporarily installed. Penelope puts up her loom in the *megaron* of the palace of Ithaca,[5] contrary to the usual assumption that she did her weaving in some sort of women's quarter of the house.[6] Before setting up the loom, the following needs to be at hand: first, two poles for the upright parts of the frame, and two rods for the horizontal parts. Although it helps when these rods and poles are straight, it

4 Hesiod *Works and Days* 779: ἱστὸν στήσαιτο γυνὴ προβάλοιτό τε ἔργον. This section of *Works and Days* establishes a prescriptive pattern of correspondence between certain days of the month ("the days that come from Zeus counsellor", lit. "Zeus who has *mētis*", Διὸς παρὰ μητιόεντος, v. 769) and certain works; a universal principle of 'right time' (*kairos*) governs the rhythm and activities of human beings. Hesiod's reference to *kairos* (v. 694 "Bear in mind measures; *kairos* is the best in all things", μέτρα φυλάσσεσθαι· καιρὸς δ' ἐπὶ πᾶσιν ἄριστος) represents the earliest instance of the term, here bearing the temporal connotation of 'right time, due season': see Trédé-Boulmer 2015, 92–105. Homograph of καιρός, καῖρος is a textile term, denoting a weaving implement (see below for *kaîros* [καῖρος] as the shed rod in the warp-weighted loom): for the semantic and conceptual connection between the textile term and the abstract notion see Gallet 1990, Fanfani-Harlizius-Klück 2016, 79–81, Fanfani (forthcoming).

5 Homer gives this account three times: first reported by Antinoos (*Odyssey* 2.94), then by Penelope herself (*Odyssey* 19.139–140), and finally by the soul of Amphimedes (*Odyssey* 24.128–146).

6 Stansbury-O'Donnell gives the following account, replacing the archaic *megaron* by the later *andron*: "It is easy to consider this space as another section of the house, well away from the entrance where Odysseus stands with his traveling pack, as well as the andron where the suitors eat and drink" (Stansbury-O'Donnell 2014, 379). Even Kistler, who demonstrates how the *megaron*-culture *with* housewife develops into an *andron*-culture *without* (Kistler 2006, 16), claims that Penelope is not weaving in the banquet-hall or *megaron*, but far away from this in a part of the house that is inaccessible to the public, whatever he indicates by this term (Kistler 2006, 22). For a comprehensive discussion of this problem, see Wagner-Hasel 1989 and 2018.

is not strictly necessary for a good weaving result.[7] Furthermore, the weaver needs ropes to connect the rods to a frame, a starting-border providing the warp threads, strings to tie the starting-border to the upper horizontal rod and to knit the heddles, loom weights to stretch and tension the warp threads, and enough yarn for the weft of the fabric.

When tying the parts of the frame together firmly, the behaviour of the elements approximates right angles quite naturally.[8] Due to its construction, the fabric tolerates slight diversions of the frame from the right angle, because the material threads arrange themselves in a rectangular manner just because of tension, friction and construction.

A pre-fabricated border today called a starting-border provides the warp-threads.[9] It carries the warp for the loom as weft of the band, extendable along all four sides of the weave.[10] The weaver attaches this border to the upper horizontal rod and tightens the weft threads, extending on one side, with clay weights.

Now, the weaver places half of the weft threads in front of the lower rod or *kaîros*. It is important to note that this manner of dividing in halves does not split the collection of threads in the middle. Instead, the weaver distributes every other thread in front or behind the *kaîros* and thus introduces the fundamental distinction of threads of odd and even ordinal numbers. From now on, she can see if a thread belongs to the odd or even group just by looking if it is in front or behind the shed bar and without knowing the ordinal number itself. It is in this operation, which the Greeks probably indicated with the verb *diazomai* (as lexicography suggests),[11] where weaving begins to generalize number properties.

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7 Some reconstructions of warp-weighted looms indeed use branches which are not quite straight pointing to the fact that the loom, traceable back to the Stone Age, did not change considerably. However, most depictions from the archaic period of the Mediterranean into the Classical period show a loom made from processed, maybe even lathed wood.

8 The heavy beams of later warp-weighted looms in the Lappish regions of the 20th century would not work with such joints, and therefore were connected in a stable manner. However, the much more elegant looms on ancient vase depictions show just such textile solutions. Compare the loom on the Skyphos Chiusi and on the Amasis vase, Hoffmann 1975, figg. 129 and 130.

9 On the Greek terminology for the starting-border (ἔξαστις, δίασμα, ἄσμα) see Barber 1991, 271–273.

10 For the role of the starting-border as both a device for pre-ordering the fabric, and as a compositional principle of archaic Greek poetics, see Fanfani and Harlizius-Klück 2016.

11 Stefanelli 1983 provides a systematic survey of Greek terminology for warping and argues that διάζεσθαι denotes the setup of the loom, i.e. the disposition and assignment of the warp threads to and through the heddle rod and the shed rod. Stefanelli concludes that

The weaver has now generated a so-called natural shed between the two halves of the warp, which allows to introduce a weft into the slight angle between the two thread-systems. For the counter-shed, she needs an additional rod or several sticks to take the threads behind the *kaîros* in front: the *kanōn* or (plur.) *kanones*.[12] Every other thread is tied to this *kanōn* with a loop that extends far enough to keep the natural shed open, but is also short enough to be managed easily. These are the basic tools for constructing the fabric: the *kaîros* and the *kanōn* providing the fundamental distinction of odd and even threads and the shed for introducing the weft by means of a spool. In Latin, the spool that carries the weft is called *radius*, and the term for the heddle rod or *kanōn* providing the order is *regula*.[13] These are also the basic tools for geometric construction: *radius* is the compass or straight-edge, and *regula* is the ruler.

Although the weaver only needs a rough idea of geometry for getting to this point, she needs to be aware of the geometrical properties that make the loom operable: the angles provided by tying together the basic frame, the plumb line of the thread with weight, the angles introduced by the inclination of the loom in interplay with the position of *kaîros* and *kanōn* and the length of the heddle loops. Based on these pre-conditions, the process of weaving and the properties of the material will put the right angles of the fabric into place.[14]

διάζεσθαι may mean "to subdivide, distribute the warp threads"; the term δίασμα (found in Callimachus fr. 520 Pfeiffer, where it is qualified as φάρεος ἀρχήν "beginning of the cloth") would indicate the result of the action of διάζεσθαι, i.e. the warp once it has been divided and distributed through the heddle and shed rods; cf. Fanfani (forthcoming) for a detailed discussion of the lexicographical sources. For δίασμα as denoting the starting-border see above n. 9.

12 The loom on the skyphos Chiusi shows one such rod, the Amasis loom has two. See Hoffmann 1975, Fig. 129 and 130.

13 *Radius* as shuttle bringing the weft: Lucretius *On the Nature of Things* 5.1352 (in the context of a survey of textile tools made of iron), Ovid *Metamorphoses* 6.56 (where the weft is brought into the warp by *radiis acutis*).

14 Opposite to what Sennett suggests, the *eye* of the weaver is not concerned with the right angle between warp and weft – which is a result of the technological construction of the loom and threads even before weaving begins (Sennett 2008, 278). Experiments of the Centre for Textile Research in Copenhagen suggest that the size of the weights directly influences the angle of the vertical threads causing the fabric to be either rectangular or taper into one direction. However, this is only the case when all weights hang at the same height and thus compete for the same space. Most depictions of warp-weighted looms instead show the weights hanging in several levels (except of the Amasis image). See Hoffmann 1975, Figs. 125, 126, 127, 128, 129 (Skyphos Chiusi), 130 (Amasis vase).

3 On Measuring and Weaving

The principles of mathematics as we know them today, which make things countable by a specific idea of number having a determined position on a number ray extending to the infinite in two directions, and measurable by a system of metrics employing standardized units that can be reproduced across space and time, do not work for ancient weaving in the same way. Of course, one can describe anything the weaver is doing by employing our type of mathematics. However, when the weaver considers the relation inherent in her work in terms of countable arrangements of monads (rather than numbers)[15] the possibilities are very different. Measurement becomes an instance of proportion, and proportion does not need a unit of measurement. Let us explain this along the famous example of Thales 'measuring' the height of a pyramid. Put into proportion, this height of the pyramid is to the length of its shadow as the height of the staff of Thales to the length of its shadow.[16] It is not necessary to know that height in an absolute length.[17]

In a same line, the weaver knows the arithmetic of odd and even integers and the relation of composed numbers and primes. Moreover, in a same line, the weaver does not measure in our sense of the word. Let us imagine a weaver preparing her loom. Which measures would she need to employ and how? The length of the starting-border needs to be a bit less than the space between the two upright poles. This can be measured by using a thread and

15 This is how Euclid defines number in *Elements* Book VII, def 2: A number is a multitude composed of monads.

16 Of the three testimonia on Thales' measuring of the height of the pyramid(s) – Diogenes Laertius *Lives of Eminent Philosophers* 1.27 = Hieronymus fr. 40 Wehrli = DK 11A1, Plinius the Elder *Natural Hist*ory 36.82 = DK 11A21, Plutarch *The Dinner of the Seven Wise Men* 2 147a = DK 11A21 – Plutarch's report (an imaginary conversation with Niloxenus who addresses Thales) has the philosopher placing a stick (τὴν βακτηρίαν στήσας) "at the edge of the shadow which the pyramid made, and as two triangles were formed by contact with the sunbeam, you [*sc*. Thales] demonstrated (ἔδειξας) that the pyramid is in the same ratio (λόγον) to the stick as the shadow of the one was to the shadow of the other". See Hahn 2017, 143, 148–153 and Hahn (forthc.) for a detailed discussion of the geometrical principles (similar triangles) implied in Thales' measuring technique. Differently from Plutarch's account, both Hieronymus in Diogenes Laertius and Plinius put the focus of the episode on the measuring of the pyramids' (in both cases plural) shadow, though no measurement is provided.

17 A form of applied geometry was the method of the Egyptian land-surveyors: see Hahn 2017, 149 and Hahn (forthc.) on the formulas for calculating a pyramid height (in royal cubits) found in the Rind Mathematical Papyrus (problem 57), and on the role of Thales in transforming this knowledge into "deductive steps of reasoning".

comparing – without any number or magnitude being involved.[18] The length of the warp introduced into the starting-border as weft needs to be at least twice the length of the fabric to be woven. Every weaver might have had a unit to compare to, but as long as they do not work across different looms of different sizes, that unit does not need to be standardized. A typical unit length could be the distance of thumb and elbow. The most common method of winding a hank or skein is based on winding the thread around thumb and elbow for a certain number of turns or tours. Other methods can include pegs on a wall (like documented in the model of an Egyptian weaving workshop)[19] or parts of the loom. For reconstructions in our laboratory, Ellen Harlizius-Klück used the length between the pegs that carry the *kanōn*, which has the advantage to give a very good estimate of the necessary weft length.[20] Thus, the important things to know are: 1) the unit or better the basic length and 2) the number of tours in the hank.

For calculating the necessary amount of yarn for a textile product, it is not necessary to know it in a length number like 263.8m; rather it can be calculated by composing the final amount based on the basic length and its relation to the equipment at hand. For this, the weaver employs proportions and ratios, but no absolute number or a standardized unit. Though interested in the relation of thread lengths, the actual measure-as-magnitude is not important to the weaver, neither is the actual thread count or position, though she is interested in the relations and properties of numbers for composing patterns.

4 On Calculating and Weaving

In order to install this complex geometric system of threads, the weaver orders and distributes threads as distinct (however, also continuous) elements.[21]

18 The usual rejection of this argument by mathematicians or historians of mathematics is to say: this is just matching and not measuring. We would not complain about this argument if the same people would apply it to ancient mathematicians. However, measuring always means comparing and the fact that there is a standard length does not make this more "mathematical".

19 See Barber 1991, Fig. 3.6, presenting an Egyptian funerary model with textile workers.

20 Of course, this is more than the width of the fabric will be; however, the weft needs to be longer than the fabric width as it is not going straight through the shed, but needs to take the form of a bow or wave in order to provide sufficient material for the weave not to taper down.

21 There is a long debate about the Euclidean representation of numbers by line segments. Numbers in that context are understood as cutting points of lines, or, as Netz has it, as the points generating the line and assimilating arithmetic to geometry (Netz 1999, 69). Knorr 1975, 308 associates the geometric presentation of number theory in *Elements* book

Some would call it counting when the weaver selects every odd or even thread or every third thread in a pattern. The reason why we would distinguish it from counting is that the thread with which to start differs from row to row as well as the direction of selecting, depending on the respective row of the pattern unit and the current beginning of the weft (right or left). This shows that the count is not related to the ordinary number of the thread within the set of the whole but is shifted across the horizontal and vertical dimension as necessary. There is no "natural" first thread in this system as long as the weaver is at work.[22]

Under this perspective, an odd thread as part of a repeat might become an even one in the next row, depending on the starting point of selection, especially as there is no preference for starting the selection from right or left. Changing counts for patterns always adjusts to the situation at place on the loom. As you may work with both hands for selecting, picking threads can actually go into either direction at the same time.

Note that the numbers in charge are always positive integers, and the properties to recognize are not bound to the actual magnitude of the number. This also applies to the more complex number arrangements that the weaver considers for patterning the fabric: the need to find greatest common divisors and prime numbers that can be composed along the established warp count. The weaver can employ the method of *anthyphairesis*, or *aphaeresis*, namely 'taking away from both sides' (later formalized as Euclidean algorithm) for finding out about the possible combinations of patterns (with their respective thread counts).[23]

For the mathematician among the authors,[24] the approach of weavers to generalize number compositions and proportions is a mathematical way of working, rather than measuring along a tape or calculating pattern possibilities down from the actual number of counted warp threads. Indeed, the methods employed by the weaver are valid across different looms and thumb-elbow

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VII as arising merely for its "convenience for the purposes of the theory of incommensurability", and for "facilitating Theaetetus' studies". When it comes to weaving, instead, the thread in a weave, being a line in itself, is assigned a number (a positive integer) while also establishing a pattern.

22 This is of course different for the final product where every thread crossing has its final position. Then, one can reasonably point to the grid and argue around the arithmetic included in the pattern as we see it. We will use this type of argumentation on patterns in section 8 below that includes the imaginary dialogue between a girl and the slave-boy facing her patterned dress.

23 We have discussed examples of pattern reckoning in several publications: Harlizius-Klück 2009, 32–33, Harlizius-Klück 2016, 94–95, Fanfani and Harlizius-Klück (forthcoming).

24 Ellen Harlizius-Klück is educated as mathematician and started weaving on the warp-weighted loom in 2006.

distances, whereas the results of calculations with magnitudes would be only valid for one loom and setup.

Before discussing the possibility of weaving the double square pattern, we review the relevant textual sources and situate the problem (and solution) of doubling the square as crucially lying at the intersection of early Greek geometry and arithmetic, while also shaping their relation and reciprocal influence with regard to a defining nucleus of pre-Euclidean mathematics: the incommensurability of the side and diagonal of the square and its broader context and implications.[25] For the purpose and scope of our argument, the exploration of the conditions for the manipulation of numbers and magnitudes across domains (geometry, dyadic arithmetic) and materials (*psēphoi*, weaving) will bear on questions related to the specific mode of knowledge that material affordance enables: for the case at stake, the 'order-through-number' that we see implemented in weaving at the warp-weighted loom – an order that partly subsumes, but is not reduceable to, nor represents an application of, the doctrine of Pythagorean number theory as we find it in the arithmetical books of Euclid's *Elements*.

5 The Double Square between Arithmetic and Geometry: Incommensurability and Three Platonic Passages

That Plato provides some of the earliest and most limpid attestations of the problem of doubling the square comes as no coincidence, given that a number of mathematicians and thinkers forming what Reviel Netz has recently labelled 'the first network of Greek mathematics' gravitated around the Athenian philosopher.[26] The so-called 'geometry lesson' at *Meno* 82b–85d will serve as

25 Among these are the historical questions of dating the discovery, first emergence, and mathematical formalization of incommensurability, or tracing the nature and shape of its early proof; scholarly work on this topic is notoriously extensive: see e.g., von Fritz 1945, a large part of Knorr 1975, and Fowler 1999, 356–365 (an exhaustive survey of the relevant sources).

26 Cf. Netz 2014, 167–171: characterizing the investigations of this first network, active in the first half of fourth century BCE and roughly corresponding to Proclus' 'Catalogue of geometers' (*On Euclid's Elements Book 1* 65.7–68.4, in turn originated in Eudemus' lost *History of Geometry*: see Zhmud 2006, 89–100), is an interest in the "classification of those mathematical terms whose representations in diagrams do not involve complex interacting diagrams" (168). As Netz specifies (169), such terms are "numbers, means, ratios, proportions, irrationals, harmonies", and Plato's Athens is the geographical and intellectual center of the network. While Netz 2014, 169–171 sees Archytas of Tarentum as the mathematician whose work can be seen as paradigmatic of the first network, Knorr 1975,

the natural entry point, as the passage explicitly addresses the construction of a double square and engages both arithmetic and geometry – in particular, as it has been aptly noted, "the practice of representing numbers by geometrical figures".[27] The implicit notion underlying Socrates' demonstration is the incommensurability of the side and diagonal of a square: once an integer number is assigned to the length of the side, then the diagonal "cannot be expressed as a *number*".[28] An overview on Plato's treatment of incommensurability, revolving around the notion of *dynamis* – which expresses the concept of quadratic commensurability of incommensurable magnitudes – is best gained by pairing *Theaetetus* 147c–148b (Theaetetus' account of his and Theodorus' achievements in the field) with the mathematical joke at *Statesman* 266a–c.[29] There are, however, features of the *Meno* geometry lesson that a) put the passage in dialogue with those two chronologically later Platonic loci on the basis

88 argues that Theodorus of Cyrene "was the principal source for Plato's conception of geometry", and the relationship between the mathematician and the philosopher was of a "master-pupil" type.

27 Knorr 1975: 90, who adds that the *Meno* passage can be sees as "an investigation into the nature of such representations: how can the number eight be constructed as a square?". *Meno* 82b–85d has aroused scholarly interest for a number of different aspects, one being the nature and function of geometric diagrams in pre-Euclidean mathematical proofs: see Patterson 2007, 1–7 (who also recasts Socrates' demonstration as a typical Euclidean proof), Lattmann 2018: 125, and the extensive discussion in Lattmann 2019, 117–151. Crucial to the argumentation of the *Meno* geometry lesson, which unfolds via the drawing of geometric diagrams, are certain features of the figures drawn by Socrates: see below n. 36.

28 Szabó 1978, 94. The Euclidean definition of incommensurable magnitudes (ἀσύμμετρα μεγέθη, *Elements* X def. 1) lays emphasis on the non-existence of a common measure (κοινὸν μέτρον) that can measure/divide each "an exact integral number of times" (Knorr 1975, 15).

29 In order to separate bipeds from quadrupeds, the Visitor from Elea invites Young Socrates to effect the division "by the diagonal, and again, of course, by the diagonal of the diagonal" (Τῇ διαμέτρῳ δήπου καὶ πάλιν τῇ διαμέτρου διαμέτρῳ 266a9–10), since human nature is, in terms of walking (εἰς τὴν πορείαν), just like the "diagonal that is two-foot in power" (ἡ διάμετρος ἡ δυνάμει δίπους), while the nature of the remaining kind is, as for its power (κατὰ δύναμιν), the diagonal of our power, being of twice two feet (εἴπερ δυοῖν γέ ἐστι ποδοῖν δὶς πεφυκυῖα [*sc.* ἡ φύσις]). The pun on δίπους δυνάμει "two-feet in power", which refers to the diagonal of the 1-foot-side square, explicitly points to the problem of the double square and the related incommensurability of side and diagonal. Though the areas of the 2 and 4 sq. ft. squares are commensurable, the diagonals are not, and this seems to imply that the nature of humans (ἡ φύσις, ἣν τὸ γένος ἡμῶν τῶν ἀνθρώπων κέκτηται 266b1–2) and that of pigs (the quadrupeds likely to be referred to at 266c5–6) cannot be compared – thus undermining the model of shepherd as analogical referent for the statesman; cf. Miller 2017.

of a distinctive arithmetical characterization of geometric problems,[30] and b) may reflect an early stage towards, or a variation on, the 'Pythagorean' manner of proving the incommensurability of side and diagonal of the square as we have it preserved in the manuscript tradition of Euclid's *Elements* at the end of book X (athetized as a late interpolation by Heiberg for reasons that will be reviewed below).[31] Indeed, Árpád Szabó (1978, 91–94) went so far as to suggest a causal relationship between the problem of doubling the square, as instantiated in the *Meno* passage, and the discovery of incommensurability: in Szabó's view, the attempt to find the number that, assigned to the sides, would obtain a square with twice the area of a given square – a search whose nature seems mainly arithmetical – was turned into a geometrical problem, namely that of finding *what* line segment would enable the construction of a square double the original square. The consequent realization that the diagonal of the original square was the sought-after line would have led to the discovery of linear incommensurability – and, Szabó adds, also of quadratic

30 A prominent element of such interrelation between arithmetic and geometry is the assignment of the unit-foot (ποδιαιά, cf. *Theaetetus* 147d6) to the length of the sides and areas of squares in contexts where Euclidean geometry presents instead abstract magnitudes: we thus have sides "two feet" in length (δυοῖν ποδοῖν, *Meno* 82c5–6), diagonals "two feet in power" (ἡ διάμετρος ἡ δυνάμει δίπους, *Statesman* 266b3), and *dynameis* "of three and of five feet" (τῆς [δυνάμεως] τρίποδος … καὶ πεντέποδος, *Theaetetus* 147d5). Knorr 1975, 90–91 observes that "this same practice of expressing lines, surfaces and solids as so-many feet in magnitude is characteristic of the metrical tradition in geometry found in Hero's work". While arguing that early Greek geometry seems "to be not arithmetised to a remarkable extent", Fowler 1999, 366 n. 12 sees the first part of the *Meno* geometry lesson as "the only arithmetised passage, anywhere up to Archimedes and beyond": strangely enough, *Theatetus* 147d–148c and *Pol.* 266a–c are not mentioned in this context. Fowler labels *Meno* 81e–85d, which he fully quotes at the opening of his book, as "our *first* direct, explicit, extended piece of evidence about Greek mathematics" (1999, 7), and *Theaetetus* 147d–148b "our first unequivocal and explicit reference to incommensurability" (1999: 290). Cf. Brown 1967, 59–63 on the first, arithmetic-centered half of Socrates' lesson.

31 Szabó 1978, 93–94 entertains the possibility of a "direct connection" between the *Meno* passage and the Euclidean proof, though the hypothesis is not discussed in depth. In the context of a detailed analysis of the formal features of *Elements* X app. 27, whose Pythagorean background is seen against stylistic and argumentative elements typical of a Euclidean proposition, Knorr 1975, 26–27 detects in the geometry lesson of the *Meno* a sample of "how a Pythagorean proof might have looked like": once the properties of the odd and even are applied to the figure drawn by Socrates on the sand, "the incommensurability of the side and diameter may be shown".

commensurability.[32] Such a reconstruction somewhat casts the structure of the *Meno* geometry lesson – with its switch from an arithmetically-oriented inquiry to a geometrically-driven demonstration – as a paradigm for the trajectory of early Greek mathematics' engagement with the problem of incommensurability. In so doing, however, it runs the risk of oversimplifying the nature of this Platonic passage – both its fascinating oscillation between arithmetic computation and the manipulation of geometrical figures, and the element of fictional pragmatics of the dialogue between Socrates and the slave-boy which serves the dramatic function of exploring the question of learning (μάθησις) as recollection (ἀνάμνησις, *Meno* 81e4).[33]

That incommensurability is not explicitly addressed as a mathematical notion in the *Meno* geometry lesson (whereas it will in the later *Theaetetus*, at 147d5–6) may have to do with matters of chronology and setting, both compositional and dramatic.[34] Not a professional mathematician in the fashion of Theodorus and Theaetetus, Socrates the character exhibits, however, the ability to guide the slave-boy through arithmetical *aporia* – the side length of the eight-feet square – by pointing to the geometrical nature of the solution to the problem of doubling the square. By his exhortation to the boy at 83d11–84a1 "try and tell us exactly [the length of the side]; and if you do not want to reckon it (καὶ εἰ μὴ βούλει ἀριθμεῖν), then show us (ἀλλὰ δεῖξον) from what line [you obtain the eight-feet square]", Socrates is on the one hand hinting at the

32 Szabó 1975, 95–96: "Since, however, this line [the diagonal] yielded a square of twice the original area, the idea of measuring linear incommensurable segments by their *squares* must have suggested itself immediately".

33 See Weiss 2001, 79–83 on how this question, and geometry as the case study for illustrating it, is in turn functional to the wider inquiry into the nature of virtue – i.e. whether virtue, as other *mathēmata*, can be taught – in the *Meno*. Vlastos 1965 is a seminal study of the nature of recollection in the *Meno*, defined as "any enlargement of our knowledge which results from the perception of logical relationships" (p. 156–157).

34 In the frame of an accurate reconstruction of Plato's trips to Magna Grecia and Cyrene, his contacts with Archytas, Theodorus, and Theaetetus, and the development of Greek mathematics around the date of composition of the *Meno* (ca. 386 BCE), Brown 1967, 77–93 proposes that the slave-boy dialogue may reflect Plato's discontent with the situation of coeval geometry: on the one hand, a type of "ocular" geometry, implemented in the *Meno* passage by the sustained use of deixis, betrays a sophistical, sense-based argument "leading not to knowledge of an eternal truth, but merely to a plausible opinion" (p. 74); on the other hand, Theodorus' and Theaetetus' study of incommensurability (as captured in *Theaetetus* 147d–148c) could only produce "an impossibility proof" (p. 89) – the oblong number 8 cannot be assimilated to a square on the basis of the coeval (pre-Eudoxian) theory of proportion, and its side could only be labelled a *dynamis*, incommensurable to the unit. Hahn 2017, 168–189 sees the mean proportional (or geometric mean) as crucial to early Pythaogrean proofs of the hypothenuse theorem.

impossibility to assign a numerical value to the side of the eight-feet square, while also exposing a methodological and theoretical caesura (in fact, a sort of incommensurability) between an arithmetical and a geometrical approach to doubling the square as each characterizes one of the two halves of the *Meno* demonstration in terms of style of inquiry.[35] A closer look at the ways in which this twofold argumentation is effected in the slave-boy lesson will in turn invite comparison with the different mode of engaging arithmetic and geometry that weaving the double square entails.

6 Arithmetic vs Geometry? Meno 82b–85b and Archytas DK 47B4

After an introductory section where the diagram of a square is drawn and some of its distinctive features – equality of the four sides, equality of the two lines '(going) through the middle', existence of smaller and larger squares – rehearsed for the slave-boy (82b9–c4),[36] Socrates' inquiry takes on a decidedly arithmetical turn as the side of the square is assigned the length of two feet (82c4–5 αὕτη ἡ πλευρὰ δυοῖν ποδοῖν) and calculation of areas from side lengths – and the reverse, side length from a given surface – becomes the prominent mathematical operation that the slave-boy is required to execute.[37]

35 Brown 1967, 57–68 offers a solid argument for the distinction between an arithmetical and a geometrical part in the *Meno* mathematical lesson, where "geometry and arithmetic stand for importantly different things in Plato's mind" (58). Such a (perhaps too neat) separation has been questioned in later scholarship (references in Boter 1988, 214), and on close reading the Greek text shows that there is a sustained interaction between the language of arithmetic exactness, conveyed by the sequence of interrogative pronouns τί ('what'), πόσος and πηλίκος ('how large/long, of what size'), and the language of geometrical form/shape (conveyed by the pronoun ποῖος 'of what kind/sort') throughout the whole passage.

36 The initial diagram, defined at 82c1–3 as a τετραγώνιον χωρίον ("quadrangular area") having all four sides equal (ἴσας ἔχον τὰς γραμμὰς ταύτας πάσας, τέτταρας οὔσας) and also having equal "these (lines which have been drawn) through the middle" (ταυτασὶ τὰς διὰ μέσου), has been traditionally understood (indeed from antiquity, as the diagrams drawn in the margin of some MMS and scholia show: see Boter 1988: 208 n. 3) as a square with midpoint transversals cutting the four sides in the middle, thus forming four smaller squares. In fact, as argued by Boter 1988 and Weiss 2001, 84–94, what Socrates might be referring to by τὰς διὰ μέσου could be the two diagonals (whose equality in length in fact defines the square in opposition to the rhombus). Cf. also Sharples 1989 and Fowler 1990 (both directly engaging with Boter 1988), Brumbaugh 1954, 19–30, Patterson 2007, 3 n. 1, and the comprehensive treatment in Lattmann 2019, 119–145.

37 See Knorr 1975: 90, for whom "the assignment of the 'foot' as unit establishes an affinity with the tradition of metrics and the mathematics of the passage is executed entirely within the field of arithmetic: only the operations of counting and of multiplications are

That multiplication is at stake here is clearly indicated by Socrates' posture and language in the first case presented to the boy: in the form of two conditional sentences – which seem to posit the arithmetical examples into a "framework of inference" at least partially detached from the diagram at hand[38] – a distinction is drawn between the area of the two-feet-side square and the area of the figure (a rectangle) with one side two-feet and the other one-foot in terms of the two-feet-side being taken "twice" (δὶς δυοῖν, 82d1) or "once" (ἅπαξ … δυοῖν, 82c8) respectively.[39] Along the same lines, when Socrates asks the slave-boy to tell "how many feet, then, is twice two?" (Πόσοι οὖν εἰσιν οἱ δύο δὶς πόδες; 82d3–4), he is explicitly inviting him to calculate (λογισάμενος, 82d3) the amount: while 'arithmetical reckoning' seems to be the primary sense of the term here,[40] the verb λογίζεσθαι and the substantivized λογιστική (*sc.* τεχνή, lit. 'the art of calculation'), either alone or, more often (as here in the *Meno*), in connection with the series ἀριθμεῖν/ἀριθμητική (*sc.* τεχνή, lit. 'the art of counting'), cover a broad spectrum of nuances within Plato's extensive and variegated treatment of the science of number. Rather than expressing

employed in the analysis". On the significance of two feet (rather than one foot) as the side length of the initial square see Boter 1988, 215.

38 So Vlastos 1965, 151 n. 10, who rightly lays emphasis on how temporal and modal syntax in the Greek of the passage (in the specific case the optative + ἄν) highlights the "exploration of logical consequences rather than factual observations", and argues that, in order for him to answer the arithmetical questions, the slave-boy "should judge merely by thinking" (p. 151).

39 Once assigned the side length of two feet to the drawn square, Socrates is first asking "how many feet would the whole (square) be?" (πόσων ἄν εἴη ποδῶν τὸ ὅλον; 82c6) and, before even allowing the slave-boy to answer, he introduces the 2 × 1 rectangle and its area at 82c7–8 ("would the area (τὸ χωρίον) be anything but two feet taken once?"). The use of the potential optative (ἄν εἴη 82c6) and of the *irrealis* imperfect (ἄν ἦν 82c8) by Socrates in this passage, in both cases the apodosis of a conditional sentence, has been taken as pointing to the fact that no links to the figure drawn (and to its subdivision according to the mid transversals or diagonals) is implied here, and that the multiplication is performed entirely on an arithmetical basis: see Boter 1988, 209–210 and Weiss 2001, 86, both of whom take the lines διὰ μέσου at 82c3 as diagonals; cf. Lattmann 2019, 130–132. According to the traditional interpretation of the διὰ μέσου lines as mid transversals, the 2 × 1 rectangle would be readily visible for the slave-boy, and thus easy for him to just count two small squares and calculate the area: see Brumbaugh 1954, 27 fig. 4.

40 Vlastos 1965: 154, who provides a synthetic overview of the semantics of λογισμός in Plato and emphasizes the aspect of "knowledge reached and justified by formal inference and analysis in emphatic contrast to sensory cognition"; Vlastos also points to Ast's *Lexicon Platonicum*, which glosses λογιστική as "*ratiocinandi* vel *computandi peritia* vel *ars*". For a complete survey of Plato's usage of λογισ- terms see Fowler 1999, 149. Back to λογισάμενος at *Meno* 82d3, Boter 1988, 209 n. 4 observes that the required sense is here "work it out" rather than counting.

an opposition between number theory and practical logistic respectively – an opposition that is in fact constructed by Neoplatonic thinkers and projected back into Plato, as Jacob Klein (1968, 10–60) has shown in full detail – ἀριθμητική and λογιστική should be seen as complementary notions, distinguished as for their specific concern but together concurring in shaping Platonic arithmetic as *epistēmē*, "independent of the practical or theoretical character of the two disciplines".[41] Throughout Plato's dialogues, and in response to the particular context at hand, the emphasis oscillates between the 'practical' dimension of correct counting (*arithmētikē*) and calculating/operating with numbers (*logistikē*),[42] and the 'theoretical' domain of classifying types of numbers and their internal structure, determining their mutual relations and relative quantity as multitudes of 'pure' units. That this second, theoretical knowledge in fact encompasses both ἀριθμητική and λογιστική, somewhat blurring their differences even as these are being formulated, is evident in the double definition offered in *Gorgias* 451a–c.[43] Here, Socrates' formulation is prompted by

41 Klein 1968, 25. The concept of λογιστική as practical computation dealing with objects of sense (αἰσθητά), i.e. with counted things (τὰ ἀριθμητά) rather than numbers, is found in Proclus' report of Geminus' judgment on mathematical sciences (Proclus *On Euclid's Element Book I* 38–40 Friedlein) and in a scholium to Plato's *Carmides* 165e (Hermann VI p. 290), basically identical to Heron's *Definitions* 135.5, 135.6 (Schmidt-Heiberg IV p. 98–99). Olympiodorus (in his scholia to Platos' *Gorgias* 450d and 451a–c) frames the distinction between *arithmētikē* and *logistikē* in terms of kinds/forms (εἴδη, being the even and the odd) and material (ὕλη) of numbers, this last being "the multitude of the units" (τὸ πλῆθος τῶν μονάδων); cf. the similar anonymous scholium to the same passage (*Gorgias* 450b, Hermann VI p. 301) and the discussion of these passages in Klein 1968, 10–16. Heath 1921, 13–16 adheres to the Neoplatonic view in his treatment of the topic.

42 *Arithmētikē* as counting: *Ion* 537e (through ἀριθμητική we know that "these fingers are five"); *logistikē* as computation: *Hippias Minor* 366c (multiplication of three times seven hundred); *Laws* 819b–c (children should be taught *logismos* through play, by dividing up apples and garlands, so that "the same totals (ἀριθμοί) are adjusted to larger and smaller groups"); *Republic* 525c (as referring to the activity of merchants). Cf. Burkert 1972, 446–7 n.119. At *Republic* 522c, in order to introduce the treatment of both "number and calculation" (ἀριθμὸν τε καὶ λογισμόν), of which "every art and science (πᾶσα τέχνη τε καὶ ἐπιστήμη) partake", Socrates presents arithmetic, ironically, as "this elementary matter of distinguishing (διαγιγνώσκειν) the one and the two and the three".

43 A growing interest in theoretical arithmetic seems to invest later Platonic dialogues (see Klein 1968, 21–25 and Huffman 2005, 242–3): two types of ἀριθμητική are distinguished in *Philebus* 56d, 'that of the crowd and that of the philosophers', the latter concerned with undifferentiated units (the same distinction is applied to λογιστική at 56e); in *Statesman* 259e λογιστική, a purely abstract science (γνωστική τέχνη) "that knows the difference between numbers", picks up ἀριθμητική at 258d, the implication being that the two disciplines are to some extent coextensive. The extensive treatment of λογιστική in the seventh book of the *Republic*, as an important part of the mathematical curriculum of the guardians and as a science that brings "to the contemplation of the nature of

an imaginary quest for the concern (περὶ τί; "about what?") of *arithmētikē* and *logistikē*: after having described ἀριθμητική as dealing "with the even and the odd, however great each of the two happens to be" (ὅσα ἂν ἑκάτερα τυγχάνῃ ὄντα, 451b4),[44] Socrates situates λογιστική in the identical domain of the even and odd (περὶ τὸ αὐτὸ γὰρ ἐστιν, τό τε ἄρτιον καὶ τὸ περιττόν, 451c1–2), its distinctive concern being "the multitude that they (the even and the odd) form both in relation to themselves and to each other" (καὶ πρὸς αὑτὰ καὶ πρὸς ἄλληλα πῶς ἔχει πλήθους, 451c3–4).[45]

Before returning to the *Meno* geometry lesson, a couple of observations are worth being laid down at this point, to be discussed more amply in the next section:

i) Plato's focus on the two fundamental kinds/types (εἴδη) of number, the even and the odd – an area of number theory bearing strong Pythagorean connotations, from Philolaus (DK 44 B5) to Nicomachus of Gerasa (*Introduction to Arithmetic* I 7 p. 13 Hoche)[46] – posits these *eidē* as a means

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numbers by pure thought" (525c1–3), takes its start from the statement that "*logistikē* and *arithmētikē* are wholly concerned with number" (περὶ ἀριθμὸν πᾶσα, 525a9–10); see the detailed discussion in Fowler 1999, 105–113, which includes a well-grounded criticism of Klein 1968, 17–25; Fowler sees theoretical λογιστική as "ratio theory" (p. 109–113); similarly Huffman 2005, 240 ("ratio and proportion").

44 The sense, conveyed in Greek by the syntactic construction ὅσα + ἄν + subjunctive (τυγχάνῃ), seems to be here that the specific quantity of the even and odd numbers is somewhat irrelevant: see Dodds 1959, *ad l.* and Huffman 2005, 240; Klein 1968, 17 renders the sentence "… with reference to *how much* either happens to be", thus taking *arithmētikē* here as 'counting' rather than 'number theory'. The interpretation is complicated by the fact that ὅσος 'how big/numerous, of what extent' occurs in relation to the concern of ἀριθμητική several times in the same section of the *Gorgias*: see 453e2–3 (ἀριθμητική teaches us "how many are the things that pertains to number" or "the extent of number features" ὅσα ἐστὶν τὰ τοῦ ἀριθμοῦ) and 453e7 (ἀριθμητική is a branch of the art of education which deals with "the amount/extent, ὅσον ἐστίν, of the even and the odd").

45 An identical, convoluted definition of λογιστική is found at *Charmides* 166a. Cf. Fanfani, Harlizius-Klück and Mamidipudi 2024, 279–80.

46 Philolaus states that number "possesses two proper kinds (ἔχει δύο μὲν ἴδια εἴδη), odd and even", each manifesting itself in "many forms" (πολλαὶ μορφαί); see Huffman 1993, 184–186 on the possible interpretation of εἴδη as "patterns of number", i.e. as numbers laid down as pebbles, in Philolaus B5. In his *Introduction to Arithmetic* (sections 6–13 of book I) Nicomachus offers an exhaustive treatment of the doctrine of the even and odd numbers, labelled as the two "first/primary kinds" (πρώτιστα εἴδη) of "the number approached as *epistēmē*" (ὁ ἐπιστημονικὸς ἀριθμός) and as "the first division (πρώτη τομή) of the domain of number" (I, 6–7 p. 13 Hoche); in apparent continuity with Plato's definition in the *Gorgias*, Nicomachus explores at length both the extent, features, and subdivisions of even and odd numbers, and their relations to each other. Important is also Aristoxenus' testimonium on Pythagorean arithmetic (fr. 23 Wehrli), on which see Zhmud 2012, 261–263: here, the definitions of even and odd numbers, different from the ones in Euclid's *Elements* (book

(perhaps even a condition) for accessing number as object of *epistēmē*.[47] Dyadic arithmetic forms a recognizable nucleus of Euclid's number theory (*Elements* VII def. 6–11, IX propos. 21–34) and reemerges in the proof of the incommensurability of side and diagonal (X app. 27 Heiberg).

ii) literary sources provide cursory references to a couple of practical/material applications of the properties of odd and even numbers, apparently displaying different degrees of arithmetical connotations: these are a game called ἀρτιάζειν, a board game called πεττεία, and the practice of representing numbers as shapes by placing pebbles (ψῆφοι) on a surface;[48] the way in which pattern generation works in weaving presents a mode of manipulating a set of elements (the threads) that is grounded on the features of odd and even – those formalized in Euclid's number theory; Socrates' definitions of ἀριθμητική and λογιστική in the *Gorgias* seem as well capable of describing the arithmetic of pattern creation: grouping threads and working with their relations (often in terms of proportions) rather than counting or calculating their amount.

Back to the predominantly arithmetic section of the *Meno* passage, enclosed in a sort of *Ringkomposition* by the verbs λογίζεσθαι (82d4) and ἀριθμεῖν (84a1), what characterizes it is a concern for quantity and size – respectively τὸ ποσόν and τὸ πηλίκον, to frame it like the Neopythagorean Nicomachus[49] – conveyed

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VII def. 6–7) and in line with the Neopythagorean tradition (preserved in Nicomachus, Theon, and Iamblichus), may preserve an older, Pythagorean stratum. Cf. the skeptical view of Burkert 1972, 437–8.

47 Klein 1968, 59 explains the *Gorgias* definitions of *arithmētikē* and *logistikē* (which, interestingly enough, do not include the term ἀριθμός) as articulating, in their rigour, "only one of the two characteristics of *arithmos*, namely that all-pervasive limitedness which is rooted in an *eidos*, so that they can cover the *whole* realm of that which is countable – and yet avoid the indefiniteness which attends the term *arithmos*".

48 The game (ἀρτιάζειν) is referred to in Plato's *Lysis* 206e, where boys and youths at the wrestling school play the 'odd-and-even' in a corner with a great number of knuckle-bones (ἐν γωνίᾳ ἠρτίαζον ἀστραγάλοις παμπόλλοις); a further mention of the game is in Aristophanes *Plutus* 816. Possibly the earliest mention of the odd and even in an arithmetical context is Epicharmus DK 23B2 (first half of fifth century BCE), a fragment from a comedy where the reference is to how, by adding or subtracting a pebble (ψῆφος) to/from an odd number, the number becomes even: as Burkert 1972, 438 n.64 clarifies, "it is precisely the notion of odd and even which makes it clear that the smallest alteration signifies a fundamental change", which is part of the broader comic argument of the passage.

49 *Introduction to Arithmetic* I 2–3 p. 5. Hoche, where the two notions serve to qualify and delimit multitude (πλῆθος) and magnitude (μέγεθος) respectively, which in themselves are limitless (ἄπειρα); at the opening of ch. 3, Nicomachus divides quantity (τὸ ποσόν) into two parts: of these, one (which later is defined as ἀριθμητική) "is viewed by itself, having no relation to anything else, like 'even', 'odd', 'perfect', and the like", while the other (which turns out to be music, seen somewhat as applied arithmetic) is conceived of in terms of

by a sustained pattern of interrogative pronouns/adjectives calling for numerical answers in Socrates' questions to the slave-boy.[50] These, which are disseminated also in the second, largely geometrical section of the passage, are: πόσος ('how great/much?' in terms of quantity), πηλίκος ('how great/large?', in terms of size and magnitude), the *hapax legomena* ποσάπους ('of how many feet?' at 85b1) and ποσαπλάσιος ('how many times multiplied' at 83b9, 84e2) and the more generic τί ('what?').[51] This seems to square with previous Platonic definitions of *arithmētikē*: at *Theaetetus* 198c5, τὸ ἀριθμεῖν (here in the sense of 'counting') consists in "examining how great (πόσος) a number happens to be". After having correctly calculated (λογισάμενος, 82d4) the area of the two-feet-side square, the slave-boy is required to imagine a square twice as big,[52] and to say (εἰπεῖν) "of how many feet" (πόσων ποδῶν, 82d7) its area would be – which he also calculates correctly. Of this eight square feet square Socrates asks the boy to determine the side length (πηλίκη τις ἔσται ἐκείνου ἡ γράμμη ἑκάστη, 82d8–9) – an impossible task as far as arithmetic is concerned, being the side of the eight feet square "incommensurable in length with the unit foot".[53] Somewhat misguided by Socrates' iteration of his question, reformulated with an emphasis on the double size of the new square (τί δὲ ἡ ἐκείνου τοῦ διπλασίου;) and preceded by a remark on the side of the original square being two feet (ἡ μὲν γὰρ τοῦδε δυοῖν ποδοῖον, 82e1), the slave-boy is ready to postulate that the side of the double square should be twice the side length of the original square (Δῆλον δή … ὅτι διπλασία, 82e3), i.e. four feet. A short exchange between Socrates and Meno follows, where the geometrical nature of the solution is hinted at for the first time: the slave-boy "thinks he knows *what* (ὁποία) is the line from which (ἀφ' ἧς) the eight-foot square will be generated" (82e5–6); by pointing to a line

relations (the examples are 'smaller', 'double', and terms specific of harmonic ratios like ἡμιόλιον and ἐπίτριτον).

50 Brown 1967, 59 observes that Socrates 'asks in the *ti esti* form, implying that he wants a number for an answer'.

51 πόσος: 82d3, 82d7, 83e9 (in all cases in the sense of 'how many feet?'); 83b5 ('how great?', referred to the area of the 4 × 4 ft. square); 85a6 ('how many such halves?'). πηλίκος: 82d8, 83e1 ('how long?' referred to the side of a square); 85a4 ('how large' referred to the area of the eight-foot square). τί: 82d1 ('what is?' referred to the side of the eight sq. ft. square).

52 Rather than simply asking for a new square with double the area, Socrates' question lays emphasis on the fact that the new geometrical figure, which has to have an area double that of the drawn square (τούτου τοῦ χωρίου ἕτερον διπλάσιον, 82d5–6), must also be similar in shape (τοιοῦτον δὲ), i.e. it must exhibit equality of sides ('having all sides equal' 82d6): while possibly pointing to the question of the squaring of oblong numbers (tackled by Theaetetus in *Theaetetus* 147e–148a), this may as well hint at the fact that the solution to the problem of the double square will be entirely geometrical.

53 To quote Theaetetus' words about Theodorus' study of *dynameis* at *Theatetus* 147d5–6.

rather than a number, the interrogative pronouns ποῖος/ὁποῖος ('of what kind, nature, species?') call for an answer within the domain of geometry, as the remainder of the lesson will make increasingly clear. The confutation of the slave-boy's first numerical answer sees Socrates drawing (ἀναγραψώμεθα, 83b1) the diagram of the four-feet-side square by lengthening (doubling, in fact) the sides of the first square, thus obtaining four two-feet-side squares (83b3–4); the argument returns arithmetical in nature as Socrates, stating the impossibility of four-times being equal to twice (83b6–7) since doubling the side results in a fourfold area (ἀπὸ τῆς διπλαίας … τετραπλάσιον γίγνεται χωρίον, 83c1), situates the substance of his confutation in the numerical fact that "four-times four is sixteen" (τεττάρων γὰρ τετράκις ἐστὶν ἑκκαίδεκα, 83c3).[54] In the course of his interrogation in search of the side length of the double square, Socrates punctuates the pattern of 'how long?'-questions (πόσος/πηλίκος) with insertions of 'what kind of line'-questions ('Οκτώπουν δ' ἀπὸ ποίας γραμμῆς; 'From what line is the eight sq. ft. square generated?' 83c3–4); one further attempt at a numerical solution, prompted by the consideration that the side length must be greater than two feet and less than four (83d1–5), has the slave-boy propose three feet as the required length, only to be confuted by the arithmetical evidence that three-times three feet is nine feet (83e7–8), which thus leads the search for a numerical value to *aporia*.

At this point, the switch from an arithmetical to a geometrical approach is effected through the admission that counting and calculating, ἀριθμεῖν and λογίζεσθαι, are not capable to determine the required side-length of the double square by assigning it a numerical value,[55] and the solution should be addressed in terms of pointing to a line, i.e. of geometrical construction: "Try to tell us exactly [from what line the eight sq. ft. square is generated]; and if you do not want to calculate it, just show us from *what* (line)" (πειρῶ ἡμῖν εἰπεῖν ἀκριβῶς· καὶ εἰ μὴ βούλει ἀριθμεῖν, ἀλλὰ δεῖξον ἀπὸ ποίας, 83e11–84a1).[56] True to the

54 Rightly Weiss 2001, 87: "… as Socrates quickly points out, the reason doubling the length of the side yields not a double- but a quadruple-size is that 4 ft. × 4 ft. is 16 sq. ft. and not 8 sq. ft.". In terms of the function of diagrams in the arithmetical section of the geometry lesson, we subscribe to Boter 1988, 214 who points out that "in the first part of the discussion the diagrams drawn by Socrates only serve to illustrate the calculations made".

55 However, the broader notion of *arithmētikē* and *logistikē* as they are defined in *Gorgias* 451b–c, i.e. as being concerned with the *eidē* of even and odd, their features and relations, is exactly what grounds the Euclidean proof of the incommensurability of side and diagonal of the square (*Elements* X app. 27 Heiberg) via a distinctive interplay of arithmetic and geometry, as we shall see.

56 Brown 1967, 63–4 points out that the particular position of ἀλλά (here with the sense of 'at all events', rather than the usual 'but, yet'; cf. Denniston 1954, 12 for this collocation) in the apodosis of this hypothetical clause "already brands the "deiktic" procedure

deictic character of the geometry advocated here by Socrates through the verb δείκνυμι (lit. 'to show'),[57] the second part of the lesson is conducted entirely through the diagrams drawn on the sand – there seems to be a material dimension of geometry at stake here, a connotation that Plato will criticize in the *Republic* against a standard of mathematical purity.[58] Starting anew from "our four sq. ft. square" (τὸ μὲν τετράπουν τοῦτο ἡμῖν … χωρίον, 84d3–4),[59] Socrates adds around it three squares of equal area so as to obtain a square four-times the first (84d4–e1);[60] he then detects and draws the diagonal, defined as "this line, from corner to corner, cutting each of these figures in two" (αὕτη γραμμὴ ἐκ γωνίας εἰς γωνίαν τέμνουσα δίχα ἕκαστον τούτων τῶν χωρίων; 84e9–85a1), for each

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which Socrates and the boy now turn to as inferior to the counting procedure" of the first, arithmetical part of the lesson; the main point of Brown's argument, as aptly resumed by Boter 1988, 214, is that "Socrates leaves the question of what the length of the side of the required square is for the question as how to construct a square with a double area, that is, he solves a τί-question by giving a ποῖον-answer"; in fact, Boter argues, "it is the slave who is compelled to make a shift from a purely arithmetical approach (that is, an approach involving whole numbers only) to a geometrical approach (that is, a method involving irrational numbers)".

57 On the deixis of the passage, with particular regards to the distinction between diagrams (or lines) already drawn and those in the process of being drawn see Weiss 2001, 89–90 n. 27: for the first type (existing figures/lines) the common deictic demonstrative οὗτος ('this') is used, while for the second category (figures/lines being drawn) recurse to emphatic demonstratives (the suffix -ι added to the common form οὗτος, or ὅδε, both meaning "this here" in Weiss' rendering) can be observed.

58 See in particular 510d7–e1 about geometricians "pursuing their inquiry (τοὺς λόγους ποιούμενοι) for the sake of the square as such and the diagonal as such, and not for the sake of (the image of) it that they draw". Brown 1967, 65–77 produces a thought-provoking argument according to which Plato disseminates signals in the text of our *Meno* passage that condemn the type of 'ocular' geometry being implemented in the second part of the lesson as deprived of 'mathematical purity', concerned with sense objects and exhibiting a patina of sophistical investigation.

59 Whether Socrates has drawn a brand new square of the same dimension of the first, or rather erased "the unwelcome appendages that form the 16 sq. ft. and the 9 sq. ft." and kept the original drawing of the four sq. ft. square (Weiss 2001, 89, who suggests that this is the case), there is no doubt that the personal pronoun ἡμῖν ('our') "introduces a relativizing suggestion, to the effect that it makes a difference whether the square in question is sensibly present to the men working out the argument" (Brown 1967, 66).

60 In this second, geometry-based section of Socrates' demonstration, in coherence with the object of the inquiry (namely, to detect a line rather than work out a number), references to the length/area of the lines/figures as expressed in units occur only sporadically, and the focus is on relations of size and length: 'double', 'four-times', 'how many times multiplied?' (ποσαπλάσιον at 84e1), 'how many of this size?' (πόσα τηλικαῦτα at 85a7), 'what is (the relation of four to two)?' (τί at 85a9). The sole quest for a 'how many feet'-answer (ποσάπουν at 85b1) coincides with the realization, on the part of the slave-boy, that the eight sq. ft. square is generated from the diagonal.

of the four squares, so that the four lines enclose the square on the diagonal of the original square (περιέχουσαι τουτί τὸ χωρίον, 85a2). Determining the area of the new square (the required eight sq. ft. ὀκτώπουν, 85b1) is for the slave-boy a matter of counting the number of right triangles (each being half a square) forming its surface (85a5–b1); he is finally able to point to the line generating the eight sq. ft. square,[61] the line "that is stretched from corner to corner" (85b2–3) of the original four sq. ft. square and that "the experts call diagonal" (καλοῦσιν δὲ γε ταύτην διάμετρον οἱ σοφισταί, 85b4).[62] Socrates' summarizing formulation, which he attributes to the slave-boy ("as you affirm" 85b5) for the purpose of showing Meno that learning is in fact recollection, states that "from the diagonal (of the original square) the square with double the area is generated" (85b5–6): the obvious implication would then seem to be that, as far as the problem of doubling a square is concerned, geometry is able to complete a demonstration that arithmetic and the domain of integers, in view of the aporia determined by the incommensurability of side and diagonal of the square, cannot deal with.[63]

But are things really so straightforward? As Malcolm Brown has solidly argued through textual comparison, the mathematics of the slave-boy passage should be seen against Plato's engagement with the work of the Pythagorean thinker Archytas of Tarentum, whose contribution to the advancement of both the arithmetic and geometry of his time has been widely recognized.[64]

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61 The ποῖος-question ("from *what* line?" ἀπὸ ποίας γραμμῆς; 85b1–2) receives an answer ("from this one" ἀπὸ ταύτης) that is almost pre-geometrical in its pointing to a sense object – a line in the sand; according to Brown 1967, 71 the answer "fails to identity it [*sc.* the diagonal] by any property which is geometrical, properly so called".

62 As argued by Brown 1967, 71–74, the *sophistai* mentioned by Socrates might just be the Sophists; we do not entirely endorse, however, the complex argument proposed by Brown for considering the second part of the slave-boy passage "essentially an exhibition of a sophistical course of argument leading not to knowledge of an eternal truth, but merely to a plausible opinion" (p. 74).

63 For this view, which is part of the broader argument about the *Grundlagenkrisis* of Pythagorean arithmetic upon discovery of the incommensurability, see, among others, von Fritz 1945; for well-grounded criticism of the 'foundation crisis' argument see e.g., Burkert 1972, 455–465, Szabó 1978, 94–97 and (in the context of the notion of scientific revolutions as coined by Kuhn 1962) Dauben 1992, 52–57.

64 Brown 1967, 77–87: the date of composition of the *Meno*, which a growing consensus places "shortly after Plato returned from a visit to Magna Grecia" (p. 78), seems to reinforce the hypothesis that the dialogue was written under the vivid memory of, and bore the influence of Archytas. Archytas' mathematical achievements (including harmonics, which was seen as an application of arithmetic) are discussed at length in Huffman 2005 and Knorr 1975, 211–225; on the relationship between Archytas and Plato see now Schofield 2014, 71–78.

Brown is able to trace the relevance, for the *Meno* geometry lesson, of several mathematical accomplishments by Archytas, especially in the field of proportion theory (geometric, arithmetic, and harmonic means) but also in his celebrated solution to the duplication of the cube.[65] There is, however, a fragment by Archytas (DK 47B4) whose significance for the question of the relationship between arithmetic and geometry is especially remarkable, since it would seem to overturn completely the conclusion of the *Meno* geometry lesson. What is said there is that arithmetic (Archytas employs the term *logistikē*, in the Doric form λογιστικά) "seems to be far superior to the other disciplines with respect to wisdom, and to deal with what it wishes more clearly (ἐναργεστέρω) than geometry. And again, in those respects in which geometry is deficient, arithmetic completes proofs (ἀποδείξιας ἁ λογιστικὰ ἐπιτελεῖ) and equally, if, on the one hand, there is an investigation on forms (εἰ μὲν εἰδέων τεὰ πραγματεία), [arithmetic completes] the treatment of forms as well …".[66] The fragment ends abruptly and presents a number of interpretative issues, but its core seems to be the emphasis on proofs – proofs that arithmetic can complete

65 Interesting is Archytas DK 47A19, the proof (via *reductio*) of the impossibility to insert a geometric mean between two numbers in 'epimoric' (also said 'superparticular') ratio (ἐπιμόριος λόγος), i.e. numbers whose difference measures each of them: thus, the ratio 4:2, a form of 'epimoric' ratio, entails that "the geometric mean between any number and its double is not expressible numerically", which in turn corresponds to the "impossibility, within arithmetical limits, of doubling the square" (Brown 1967, 80). Brown (p. 83f.) sees in Archytas' geometrical/mechanical solution to the duplication of the cube an instance of the kind of 'material' geometry that Plato regarded as suspicious (Plutarch *Table-Talk* 8.1). Hippocrates' reduction of the problem of doubling the cube to finding two mean proportionals between two given lines in continuous proportion (Eratosthenes in Eutocius, *Commentary on Archimedes' de Sphaera et Cylyndro* II = Heiberg III 88.10–14) is apparently the earliest attempt at a solution; Eratosthenes' 'letter' to King Ptolemy (reported by Eutocius = Heiberg III p. 104) mentions even earlier attempts at solving the cube duplication, cursed by "the naïve assumption that to double a given solid, one needed only double each of its sides" (Brown 1967, 82): the wordings of Eratosthenes in explaining the mistake are very close to *Meno* 83b–c.

66 The translation is mainly based on the one offered by Huffman 2005, 225. Huffman's defense of the authenticity of the fragment, deemed spurious by Burkert 1972, 220–221 n. 14, is convincing and well-grounded (Huffman 2005, 225–227), as are the additional arguments brought by Burnyeat 2005, 42–44 to redeem the apparent mathematical nonsense (so Burkert) of the statement that λογιστικά helps where geometry fails. Burkert (1972, 221 n.14) protests that "Archytas could determine $\sqrt[3]{2}$ (used in doubling the cube) geometrically, but not arithmetically": as Knorr 1975, 311 observes, "certain classes of problems in geometry, e.g., the construction of irrational lines, can only be completed by means of arithmetic principles".

and that geometry cannot.[67] And while arithmetic and geometry are generally kept as separate disciplines in 5th–4th century BCE Greek philosophy, each having its own domain of definitions, subject matter, and demonstrations,[68] there is a particular area of ancient mathematics that "needs the techniques of both disciplines, and thus must be viewed as a composite of arithmetic and geometry":[69] this area is the study of incommensurability, and the so-called 'Pythagorean' proof of the incommensurability of side and diagonal of a square, transmitted at the end of the tenth book of Euclid's *Elements*, seems to provide a remarkable instance of the case made by Archytas (a Pythagorean himself), i.e. of arithmetic (or, better, number theory) completing a demonstration that geometry cannot complete.

7 Arithmetic *cum* Geometry: the Proof of Incommensurability (*Elements* X app. 27 Heiberg)

But what exactly is the mode of interaction of arithmetic and geometry in the study of incommensurability? A point of immediate evidence has been made by Wilbur Knorr, who observes that, although book X of the *Elements* (which treats incommensurable magnitudes) only preserves the geometric portion of the theory of incommensurability, "the very notion of 'commensurability'

67 Burnyeat 2005, 38–42 draws on another, probably Aristotelic passage (Iamblichus *On the General Science of Mathematics* 25, p. 78 Festa) connecting Pythagorean philosophy with mathematical proofs – a trait that does not emerge in Aristotle's account of Pythagoreanism in the first book of the *Metaphysics* – to delineate a picture of Archytas as a 'non-canonical' Pythagorean, interested in applied number theory (harmonics) and applied geometry (optics).

68 See e.g., Aristotle *Posterior Analytics* 75a38–b6, aptly quoted by Knorr 1975, 309–310, where the fact that *arithmētikē* and *geōmetria* have each its own *genos* and style of proofs is exemplified by the impossibility to prove a geometrical proposition by arithmetic (75a39), and more specifically, "to apply the arithmetical proof to the attributes of extended magnitudes, unless magnitudes are integers"(75b4–5). Brown 1967, 84–85 discusses Proclus' assessment of the relation between arithmetic and geometry, one case of which is just the problem of the double square, where "it is possible to find out in geometry the square which is the double of another square, while we do not have the numerical solution (ἐν ἀριθμοῖς δὲ οὐκ ἔχοντες) if not with one unit missing (ἑνὸς δέοντος)" (Proclus *On Euclid's Elements Book I* p. 59–61 Friedlein).

69 Knorr 1975, 311. One branch of ἀριθμητική prominently contributing to the theory of incommensurability is number theory; as for Archytas' notion of λογιστικά in fr. B4, it seems to be encompassing the whole sphere of the "science of number" (Huffman 2005, 240). The first scholium to book X of the *Elements* (Heiberg 1888, V, 416) traces the discovery and study of incommensurability to the Pythagoreans: see Heath 1956, vol. III, 1.

immediately entails an arithmetic equivalent":[70] the reference is to proposition 5 of book X, where commensurable magnitudes are said to have "to one another the ratio (*logos*) which some number has to another number" (τὰ σύμμετρα μεγέθη πρὸς ἄλληλα λόγον ἔχει, ὃν ἄριθμὸς πρὸς ἀριθμόν).

In a different fashion from the style and mathematical manner of book X, the arithmetic of the proof of the incommensurability of side and diagonal (from now on, for the purpose of brevity, proof X app. 27) draws on the theory of odd and even, a fundamental doctrine of Pythagorean number theory which is preserved in two sections of the arithmetical books of the *Elements*: definitions 6–11 at the opening of book VII, and propositions 21–34 in the final block of book IX. This body of dyadic arithmetic, extended to include the notions of prime number, reduction to least terms of a ratio, greatest common divisor, and a relevant part of the propositions of book VII, represents essentially the type of number manipulation that allows a weaver to consistently generate patterns on a loom, as we have shown elsewhere.[71]

The inclusion of the doctrine of odd and even into Euclid's *Elements*, in Burkert's dismissive opinion "a trivial appendage to the sophisticated number theory of books 7–9",[72] seems to serve the only scope to ground the arithmetical basis for proof X app. 27 – no other application of the propositions 21–34 of book IX is found in the whole of the *Elements*, with the sole exception of prop. 36 on perfect numbers. Oskar Becker's reconstruction of an archaic, genuinely Pythagorean shape of proofs for the self-contained complex of dyadic arithmetic, carried out via the arrangement of *psēphoi* and with each proposition deriving from the previous one in a sequence of logical concatenation, has made a strong case for the existence of an early Pythagorean corpus of deductive mathematics based on the features and properties of odd and

70 Knorr 1975, 310. The geometrical method of *anthyphairesis* (ἀνθυφαίρεσις), i.e. 'continual subtraction', laid down at *Elements* X 2, allows for proofing the incommensurability of two magnitudes in the case when no common measure will be found (in the language of Euclid, when "the remainder of two magnitudes never measures the magnitude before it") through mutual subtraction (on *anthyphairesis* in Book X see Knorr 1975, 255–257).

71 Cf. Fanfani and Harlizius-Klück (forthcoming).

72 Burkert 1972, 434. Similarly, Becker 1992, 87: "the content of the propositions [book IX prop. 21–34] is extraordinarily elementary, not to say trivial, in relation to the deeply penetrating and carefully worked out number-theoretic ideas of the preceding sections of the arithmetic Books VII, VIII, IX, and offers in contrast to them nothing at all". In fact, as Burkert 1972, 435 is ready to admit on the basis of Oskar Becker's reconstruction of the original shape of the proof of IX 35 and 36, the theory of odd and even finds a significant application in the proposition (36) about perfect numbers which closes book IX of the *Elements*: see Becker 1936 (excerpts from this seminal article are quoted here in the English translation published as Becker 1992).

even numbers, with pebbles representing a support for proof. Such corpus, apparently included in the *Elements* for its historical value, has been partially reshaped in order to fit into the style of Euclidean mathematics – a cosmetic operation that has left visible traces in the transmitted form of the proof of the incommensurability of the side and diagonal of a square.[73]

In terms of contents, proof X app. 27 sets up to prove that "in square figures the diagonal (*diametros*) is incommensurable in length with the side"[74] in the form of a *reductio ad absurdum*: Euclid demonstrates that the assumption of the side and diagonal being commensurable leads to the contradictory result that "one and the same number is odd and even" (συμβήσεται τὸν αὐτὸν ἀριθμὸν ἄρτιον εἶναι καὶ περισσόν). Because of this, the opposite, which is the incommensurability of side and diagonal, must be true.

The proof unfolds along a "continued reflection"[75] on the double square, in an interesting interplay of geometry and number theory: the hypothenuse theorem (*Elements* I 48), referred to at the beginning of the demonstration, grounds the geometrical component of the proof on the knowledge that the square on the diagonal is double the square on the side; however, a switch to dyadic arithmetic is necessary for the *reductio*-argument to work: if the side and the diagonal have to be commensurable, it is necessary that, once seen as representing two integers, one of them be odd and the other even, i.e. they have to be in reduced terms. At this point, the features of even and odd numbers play a prominent role in the demonstration: the square on the diagonal, being double the square on the side, has to be an even square number, and its side (the diagonal) must thus be even as well, with the side of the original square necessarily an odd number (and its square an odd square number). The proof makes then its final step: being the diagonal an even number, it can

73 See especially Becker 1936 and, for a slightly different version of the *psēphoi* proof of X app. 27, 1966, 52. Becker's attempt at reconstructing a layer of deductive arithmetic in the Pythagorean practice of arranging pebbles to represent numbers (the so-called 'figured numbers') remains a fascinating hypothesis to these days, in that it makes excellent sense of the incorporation of dyadic arithmetic into the *Elements*: with slight changes, Becker's view is endorsed by Knorr 1975, 131–154 and accepted by Zhmud 2012, 262 fnn. 81,82; Burkert's more skeptical attitude towards the deductive character of proof through pebble arithmetic is grounded on the fact that "a proof with ψῆφοι is essentially inductive and pictorial" (1972, 435).

74 Προκείσθω ἡμῖν δεῖξαι, ὅτι ἐπὶ τῶν τετραγώνων σκημάτων ἀσύμμετρός ἐστιν ἡ διάμετρος τῇ πλευρᾷ μήκει (Heiberg-Stamatis vol. III p. 231). Detailed accounts of the proof are Knorr 1975, 23–28, and Hahn 2017, 142–248.

75 We borrow this expression from Robert Hahn, who defines the proof "a continued reflection on just the sort of diagram that must have been made by Thales when he measured the height of a pyramid …", namely "on the isosceles right triangle" (Hahn 2017, 147).

be halved, and a square can be constructed on its half: this square, in turn, will represent an even square number, and it will be a fourth of the square on the diagonal. Being the square on the side (of the original square) half the square on the diagonal, it has to be the double of the square built on the half of the diagonal: it thus needs to be an even square number, and its side (i.e. the side of the original square) has to be an even number – which is impossible, given that it is an odd number.

Admittedly, this is a reduced summary, a sort of skeleton of the proof, stripped of a number of stylistic features and minor argumentative passages serving its inclusion into the manner of proofing typical of the *Elements*. Our purpose is rather to invite comparison with the *Meno* geometry lesson: once the arithmetic of reckoning characterizing the first part of the slave-boy dialogue is substituted by the assumptions of dyadic arithmetic, the diagram drawn by Socrates on the sand – including the initial square, the double square on the diagonal of the first, and the larger square having four times the area of the initial square – could be used as an illustration of the proof of incommensurability.[76] Indeed, when cast in this basic, unadorned version, proof X app. 27 might be thought of as an instance of *logistikē* (as number theory) assisting geometry in completing proofs, to use Archytas' wording in the fragment discussed above (DK 47B4). A further attempt at recasting proof X app. 27 in its alleged 'primitive' Pythagorean form, namely as an arrangement of *psēphoi* illustrating the arithmetic operation of continuous halving, has been proposed by Becker: we shall see that the manner of indirect proof through pebbles does not work for the incommensurability proof; however, as the final section of this contribution shows, constructing the woven pattern of the double square with *psēphoi* representing threads allows for a different manner of demonstration (proof by contradictory cases), and helps understanding how weaving handles both the geometrical and the arithmetical problem of doubling the square.

On the one hand, proof X app. 27 has been seen as the genuine, Pythagorean proof of incommensurability, placed for its intrinsic historical interest at the end of book X as a sort of archaeological homage by the collector of the *Elements*.[77] However, the most authoritative modern editor of the *Elements*, Heiberg, considered it spurious and relegated it to an appendix for reasons of content and style. By providing a short historical-philological review of the question, our purpose is to raise a few points of interest: either embracing or rejecting the authenticity of the version that we possess, i.e. the one

76 The comparison is in fact proposed by Knorr 1975, 26–27: see above.

77 Becker 1992, 88 proposes to see the placement of the proof at the end of book X as grounded "on reverential grounds"; cf. also Heath 1921, I, 90–91.

transmitted by (at least a branch of) the manuscript tradition of the *Elements*, has no direct impact on the argument that we are making, since the antiquity of *a version* of the proof employing the properties of the odd and the even is an uncontroversial fact.

A sketch of this proof is famously provided by Aristotle in *Prior Analytics* 41a29 as a paradigmatic instance of argument *per impossibile*:[78] this testimonium, and the fact that for Aristotle it is sufficient to hint at the proof without giving any details, have been taken as substantial evidence for the relative antiquity of the theorem. There are, however, spies in the text of an older stratum of Pythagorean number theory: the most telling is the neat distinction between unit (μονάς) and number (ἀριθμός) early into the proof, when the numbers EZ and H (having the same ratio as AΓ and AB, respectively diagonal and side of the original square) are required to be the least terms in that ratio; EZ cannot be a unit, since it is a greater number than H, and both have to be integers. Aristotle (*Metaphysics* 986a20, fr. 199 Rose) reports that the unit was both even and odd for the Pythagoreans – his source is probably Philolaus DK 44b5, where the even-odd (ἀρτιοπέριττον) features as the third species of number, resulting from a mixing of the two proper species of number (δύο μὲν ἴδια εἴδη), even and odd; there is, in fact, another possibility to interpret ἀρτιοπέριττον, i.e. as an even number whose half is odd (e.g., 6 or 10; this variant is also found in Aristotle, fr. 47 Rose, reported by ps.-Plutarch in *De Musica*).[79] In the first hypothesis, the author of the proof would with this move wish to avoid the one case where a number not only might, but *has* to be both even and odd – namely, the case of the unit. Interestingly, as noted by Knorr, necessary

78 While illustrating the mechanism and logic of an argument *per impossibile* (inferring syllogistically what is false, and proving hypothetically the original conclusion when impossibility arises out of contradiction), Aristotle readily gives the example of the incommensurability of the diagonal and the side, "since odd numbers are equal to even if it [the diagonal] is supposed to be commensurable" (διὰ τὸ γίνεσθαι τὰ περιττὰ ἴσα τοῖς ἀρτίοις συμμέτρου τεθείσης); a second reference occurs a few pages further into the *Prior Analytics* (50a35–38). The most thorough textual analysis of proof X app. 27 is carried out by Knorr 1975, 22–26. As Fowler 1999, 290–291 observes, the incommensurability of side and diagonal of the square is an all-favorite mathematical example in Aristotle, who refers to it around thirty times.

79 See the rich discussion on ἀρτιοπέριττον in Huffman 1993, 186–190, who propends for identifying the even-odd as the unit; cf. also Burkert 1972, 264 n. 124, who points out how the even-odd (in the sense of an even number having its half odd) becomes with the Neopythagoreans a subcategory of even (see Nicomachus of Gerasa *Introduction to Arithmetic* I 9.1).

for the proof is that H, rather than EZ, not be a unit: H is in fact the number that expresses the contradiction, resulting to be both odd and even.[80]

Against this archaic layer, several clear signs of stylistic and argumentative reworking stand out; one is the recourse to, or explicit quotation of, theorems much more general than what the proof would require:[81] the reduction to the least terms of a ratio is unnecessarily complemented by the theorem of relative primality (VII 21), while all that is needed is that the two numbers are not both even; to state that the square of an odd number is odd, the proof recalls theorem 23 in book IX (and odd multitude of odd numbers results in an odd number);[82] the explicit move from magnitudes to integers, with the appeal to X 5,[83] is obviously a switch that would not have been available to early Pythagoreanism, as it presupposes the theory elaborated within the logic of book X of the *Elements*.

Heiberg's reasons for considering proof X app. 27 a late interpolation have to do partly with matters of manuscript traditions, and partly with the impression that the proof is mainly reiterating an aspect of X 9 (squares on straight-lines that are commensurable or incommensurable), without adding anything substantial to the mathematical contents of book X. However, Heiberg is ready to admit the antiquity of the *argument* of the proof, and even to follow Hankel in tracing it back to the Pythagoreans: the proof might thus have been added for historical interest at some point in the textual tradition of the Elements.[84]

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80 See Knorr 1975, 24, who aptly remarks that in the alternative version immediately following proof X app. 27 in the Heiberg-Stamatis edition (III p. 410–412, introduced by the label Ἄλλως) "the step is given correctly".

81 An aspect that Becker 1992, 89 explains as the lack of "a sense for the economy of the means of proof", a characteristic of the *Elements* as a whole that imposes the necessity, for the historian interest in reconstructing "the original form of a propositional complex later included in Euclid's complete systematic presentation", of replacing "all lemmata framed too generally with immediately sufficient, simpler ones"; cf. Knorr 1975, 25–26.

82 As Becker 1992, 88 observes, this mention of IX 23 is "the sole place in the *Elements* in which the theory of odd and even is used".

83 *Elements* X 5 "Commensurable magnitudes have to one another the ration which (some) number has to (some) number" (Τὰ σύμμετρα μεγέθη πρὸς ἄλληλα λόγον ἔχει, ὃν ἀριθμὸς πρὸς ἀριθμόν).

84 Knorr 1975, n. 15 p. 52 discusses this matter at length, valuably reporting that the proof appears as the last of book X in codex P (Codex Vaticanus Graecus 190) and in the Theonine branch of the manuscript tradition. Heiberg's note (in the 'Prolegomena critica', vol. V, p. LXXXIV of his 1888 edition of the *Elements*) reads as follows (our translation from the Latin): "app. 27 is certainly spurious, not just because it is inserted among other patently spurious additions, but also because this demonstration is, after X 9, completely useless, in that it verbosely exposes a particular case of that proposition. In fact, we know from Aristotle that this same demonstration was known to him, and plausibly Hankel

A further, philologically strong argument against the transmitted version of the proof has been adduced by Knorr on the basis of the commentary by Alexander of Aphrodisia on the *Prior Analytics* passage mentioned above: it can be shown that Alexander, writing in the 2nd century AD, had a copy of the *Elements* which did not feature proof X app. 27 as we have it.[85]

Be this as it may, we return to Becker's reconstruction of a 'primitive', authentically Pythagorean manner of proving the theorems of dyadic arithmetic through the arrangement of numbers as *psēphoi* and via the mere doctrine of the odd and even – that is, without recourse to the theory of proportion and to concepts like 'relative prime to' and 'smallest terms of a given ratio', both of which are part of the 'Euclidean' presentation of proof X app. 27. While different dispositions of pebbles (linear, right-angled, squared, rectangular) seem able to illustrate, and even prove, a number of propositions of dyadic arithmetic in Becker's reconstruction, including part of the complex prop. 36 on perfect numbers, problems arise when addressing proof X app. 27 through his elementary version of dyadic arithmetic and the type of ψηφοφορία (i.e. arrangement of *psēphoi*) he proposes.[86] As Burkert aptly objects, it

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ascribed it to the Pythagoreans, founders of this doctrine; therefore, also in this edition we have considered it an interpolation inserted for historical purposes".

85 Alexander of Aphrodisias *On Aristotle Prior Analytics* I 23 p. 260 Wallies; as Knorr 1975, 228–230 demonstrates, Alexander is able to quote correctly a number of passages from the *Elements*, but when he is expected to draw on proof X app. 27 for explaining the context of Aristotle's reference to the incommensurability, the demonstration he gives is a different one and, characteristically, it deviates significantly from proof X app. 27 when the odd and even are introduced. Knorr's conclusion, not entirely convincing, is that Alexander had a copy of the *Elements* where the proof of the incommensurability of side and diagonal did not include the odd and the even argument, and he is forced to draw from different sources in order to integrate the odd and even part as a commentary to Aristotle's mention of it.

86 See Becker 1992, 99 (proof through continuous halving, with description of pebbles arrangement) and 1966, 52 ('primitive' demonstration of $a^2 = 2b^2$ through the support of a graphic proof, different from Becker's usual *psēphoi* representations, where the square number a^2 should be laid out with *psēphoi* once, and b^2 twice). Literary attestations of the practice of investigating the features of numbers by arranging *psēphoi* in several (often geometrical) shapes are limited in number, but significant; one, in particular, seems to allow for a connection between *petteia*, a board game played with pebbles, and the study of incommensurability. In Plato's *Laws* 820c4–d2, in the context of a broader discussion of the notion of commensurability and incommensurability (and the dishonorable status of ignorance in these matters enjoyed by the Greeks), the Athenian addresses the nature of the reciprocal relation between commensurables and incommensurables (τὰ τῶν μετρητῶν τε καὶ ἀμέτρων πρὸς ἄλληλα ᾗτινι φύσει γέγονεν, 820c4–5); it is highlighted the importance to distinguish (διαγιγνώσκειν) the two kinds when investigating them and "constantly proposing such matter to one another, spending time in a much nicer

appears counterintuitive that early Pythagoreans, following the steps of the *reductio* proof, would have thought in advance of a pebble arrangement corresponding to $a^2 = 2b^2$, "so as to go on drawing further conclusions from this contrary-to-fact postulate": every practitioner of pebble arithmetic would have known very well, as a result of an *inductive* discovery, that "there are no pebble diagrams to be devised which satisfy the equation $a^2 = 2b^2$".[87] Becker's 'algebraic' demonstration through continuous halving of the diagonal and the side brings to two alternatives, according to IX 32–34:[88] an odd number either on the left of the equation (i.e. the diagonal being an odd number) or on the right (i.e. the square being an odd number); both are impossible: the first alternative yields an odd square number which has to be double of another square number, and the second gives a number having its half odd, i.e. (according to IX 33) an even-times-odd number, and thus never a square. While the *reductio*, as indirect proof, does not comply with the way of arguing through pebbles typical of Pythagorean arithmetic, we propose to look at *psēphoi* arrangements as representation of woven patterns made of discrete units and implementing many of the definitions and propositions of dyadic arithmetic:[89] in the case at hand, i.e. the double square pattern, the ψηφοφορία of threads is able to engage both the geometry and arithmetic of weaving, as we shall see, and allows the proof of the incommensurability of side and diagonal to be illustrated (though not demonstrated!) as a proof by cases. The two different alternatives, the side of the original square being either an odd or an even number, may be explored in order to demonstrate that incommensurability in arithmetic and geometry cannot be directly transferred into weaving, but weaving (as a variant to pebble arrangements) can illustrate certain aspects of incommensurability.

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way than like old men do, playing *petteia*" (820c5–9); Clinias' answer is remarkable, since he observes that the game-board (πεττεία) and "those disciplines" (ταῦτα τὰ μαθήματα, clearly referred to the study of commensurability and incommensurability) "do not seem to be very different from each other" (ἔοικεν … οὐ πάμπολυ κεχωρίσθαι, 820d1–2).

87 Burkert 1972, 436.

88 IX 32: "Each of the numbers (which is continually) doubled, starting from the dyad, is an even-times-even number only"; IX 33: "If a number has an odd half then it is an even-times-odd number"; IX 34: "If a number is neither (one) of the numbers doubled from a dyad, nor has an odd half, then it is both an even-times-even and an even-times-odd (number)".

89 A detail discussion of how ancient weaving and dyadic arithmetic are related is carried out in Fanfani and Harlizius-Klück (forthcoming).

8 Geometry Dressed as Algebra or: Why There Is No Incommensurability in Weaving

Weaving employs threads that come as continuous lines in our imagination and thus are perfectly suited to do geometry. In fact, early geometry was done with threads which supply the geometer with a ruler that is not only easy to carry, but perfectly straight under tension (thus the words for the geometric lines stem from words for operations with threads: English "line" and German *Linie* from *linum*, the Linen thread, "stretched line" from the taut thread, German: *Strecke*, a derivative from the verb *strecken* which denotes the stretching of the thread) and with a similarly easy-to-carry and variable compass. However, this is not how a weaver employs her threads. Beyond aligning the horizontal and vertical parts of the loom along the parallels and plumb lines of the warp threads, the weaver does not use geometry for designing the pattern of the fabric. The calculation of the doubled square pattern might give a good example for understanding this crucial difference between a pattern approach informed by weaving and one by geometry.

Supplied with several elements from the mathematical discussion of the double square, we now move back to the weaver and her typical approach to generate patterns by classifying threads according to number properties and organizing them as lines. We pick up such elements, namely the odd-even difference, the representation of numbers and their forms as pebbles, as well as the possibility to argue about number properties with such pebbles, in order to sharpen out a further difference between calculating in ancient weaving and our common mathematical approach to counting and measuring. For the following, we concentrate on the relation of arithmetic and geometry as they play out in the construction of a fabric.

Let us imagine the slave-boy going home after his lesson in the *Meno*-Dialogue still pondering the exercise in his mind. When entering the house, he encounters a girl[90] wearing a *peplos* with a pattern that he never realized in detail. Now, he instantly notices the pattern with the double square evenly distributed over the whole fabric (Fig. 8.2).

Happy to contribute some intelligent remark to her work, the slave-boy points to the basic diagram he recognizes as the one drawn by Socrates and

90 This girl is probably not a slave. The Andokides painter frequently depicts that *peplos* type with double squares as dress for Athena, goddess of wisdom, technology, and weaving, on the red-figure side of bilingual vases. See the bilingual amphorae in Munich, State Collection of Antiquities 2301, Paris, Musée du Louvre F204, and London, British Museum B 193.



FIGURE 8.2 Drawing of Grecian female with dress, from Hope 1812, Plate 143
PUBLIC DOMAIN

claims by pointing to the respective visible lines (Fig. 8.3): "This square area here is exactly double the size of this square."[91]

The girl looks down at her dress and says, "Oh, I see what you want to say. Indeed, by looking at textile patterns, you might get an idea how to compare areas like in geometry."[92] And in order to show off with his new knowledge, and as the crossings of the threads can be counted, the slave-boy is keen to demonstrate the doubleness of the diamond square in relation to the small square in the middle of the selected pattern repeat, starts to count, and – shrinks back in astonishment.

Encountered in that weaving grid, the doubleness that seems so obvious does not hold: "There is one thread crossing too much for making the diamond square double the small one" the slave-boy interjects. "Yes", says the girl, and explains, "To weave such a diamond square which has its geometrical diagonals

91 There are at least four possibilities to detect the diagram in the pattern. We concentrate on one where the sides of the original square lie parallel to warp and weft direction, and thus the diagonal is not represented by a thread to point at.

92 A stunning example for this is the binomial formula $a^2+b^2 = a^2+2ab+b^2$ that is readable from several diced patterns some of which have been found in the remnants of Palmyra. See Harlizius-Klück 2009, Fig. 22, p. 45. For diced fabrics in Palmyra see Schmidt-Colinet, plate 13 a, b, c.

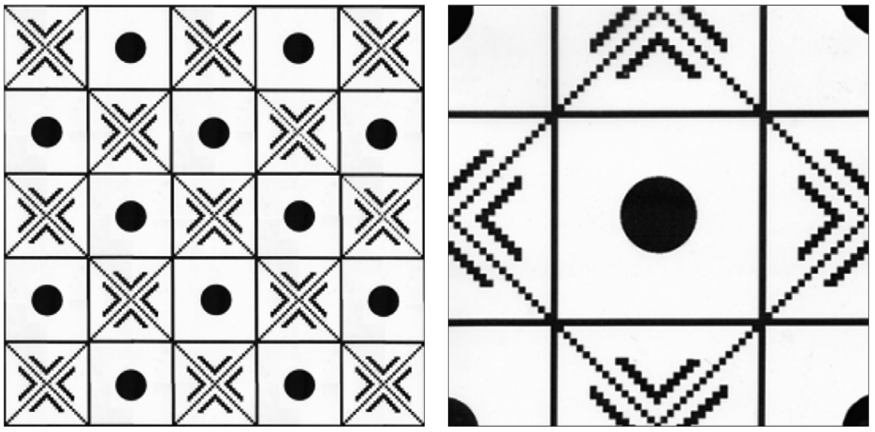


FIGURE 8.3 Representation of the peplos-pattern and detail with square diagram to the right
PUBLIC DOMAIN

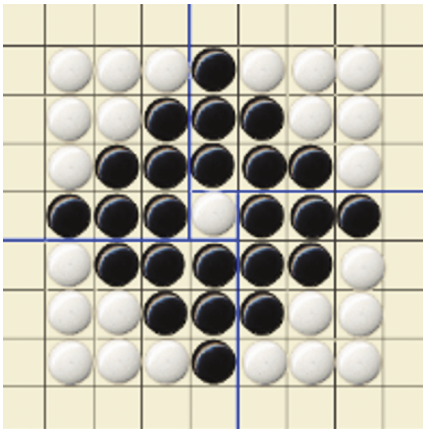


FIGURE 8.4
Pebble representation of repeat demonstrating the composition from eight triangle numbers plus one monad
GRAPHICS ELLEN HARLIZIUS-KLÜCK

in weft or warp direction I need an odd number of warp threads in the repeat, which results necessarily in an odd number of crossings. Instead, the number of crossings covered by the small square, doubled, would require an even number." As illustration, she arranges a diagram of pebbles on the floor in columns and rows representing the thread-crossings and the problem (Fig. 8.4).

When you now try to find the shape of the original small square, you can only come up with oblong numbers here consisting of two triangle numbers (Fig. 8.5). "And then you can see the surplus pebble in the middle." "And when you simply take thinner threads?" "Then you will have bigger oblong numbers, but cannot get rid of the middle monad."

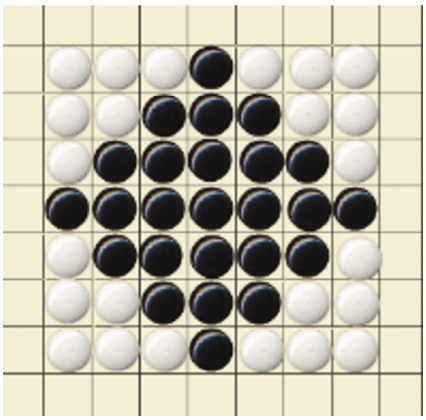


FIGURE 8.5
Pebble representation of repeat with an odd number of threads. The diamond square has 25 pebbles
GRAPHICS ELLEN HARLIZIUS-KLÜCK

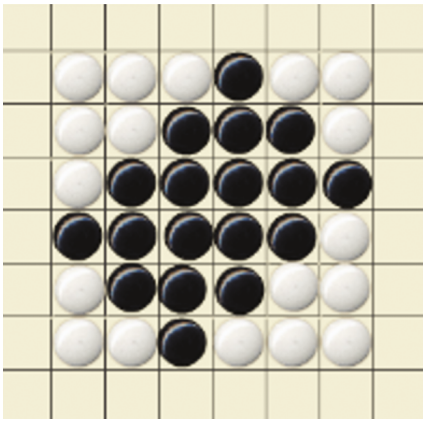


FIGURE 8.6
Pebble representation of even repeat: Black area with 18 pebbles and small squares of 9 pebbles
GRAPHICS ELLEN HARLIZIUS-KLÜCK

"But then, why do you not use an even repeat? It should work like this …" And by re-arranging the grid, he comes up with a new figure (Fig. 8.6) and needs to admit, "Oh, then the calculation does work, but the diamond is not a true square!" "We do not use our threads as you can use them in geometry. We can only generate points at rectangular crossings whereas in geometrical argumentation you can ignore the direction. However, by weaving the solution that you might call wrong from your point of view, we get a better visual result. The eye is able to see the abstract geometrical figure without following the material substrate of its construction. This is the same for woven patterns as it is for the diagrams that the philosophers draw, which are also there to get the ideal construction as an idea from it, but not as a physical and measurable result. You can recognize the woven patterns as made up out of squares, even though they are never flat and plane when they stretch and squeeze around my

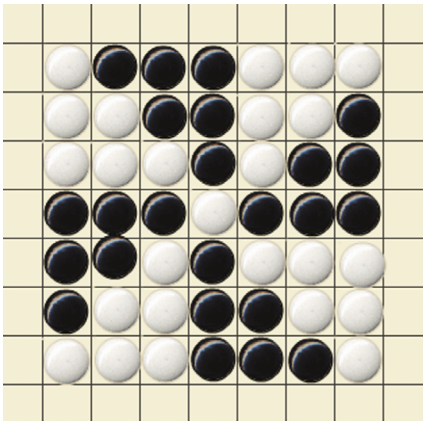


FIGURE 8.7
What we would today write as:
$\sum_{n=1}^{\infty} 8\frac{n}{2}(n+1)+1=(2n+1)^2$
GRAPHICS ELLEN HARLIZIUS-KLÜCK

body. In weaving, we have everything commensurable and whatever small and thin our threads are, the doubled square will never have double the amount of crossings. Still we perfectly understand how to come closer and closer to that figure, as well as understand, why we never achieve it.

By the way, there are people in that group of Socrates who use the same argument of odd- and evenness so important for our practice for conducting what they call proofs. In particular, I know a proof that shows the impossibility of measuring the diagonal of the square-to-be-doubled by using similar arguments as we employed before. I think it is very clever to look at what weavers are doing. However, I dislike that they say at the same time that, of course, no man of sense would pursue the discussion of weaving for its own sake."[93]

"You see, the example I demonstrated before – and she again puts the pebbles in the form of the eight triangle numbers with one monad – was known to Pythagoras, condensed in the rule that each eightfold triangle number is by a monad bigger than a square number.[94] It is easier to see when you rearrange the pebbles like this. (Fig. 8.7) I would even call this a proof, because it is clear that, by increasing the image or the numbers of threads, you will never get rid of the one excess pebble in the center.[95] Oh, by the way, I use the same

93 ἦ που τὸν τῆς ὑφαντικῆς γε λόγον αὐτῆς ταύτης ἕνεκα θηρεύειν οὐδεὶς ἂν ἐθελήσειεν νοῦν ἔχων: (Plato, *Statesman* 285d).

94 According to Heath, this 'algebraic' rule was probably known to the early Pythagoreans, quoted by Plutarch, and used by Diophantus (Heath 1921, 84, with reference to Plutarch, *Platonic questions* v 2.4, 1003 F, and Diophantus IV 38). See also Becker 1966, 42.

95 Generating the sequence of square numbers by pebbles arrangement through placing successive odd numbers round the unit must have been a well-known arithmetical practice of early Pythagoreanism, as Aristotle reports in *Physics* 203a10–15. The passage

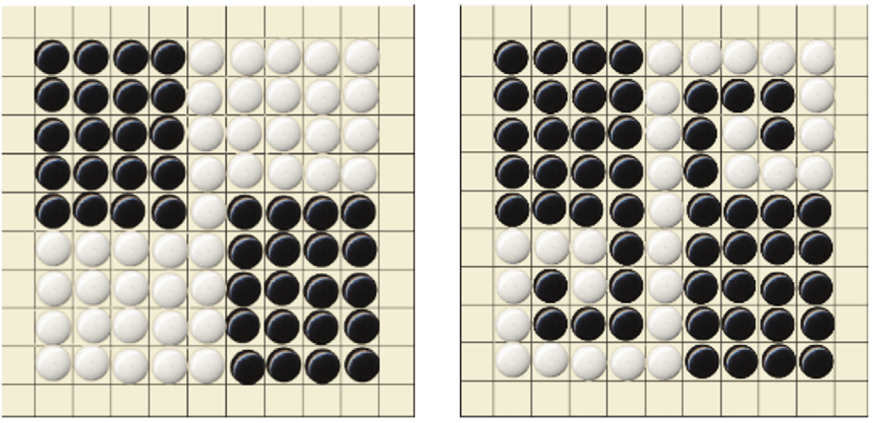


FIGURE 8.8 How to calculate a double spiral pattern
GRAPHICS ELLEN HARLIZIUS-KLÜCK

principle when I weave the S-spiral from the lower border of my dress in tapestry. Then I represent the pairs of triangles as rectangles (see Fig. 8.8) and add some black pebbles in the white areas for the figure S."[96]

"Then you only need to count the pebbles for making your patterns. That is clever," says the slave-boy. However, the girl answers with a smile: "No, I can use such diagrams for odd-even calculations and for understanding the minimum requirements of the pattern I'd like to weave. The actual weaving needs many additional considerations like: will the repeat fit into the whole of warps provided by my starting-border? Will it be repeated odd or even times? How many

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is especially interesting for the use of the term *gnōmōn* in its arithmetical-geometrical sense, as "a numerical/geometrical shape preserving the species/form of the object to which it is applied" (Acerbi – Ugaglia 2015, 603), though here, as often in Pythagorean and Neopythagorean texts, it may well correspond to 'odd number' (περιτιθεμένων γὰρ τῶν γνωμόνων περὶ τὸ ἕν "the gnomons being placed round the one"; see Burkert 1972, 33 n. 27, Acerbi – Ugaglia 2015); cf. the detailed discussion in Hahn 2017, 149–153. As Burkert (1972, 427) observes, the practice of arranging *psēphoi* led, in addition to the "discovery of the rule for the series of square numbers", also to the generation of oblong/rectangular numbers (ἑτερομήκεις ἀριθμοί), "constructed … from the even numbers" and in which one could recognize "the triangular numbers, double"; on the oblong numbers see Theon of Smyrna 26.21, Nicomachus *Introduction to Arithmetic* I 19.19, II 17.1, Iamblichus *Commentary on Nicomachus' Introduction to Arithmetic* 74.19. In the context of an account of the practice of the Pythagorean Eurytus (*Metaphysics* 1092b11), who seems to have placed pebbles in shapes/pattern as to represent the structure of different beings, Aristotle compares such procedure with those who "cast numbers in the shape/form of a triangle or a square", possibly a further reference to Pythagorean and pebble arithmetic, but potentially a fitting formulation for what a weaver does, thinking of number as possibilities of form.

96 For this motif and a textile find from 9th century Gordion, see Holzman 2019, 545.

warps will I need to make it look square in the end, i.e. what is the proportion of weft to warp density. And much more."[97]

9 Concluding Remarks

The reader might wonder whether any female weaver in antiquity would be able to discuss her knowledge this way. We actually do not claim that every weaver could do it. In fact, the complexity of pattern construction mentioned in this short dialogue is the reason why formalizations of patterns historically appear very late. South American weavers who do some of the most complex textiles in the world still do not use writing or other forms of formal representation for their patterns.[98] It is the Western industrialization that forced weaving into a standard notation and technology that actually restricts the possibilities for the weaver.[99] The wide range of techniques possible to employ at a warp-weighted loom makes it difficult to determine any of them as being the one used for making the double square pattern on the *peploi*. Among the structures of the textile finds from Greece, only tapestry techniques, supplementary weft, or weft-faced patterning would do the job. Tapestries from Gordion demonstrate how complex and geometric this technique can work out.[100] In Southern Italy, apart from tabby, also twill is attested which suggests that the double square grid is possibly an abstraction of the broken diamond square (see Fig. 8.9), where threads interlace in a manner that makes geometrical shapes appear without the eye being able to follow them along any of the threads employed.[101] The lines of such geometric shapes are even less material than any triangle constructed on either paper or sand.

In the history of mathematics, the possibility to proof mathematical facts like the propositions of the theory of even and odd is deemed to transgress everyday experience. Reidemeister claims that theorems like "If an odd number measures an even number then it will also measure the half of the even

97 For several aspects of the necessary knowledge for patterning, see Fanfani and Harlizius-Klück (forthcoming).

98 For a comprehensive overview on the complexity of weaving in South America, see Arnold and Espejo 2015. Especially remarkable is their claim to speak of an Andean 'science' of weaving (19–20).

99 See Harlizius-Klück and Mamidipudi 2021.

100 Nevertheless, tapestry today is the preferred choice for figurative motifs and for weaving out the painted cartoons of artists who are not bound to the grid of a weave.

101 Textile finds of such stuctures are frequent among the preserved fabric finds in the salt mines of Hallstatt, Austria.



FIGURE 8.9 Diamond twill and detail
PHOTOS HARLIZIUS-KLÜCK

number" (Euclides *Elements* IX 30) have no practical use.[102] The reason given is that such theorems reverse the generation of numbers and instead aim at gaining knowledge on the presuppositions for constructing numbers with specific features. This is an argument taken as purely mathematical, and never practical. However, to understand the conditions for composed numbers with specific properties underlying the patterning is exactly what the weaver needs to know.[103]

The difficulty in establishing the argument of a textile origin of such an abstract way to consider numbers is mostly a matter of misunderstanding the shapes of the patterns as material substrate of the geometrical construction. To make the grid of warp and weft responsible for the geometric shape is true and false at the same time: this is what we tried to demonstrate in the fictive dialogue. For this reason, we understand the pondered conditions of weaving a double square (the distinction of odd and even numbers) as well as the resulting geometric shape (the imaginary diagram emerging from the constructive interlacement of threads) not as material but rather as immaterial conditions. If indeed, Plato refers to weaving in the *Statesman* after having observed and reflected on the processes of classification (odd-even, *diairesis*) and organization (compound numbers) of a weave,[104] and if we can imagine that readers

102 Reidemeister 1972, 10.

103 She indeed needs to *know* these preconditions. Finding out by trial and error would waste a lot of time and material.

104 The distinction into even and odd numbers provides a model for correct *diairesis* in the *Statesman* (262e3–5): further on into the dialogue, the *paradeigma* for the art of the

and colleagues follow this idea, there is a material substance, namely woven textiles, which indeed is able to shape philosophy as far as it concerns the treatment of numbers. It is incommensurability, not being a problem the weaver ever encounters, that marks the threshold where geometry needs to be established as something very different from what one can do with numbers and what one can do with (woven) threads.[105]

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statesman chosen by the Visitor from Elea (and operating through διαίρεσις) is weaving, a technology whose primary operation, διάζεσθαι, consists in fact in separating odd and even threads. In the passage, the Visitor from Elea proposes the division of number into even and odd as a mode of διαιρεῖν ('dividing') which is "better (κάλλιον) and more (closely adhering) to forms and dichotomous/dyadic" (μᾶλλον κατ' εἴδη καὶ δίχα).

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DK = Diels, H. 1951. *Die Fragmente der Vorsokratiker*. 6th ed. by W. Kranz. Berlin: Weidmann.

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PART 3

Philosophical Media and Their Messages

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CHAPTER 9

The Limited Relevance of Writing in Early Greek Philosophy and Science

Harold Tarrant

1 Writing and Effort

Before scholars had begun to reflect sufficiently on how ancient writings were composed it was perhaps natural to assume that both writing and publication in antiquity operated much as it does today, when they have become a defining characteristic of professional academics in the humanities. We worry too much about why philosophers like Socrates, Arcesilaus, and Carneades failed to write books, and insufficiently about why it was that others, especially Anaximander and most subsequent Presocratics, came to do so. However, reflection on the evidence will show us that in the late fifth and early fourth century BCE both the process and its profile in Greece must have been very different. Hence, in considering the path by which Greek science and philosophy arose and flourished, it is important to consider the place of writing and of books themselves in intellectual life down to the time of Plato.[1] We must think of the challenges that writing involved, and why it was considered worthwhile for an intellectual with new ideas to present them in written form.

When the Presocratics (and arguably even Plato) were at work, writing was certainly not the easiest of processes. Every letter had to be separately formed, and they could not be run together seamlessly let alone be typed into one's word-processing program. Once marks were made on papyrus they could not easily be corrected, so one could not record the first thoughts that came into one's head on a scroll for circulation, especially in subjects like cosmology, psychology, or political theory, where the exact choice of word could make an important difference to one's arguments and analogies. Wax writing tablets, such as were sometimes depicted in educational scenes on vases, might have been useful for drafting small important sections, as an anecdote about

1 Plato will be the source of much of my evidence, even though my primary focus will be on a slightly earlier period, rather than on the conditions in which the mature Plato worked.

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various versions of the opening of Plato's *Republic* suggests,[2] but Plato seems to have been aware of all sorts of problems that might arise from deficiencies in the actual wax.[3] While these were useful for organizing materials that would ultimately become a finished book, materials other than papyrus were bulky,[4] and not usually a convenient form for the final recording and dissemination of complex ideas woven together into a *suggramma*. Writing such as most early Greek philosophers are presumed to have engaged in required time and effort.

Important insights into the process of writing in a later era, namely the first century BCE, can be found in the papyri that preserve the so-called *Academic Index* of Philodemus.[5] The principal papyrus (PHerc. 1021, with 1691, Philodemus' two papyri constituting the *Index Academicorum* or *History of the Academy*) offers Philodemus's *draft version* of the text. Often we are informed of the sources of particular sequences of material about the Academy, so that at some time there has been some copying from sources, no doubt with changes to style and wording, but not sufficient to hide the fact that Diogenes Laertius has sometimes used the same material. Indeed Philodemus sometimes seems to cover the same matters twice, as on the date of the death of Philo of Larissa (col. 33.17–19 and 42–44). Like most of us he found the need to correct some material, which might be done with interlinear corrections or marginal notes. Sometimes he will find unexpected new material and feel the need to add it in, which might be done close to the column anywhere space was available, but might be done at greater length by an appropriate note at the relevant point (*opisthen*), followed by recording the material that had originally been omitted on the verso. Hence, this is a fine example of an *opisthograph*, and, while we have the remains of forty columns on the front, another twelve may be found on the back. Nor would it have been unproblematic to line up the verso

2 See especially Quintilian, *Institutio Oratoria* 8.6.64: neque alio ceris Platonis inventa sunt quattuor illa verba, quibus in illo pulcherrimo operum in Piraeum se descendisse significant, plurimis modis scripta; cf. a version of this story ascribed to Euphorion and Panaetius at Diogenes Laertius 3.37. There must be some truth lurking behind such stories of Plato's reworking the *Republic*, on which see Thesleff 1982, 84–85 [= 2009, 232], who also discusses Dionysius of Halicarnassus, *De Compositione Verborum* 208–9 in this context.

3 I judge from *Theaetetus* 191c–195b, especially 194c–195a, where he shows his familiarity with wax that is too hard, too soft, or insufficiently pure. Though he is talking here of the ability of wax to retain the imprint of a seal, his concept of something like wax in the soul's memory recalls the postulation of a 'writer' there at *Philebus* 39a.

4 They would defy being hidden beneath Phaedrus's cloak for instance, as happens in Plato, *Phaedrus* 228d–e.

5 Fleischer 2022 combines a great deal of information on this text in particular, from its discovery to very recent advances. Fleischer 2023 now offers a new edition in extraordinary detail, and with a considerable amount of background.

columns against the recto to judge from recent work by Kilian Fleischer and his collaborators,[6] which shows that columns on the verso may be detected running right across the space between recto columns. Finally the working copy becomes the basis for the final version, fragments of which are available in the first two cornices of PHerc 164.[7] Hence centuries after the Presocratics and Plato, composition could still be a clumsy business, even for a well-resourced author. One needed good reason to write.

2 A Plausible Story about Transmission in the Sixth and Fifth Centuries

Plato's enigmatic character 'Critias' claims in the *Timaeus* that the story of Atlantis had been passed down in his family by enthusiastic story-telling, as one might indeed expect. Verbs of hearing abound. When one meets the term γραφή at 26c3 it does not mean 'writing':

> ὥστε οἷον ἐγκαύματα ἀνεκπλύτου γραφῆς ἔμμονά μοι γέγονεν.
>
> that the story has stayed with me like the indelible markings of a picture with the colors burnt in (trans. Zeyl)

This should remind us that there was *no dedicated noun or verb for writing* in the early days. If we look up the verb γράφειν in *LSJ* we meet the meanings 'scratch' and 'draw' before we get 'write'. Critias reports that the Egyptian priest had spoken of his own country's γράμματα or γεγραμμένα which could be found in the temples, but what was he speaking of? The Academic Crantor (fr. 8) reported that 'Egyptian προφῆται said that these things were recorded (γέγραφθαι) on στῆλαι that were still preserved', but were the available records supposed to be purely pictorial, purely in writing, or a combination? What kinds of things did Egyptian records show? Surely if they were anything like the Medinet Habu 'Sea Peoples' relief (often discussed in the context of Plato's 'Atlantis'),[8] they recorded much in pictures, probably supplemented by hieroglyphics. One may compare the presence of written names on Athenian vase-paintings, for

6 See Tourniér *et alia*., 2019. Also Fleischer 2022, 57–60.

7 The third cornice has recently been identified as written in a different hand; see Fleischer 2018.

8 Here I am indebted to Victor Gysembergh's response to the paper of Christian Vassallo at a 2020 workshop in Milan on Crantor. I understand that the paper itself will appear in due course in the proceedings.

identification purposes. A story as complex as Critias's could not have been told purely by sacred *written* inscriptions on stone. So the γράμματα or γεγραμμένα which could be found in the temples either in Crantor's own day or, on a less natural understanding of the Greek, in Plato's day, might have involved quite limited use of hieroglyphs.

While I do not wish to imply that the Atlantis-story is not fiction, it is still evidence for Plato's understanding of the workings of oral and written transmission. It so happens that the *Critias* makes mention of something that might well have been written, for it emerges at 113a–b, that Solon discovered that the names had been translated into the Egyptian language; so he translated them back into Greek, and recorded them in some form now in Critias's possession. The *Critias* itself, at least in its extant form, has no names of Greeks to offer, but several names in Greek form for the people of Atlantis, their spheres of influence, and their god Poseidon. Clearly there is no suggestion here that Solon diligently recorded the entire story as it would be told by Critias, just certain details that he wanted to get right and that he could get information about. Plato appears to have assumed that, in such a case as his story presumes, the names at least would have been in script, both on the stele and in what Solon 'brought back': since a large collection of new names was not something that Solon could be expected to remember.

What this reminds us of is that the didactic and mnemonic armory in Solon's day, more or less as Greek philosophy and science was born, would have included much other than letters that could be drawn. It would have been strange, I submit, if the earliest cosmologists did not exploit pictures and diagrams to illustrate their idea of how the world functioned in much the same way as they used written illustrations such as analogies. Whatever use they made of astronomical observation would surely have had to be accompanied by diagrams. When conveying their ideas to a small group of intellectuals, this would have been an effective technique, as also for private mnemonic and research purposes. Of course the diagrams could be accompanied by some wording, telling us what a particular shape illustrated was supposed to represent, and perhaps quasi-geometrical diagrams could use letters too for identification purposes. While I know no evidence before Aristotle,[9] I should also guess that early Greek medicine would have sometimes employed visual material, either

9 In an anatomical work referred to in various places, and apparently striving for greater clarity through such illustrations, e.g., Aristotle, *Generation of Animals* 746a14–19, *History of Animals* 497a32, 511a11–14, 565a12–13, and 566a13–15. See further Cunningham 1999 and Lennox 2018. My thanks to Julius Rocca for assisting here.

to explain physiological details or to illustrate particular symptoms. Here too drawing and writing could go together for didactic or mnemonic purposes.

3 Towards the Book

Only a little writing was needed to help others visualize an early Presocratic universe, and then only if one could not speak to one's audience; writing, after all, was regarded as a *speech-substitute*. The book *speaks*.[10] More writing might be needed to explain how that universe moved and evolved when actual models or close analogies were not available. So gradually the balance shifted.[11] Until the time of Democritus,[12] perhaps, it is unlikely that many Presocratics wrote for pleasure. They wanted maximum impact for their effort, even if this could not do justice to the research and reasoning that had gone into developing their ideas. But it was not purely for their own convenience that they kept what they wrote rather brief. Reading was also more difficult, and it required trained and sympathetic readers to successfully articulate an author's intentions, especially when the subject itself was likely to involve much that was obscure. If their works were to travel around the various Greek communities of the Mediterranean independently of their author, then people had to want to read them aloud to potentially interested groups. The material needed to be condensed, and interesting at every turn. Even that did not enable much to survive very long. And in most cases it is through a combination of Aristotelian reports and late antique fragments that we know these pioneers of western philosophy and science.

The problems of studying philosophers through 'fragments' is familiar to anybody who has studied the Presocratic philosophers, the old sophists, or even the Stoics. The 'fragments' can be conveniently packaged in modern

10 The *Phaedrus* is a classic text. At 228e1 the presence of Lysias' book is treated as if Lysias himself were present and ready to deliver. Later problems with the book include its failure to answer questions or to speak in its own defence when criticized, as well as its ignorance of whom it should speak to and whom it should not (275d–e).

11 There is a growing literature on these changes, in which such works as Havelock 1963 and 1982, and Derridà 1968; my own views have been shaped by numerous predecessors and conferences. Here I shall avoid the theoretical aspects and concentrate on the relevant evidence.

12 I single out Democritus, since he differs in having had an impressive range of titles attributed to him, arranged in thirteen tetralogies by Thrasyllus (Diogenes Laertius 9.45–49) and presumably outlined in his *Preliminaries to the Reading of Democritus' Books* (*ibid.* 9.41). My guess is that he enjoyed writing and employed it as a research tool, helping him to think through the issues that occupied him.

volumes, but even in the original sources they are often found with little context and not in the same words as were originally used. It is like piecing together tiny scraps of a red-figure vase, and hoping to be able to imagine the original of which they were part. But how many of us stop to ask what these few precious shards are fragments of, and how legitimate it would be to base our assessment of the potter and illustrator upon even the whole vase if we had possessed it. Suppose we knew that this vase was one of three hundred and sixty-two that our craftsman had produced. We would surely be nervous of jumping to general conclusions on this basis.[13] But even if this was the one and only work for which he was responsible, and that he had only produced it as a variation of his other work, perhaps as a sculptor, perhaps as a painter, perhaps as a craftsman of bracelets or torques, what picture of this person as an artist could possibly emerge whether from the dismembered shards or from the reconstructed vase? We would have to have some reason for supposing that the vase *represented* the craftsman's main work, and the shards offered a representative sample of the whole.

Now let us leave the analogy and consider the implications for philosophy. *We* know each of the Presocratics as a physicist or philosopher, but how many of them would have put this down as his 'job description'?[14] Was their cosmology any more for them than an area of substantial interest? What did they see themselves as doing for their families and their wider community? And, even in the case of those who communicated in verse, what importance did they attach to their actual writing? Who was it for, what was it supposed to achieve, and how are we to judge it? In particular do the writings (or in many cases the single work) contribute centrally or peripherally to their philosophic activity? Here my view is that writings did not constitute any philosopher's philosophic activity *per se*. This does not entail that the fragments are misleading *per se* either, only in the sense that they resemble selected sound-bites bluntly stating

13 I appeal here to the problems experienced by Sextus Empiricus (or rather by his source at *Adversus Mathematicus* 135–140), in trying to make sense of Democritus' view of the criterion of truth in different works. One lacks evidence as to how any given work relates to the rest of the corpus.

14 Moore 2020 provides an important account of the developing use of the term 'philosopher' in ancient Greece. My question here concerns whether they would have used any such term to describe their profession or role in society. For the view that Xenophanes might better be described as a sophist, see chapter 14 of this volume; one lesson that we may draw from chapter 10 is that philosophers could, particularly if writing prose, try to establish a collective 'we' (an 'imagined community') who shared a common experience, a 'we' into which the philosopher himself could be fitted, but which would not, presumably, be composed entirely of philosophers any more than oral classes or discussions would be restricted to philosophers.

the doctrines that studying with them could hope to explain. In the hands of the friends of the author[15] the writings could create interest in studying without actually satisfying the curiosity very much at all. I believe that we have a parody of just such a sound-bite that could encourage study in Aristophanes' *Clouds*. Strepsiades encourages Phidippides (95–96):

> In there live chaps who when they speak convince people that the heaven is a bread oven (*pnigeus*), and it is all around us, and we are the hot coals.

> Ἐνταῦθ᾽ ἐνοικοῦσ᾽ ἄνδρες οἳ τὸν οὐρανὸν
> Λέγοντες ἀναπείθουσιν ὡς ἔστιν πνιγεύς,
> Κἄστιν περὶ ἡμᾶς οὗτος, ἡμεῖς δ᾽ ἄνθρακες.

Note that this comparison with a familiar piece of equipment from every-day life is presented as paradoxically as possible. There is no ὡσπερ or equivalent. Amazingly, we are going to *believe* that we really *do* play the role of hot coals! At that point Phidippides is sufficiently curious not to interrupt, and only at 99 does he ask who the occupants are. And only after Strepsiades' response does he react in horror. More importantly the audience's curiosity is aroused. This is the sound-bite by which Aristophanes announces his own parodic venture into Presocratic physics, one that illustrates the kind of *materia philosophiae* that is relevant to this volume.

4 Platonic Evidence on Writings

Plato, as he often does and without any intention to do so, offers considerable insights into the role of writing and how little it had really changed society by the close of the fifth century BCE. In his dialogues we encounter books by Anaxagoras, Zeno of Elea, and Euclides of Megara among the 'philosophers',[16] from Protagoras the 'sophist', and from Lysias and (less prominently) Polus among the 'rhetors'. We also meet a variety of readers, from authors and their admirers to the slave of Euclides. But the book was still rather peripheral. Even

15 I have often been concerned with the performers of Plato's works, perhaps most obviously in Tarrant 2013.

16 *Phaedrus* 97b–c, *Parmenides* 127c–128e, *Theaetetus* 142c–143c; naturally other 'philosophic' books feature in a background role, particularly that of Parmenides whose verse format ensures that it attracts quotations (*Sophist* 244e, *Theaetetus* 180e, *Symposium* 178b); also various unnamed Heracliteans at *Theaetetus* 179e7–8.

if Theodorus knows the books of the lesser Heracliteans, his condemnation of them is almost entirely based upon what they are like in face-to-face situations (179e5–180b3, b9–c5), which apparently did not include even conventional teacher-pupil situations.

We are dealing with a society that still operated much as it had done before ordinary citizens had learned to read and write. A 'sub-oral' society, perhaps. The culture of storytelling was not confined to its traditional myths, but extended to contemporary matters,[17] and the very introductions of such works of Plato as *Symposium*, *Phaedo*, and *Parmenides* demonstrated the health of the culture of story-telling in the years around and soon after Socrates' death in 399 BCE.[18] According to the account of Diogenes Laertius (2.122–123) the writing of Socratic dialogues began when a cobbler named Simon made notes on Socrates' conversations based on what he heard when Socrates visited his workshop, subsequently using them as a basis for *Sokratikoi logoi*. A single ancient book-scroll was apparently able to include just over thirty of these, so that they presumably cannot have been longer than some of the shortest contributions to the second and third books of Xenophon's *Memorabilia*, or the individual components of the *Demodokos* in the Platonic *spuria*.[19] So how long was the typical Presocratic Περὶ Φύσεως?[20] Was it any longer than the Derveni papyrus of less than 30 columns?[21] Even the *Republic* and *Laws* averaged only about 27 Stephanus pages, or fewer than 9000 words a "book",[22] presumably telling us something about what a scroll could conveniently hold. Several of what we think of as the early dialogues are also of a similar length.[23]

17 This story-telling is still visible, in different ways, in the historians Herodotus and Thucydides, much of it being due to the story-telling culture of which their sources were a part. We should remember that even drama had its origins in the telling of a tale, benefitting also from the Greek love of dramatizing stories.

18 According to Nails 2002, 308–323, the narration of these dialogues takes place in ±400, 399, and ±382 respectively, but precision is unnecessary for my purposes.

19 The four miniatures that make up this work total nearly seven Stephanus pages (about 23,000 words), and the *Republic* would suggest that it was normal for a book to contain four to five times that, i.e., not more than twenty individual contributions of that length.

20 Perhaps the easiest case to visit is that of Parmenides, for whom we possess the entire prologue, most of the *Alêtheia*, and rather little of the *Doxa*. But this last should perhaps not have been much longer than the two preceding parts together. This would mean a total of less than 300 epic lines. Nor would I exclude the possibility that Parmenides also supplied a diagram of the heavenly motions as he interpreted them.

21 Or perhaps 66 columns, since Janko 2016, 12–13, now argues for 40 missing columns on the basis of a scribal mark.

22 Details in Tarrant 2012, 53.

23 The most obvious exception is *Gorgias*, three times this length, justifying the suggestion of Dodds (1959, intro. xv, n. 3) that an Against Callicles of three books in an ancient bookseller's list referred to a *Gorgias* in three scrolls.

Simon's activity illustrates how the Socratic dialogue, as a genre of its own, could have arisen directly from the oral activities of Socrates, influenced partly and temporarily (a) by the memory of informants and (b) by the limitations of book-scrolls. Another illustration of this process is found in the extant prologue to Plato's *Theaetetus*, which details the path by which a Socratic conversation overheard by Euclides could be written in note form soon afterwards back in Megara, then expanded as well as memory would allow, checked further with Socrates himself, and revised as a result. Presumably such a process is assumed to have been natural, perhaps even normal, by Plato.[24] The fact that Euclides's close and long-term[25] friend Terpsion has only heard from him that the conversation took place, not its content, (142d–143a) implies that the book is not, at this stage (spring 391 BCE at the earliest),[26] in circulation even within a very limited intellectual circle. So, the writing of a Socratic dialogue could be expected to be a leisurely activity that involved fine-tuning, but it might well not have been intended to result in 'publication' at all. In fact 'Zeno' in Plato's *Parmenides* laments that he was denied the chance to decide whether his youthful work was to be made public or not, because somebody had stolen it and pre-empted his decision by bringing it 'into the light' (128d–e); the same passage, however, clearly implies that Parmenides' book had been brought to light, for it was known to critics and detractors (128c–d), and even to a very youthful Socrates (128a). Something akin to publication may have been intended for some writings, but not for all.

Let us then consider some of the 'books' that Plato mentions. Socrates himself is very familiar with Protagoras' *Truth*, but more importantly the young Theaetetus has read it many times (*Theaetetus* 152a). Admittedly he is studying with a mathematician who had in turn studied with Protagoras, but a young person's repeated study of a text, even of a particularly famous one, is nevertheless remarkable. But, when they try to pass beyond the *homo-mensura*

24 I do not include the detail that the close of the dialogue marks its dramatic date shortly before the trial of Socrates (by perhaps two months, Nails 2002, 321), and thus made it difficult to envisage the repeated visits between Megara and Athens of which Euclides speaks (pace Nails 2002, 320). Euclides had first made the journey home to the Megarid, a journey of well over thirty kilometres, written his notes, and waited until he was at leisure to expand them.

25 Note that Terpsion was the only other Megarian reported to have been among Socrates' *hetairoi* on the day of his death, *Phaedrus* 59c2. He, if anybody else from Megara, should already know about it.

26 Nails 2002, 320; the date of Theaetetus' battle-wounds and sickness is controversial, most scholars accepting that date of 369 BCE, which would involve his having been part of an elite force at the late age of ±45. Nails' date would presume that Theaetetus had made the discoveries for which he was known by ±25, *or* that he recovered from his bad health after the battle.

sound-bite, Socrates and Theaetetus cannot easily fathom its meaning, and there is a suspicion that this was reserved for those initiated into the 'mysteries' (156a2–3). The young Hippocrates could be depicted by Plato as convinced, in a conversation around thirty-four years earlier than that with Theaetetus, that he could acquire Protagoras's 'wisdom' only by studying with him directly – that such a person might at that time have been content to study Protagoras *through his books* does not seem to have occurred to Plato. The Peloponnesian War had not yet impeded travel between Greek *poleis*, and sophists were keen to visit Athens in search of wealthy customers. But in the second phase of the war Athens became increasingly unsafe to visit and lost much of its wealth, so that in the *Apology* (set in 399 BCE) Socrates could suggest that the youth of Athens would buy copies of Anaxagoras' books rather than be interested in learning his doctrines through an intermediary like himself (26d–e). Certainly, a book could be obtained for a fraction of the price that one would have to pay for direct instruction by a major sophist – a drachma at most, which was the price of the cheapest instruction[27] by Prodicus, which even Socrates had paid (*Cratylus* 384b–c). So, it seems that books were seen as a poor substitute for direct contact with the author himself. Indeed, if this were not so then it is doubtful whether the sophists would have been happy to see their writings in circulation at all. Protagoras and others could amass a small fortune from their teaching, while they would have no control over their books once then had passed into the hands of others. Once somebody had obtained one, there was every chance that it would be read aloud in public, like Anaxagoras' book at *Phaedo* 97b–c, thus putting whatever wisdom it contained into the hands of whoever wished to listen. The obvious solution is not to try to include one's entire wisdom in a circulating text, but to circulate only as much as would serve to generate interest.

5 The Path to 'Publication'

So, why did sophists and Presocratic philosophers turn to 'publishing' at all? For some there would surely have been the lure of eternal, or at least long-lasting memory once they had passed away. Plato's 'Diotima' testifies to the power of such ambitions, particularly where poetry was concerned (*Symposium* 209c–e), and the famous introduction to Thucydides' *Histories* (1.22.4) makes it clear that prose writing could also have that intention – not only so

27 The word used here is *epideixis* ('display': 384b4), which suggests the brief instruction of a large audience rather than personal education or for an extended period.

that the writer himself should always be remembered but also so that his subject matter should continue to ring in our ears. So, it is not hard to explain why intellectuals made provision for their writings to circulate posthumously, as those of Protagoras, Anaxagoras, and others clearly did. However, it is perfectly clear that some texts were circulated during their author's lifetime. This could happen in a variety of ways. At the beginning of the *Phaedrus* the eponymous character has come from an oral display, described at 227b6–7 as a 'feast' (as at *Republic* 354a10–b6 and at *Timaeus* 17a1–b4 and 27b7–8): a feast given by Lysias, who, it seems, has repeatedly and enthusiastically read his *erôtikos logos* to Phaedrus (228a). He in turn had eventually taken it, practised delivering it, and still kept it beneath his cloak (228d–e). Lysias himself, it seems, had been given little choice about how his little speech circulated; rather it had been the natural consequence of a particularly enthusiastic reception. And we have already seen how the evidence of *Parmenides* 128a–e shows how the theft of Zeno's book could have denied him the choice, but no hint is given that the circulation of Parmenides' own text, differing to the extent that it was in verse, had been anything but deliberate. So here was a book that was evidently intended for circulation during its author's lifetime, and another was Polus's rhetorical *tekhnê* that Socrates had recently read for himself (*Gorgias* 462b–c). In fact all who prided themselves on their eloquence and their ingenuity in finding arguments would have been tempted to send evidence of this into circulation, but that, I submit, is not a case of publishing one's most serious thoughts.

What the evidence concerning both Lysias and Zeno suggests is that the initial purpose of a prose writing is for the author to communicate it in person before an audience, whether public or private. That had presumably been the case with most of the poetry that had preceded, and which authors would surely have wanted to recite in person where possible, establishing the closest possible connection between their Muse and themselves.[28] Such communication provides the basis for a display of two rather different talents, the ability to compose attractive speeches and the ability to deliver them in a persuasive or interesting manner. When it came to a performance that relied on deciphering a long string of uninterrupted characters the author is likely to have had a

28 In the case of poetry, it is likely that such a connection would imply some inspiration (or *enthousiasmos*) that somehow gave the author-and-performer some special authority. No doubt a different kind of authority would usually be claimed by the prose-writer. It in in the *Phaedrus* where Plato's 'Socrates' is at his most poetic that he also tends to speak in an inspired manner. It is no accident that in the same dialogue Plato most reflects on the processes of written communication too, showing his 'metadiscursive awareness' (on which see Basile, elsewhere in this volume).

substantial advantage over others, though those to whom he had read it might also have given a fluent reading. Ultimately this would of course lead to the composition of speeches for other persons to deliver, the purported intention of the majority of the speeches of the *Corpus Lysiacum*, though the epideictic branch of oratory, that which produced display pieces, would normally be intended for one's personal use. That may have been the case with philosophic pieces too, at least until such time as the author had already achieved fame and circulation would only serve as a further advertisement for his acknowledged talents.

In the case of Protagoras we have hints as to *why* he did not fear that his writings would make his personal teaching redundant: the writings simply did not *explain* very much. At *Theaetetus* 152c8–11 Socrates suggests that Protagoras was perhaps some all-wise[29] person, and was speaking in riddles to us common folk, but tried to explain the truth to his pupils behind closed doors. Socrates here suggests that the long-popular idea that everything is in flux had been behind the claims made in the book about man's being the measure of all things. Then at 155d–e he proceeds to explore the concealed truth underlying the ideas of such privileged persons. It simply does not seem to be accepted that what Protagoras had written adequately reveals to ordinary persons the world-view that had informed his epistemological claims. These claims may have been bold and fascinating, but they were no substitute for the sophist's oral theory. One might suspect that this is refuted at 166c9–d2: "For I affirm that the truth is as I have written: each of us is the measure of things that are or are not. …" But this is not a claim that all relevant details have been explained; it simply affirms that everything is correct *when the correct interpretation is put upon it*. The book speaks as if making an *ex cathedra* pronouncement, boldly asserting rather than explaining things, in a manner not atypical of Presocratic philosophy; it tends to leave sound-bites ringing in the ears;[30] it arouses strong interest without satisfying that interest.

This may remind one of Plato's own complaints against the book: it speaks as if it meant something (or had some intelligence: *hôs ti phronountas*; *Phaedrus* 275d7), but if one asks about something with the hope of understanding it then the book just carries on saying the same thing.[31] Plato himself seems

29 *Passophos*, an adjective that, like other pan-compounds, was liable to be used somewhat disapprovingly and with a hint of irony; see Hawtrey 1983.

30 See Schofield 1980.

31 This also makes it impervious to the friendliest attempts at elenchus, conceived as purging away elements that are resistant to those doctrines that would restore the discourse to health (cf. *Sophist* 230b–e); and perhaps it would also make readers reinforce in their minds false doctrines about what is and is not to be feared, making them impervious to

to have worried about what he wrote being misunderstood once it was in circulation, and no doubt there would have been misunderstandings and gross simplifications of his works from time to time. But in the *Theaetetus* (166a–c) 'Socrates' seems no less concerned about the distinct possibility that he is guilty of failing to do justice to the thought of Protagoras' book. It seems perfectly plausible that the worries about the reception of one's writings that are expressed in the *Phaedrus* are rather more general a feature of the age than one usually supposes.[32] Furthermore the main message of the passage is that one's own face-to-face teaching should be taken far more seriously than any writings one produces, unable either to *come to their own defence* or adequately to teach the truth (276c7–9).

The reference to the need for somebody to come to a work's defence (*boêthein*) is important, as it highlights the agonistic nature of the Greek intellectual world at the time. While the verb seems to have a particular application to the maneuvers of war, and Plato often employs it and its cognates in a military context,[33] there are also uses that pertain rather to the battles of the law-courts,[34] to the struggles of life more generally,[35] and to a wide range of *logoi* etc., both written and oral.[36] In fact many more dialogues talk about coming to the defense of a *logos* or of its proposer than to the defense of soldiers, legal defendants, and the like, and, if one ignores the *Laws* and works of doubtful authenticity just over a third of all uses of this vocabulary are somehow concerned with *logoi*. This serves to underline the competitive nature of Greek *logoi*, whether presented orally or in written form. Whatever one argued publicly was likely to provoke criticism or hostility; and the wider it became

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the reception of true beliefs (or laws) that will make them brave – just as traces of previous colours (other than white) must be purged away before the wool can permanently take on the desired colour (cf. *Republic* 429c–430b).

32 Such worries should, for instance, have occurred to Parmenides given the way that pluralists had sought to mock his *logos* according to *Parmenides* 128c–d.

33 See *Symposium* 179a6, e5; *Alcibiades 1* 115b2–116a6 (7 times); *Laches* 193a4; *Euthydemus* 297c7, d1; *Hippias Minor* 370e8; *Menexenus* 240c6–245a6 (10 times); *Critias* 120c7; *Republic* 471d6; *Laws* (often).

34 See *Apology* 34a7, b2, b4 and *Euthydemus*. 273c8. I have not tried to isolate a separate group of legal uses in the *Laws*.

35 See *Apology* 32e3; *Protagoras* 322b4, 352c7; *Gorgias* 483b4–526e5 (15 times); *Republic* 414b5–602d6 (14 times, often with regard to help within the tripartite constitution or soul); *Timaeus* 77a3.

36 See *Apology* 23b7; *Phaedrus* 88e2 (twice); *Theaetetus* 164e6–171e1 (8 times); *Politicus* 284d3; *Parmenides* 128c6; *Phaedrus* 272e3–278c5 (6 times); *Laches* 194c3; *Euthydemus* 303a3; *Protagoras* 309b6, 340a1, 341d9; *Hippias Major* 291e5; *Republic* 362e1–474b1 (8 times); *Timaeus* 52e6; *Laws* 891a6.

known the greater the chances of adverse reaction, whether out of the desire to compete or out of the desire to correct something. The public performance of one's work and its release into the wider Greek world gave one the chance to shine, but it also presented dangers. One would therefore feel the need to defend it either in person or through others who could assist, or even perhaps to apologize for it as Zeno does at *Parm*. 128c–e.

There is one other area in which writing presented limitations. The location of schools and the like had the undoubted advantage that the teacher, instructor or mentor could draw attention to surrounding features that could influence the reception of what is said. It has recently been shown that the siting of Plato's Academy is no accident, and that it was a natural site of civic education and for 'falling in love with the city, as Thucydides' Pericles would demand (2.43.1). It was situated close to the site where its celebrated war-dead were buried, and in an area with shrines to such figures as Prometheus, Athena, Hermes, and the Muses, and perhaps two dedications to Eros as well.[37] It was a natural site to encourage one's listeners to be mindful both of the greatness of the city but also of those superhuman forces that were most important for the intellectual. Plato's 'Gorgias', wherever he was supposed to be speaking, could draw attention to the walls and dockyards of Athens to illustrate the power of his art (*Gorgias* 455d–e). Oral presentations had the advantage that they could take place at venues that the speakers chose, venues that made it easier to illustrate and illuminate materials that were about to be presented. Even the itinerant teacher had some control over where he would perform and to whom; he had little control over where any book no longer in his possession would be read.

Undoubtedly, then, the circulation of one's writings could be a source of trouble and distraction for anybody who saw their main mission as lying elsewhere. Some Greek intellectuals might have thought of it as a necessary evil – primarily, perhaps, as a way to arouse interest among potential pupils and followers. Even those who had no need to charge students fees might well have appreciated bright pupils to act as a catalyst in their research. One imagines, however, that some gifted individuals like Plato and Democritus, to whom writing seems to have come naturally, sufficiently enjoyed writing to want to engage in it even without much additional motivation.[38] Yet one cannot take it for granted that everything Plato wrote was intended for publication. Some dialogues seem to engage more with the public debates of the day or to include polemical material that would have been wasted if it were not circulated. Others seem more exploratory, and best shared only within his school. Some

37 See Marchiandi 2020, especially 21.

38 See perhaps Tarrant 1994 and 1996.

have left their mark on other authors of the time, while others have gone unnoticed in extant literature. Enjoying writing did not mean that one had to share widely the products of one's enjoyment.

For Socrates, who had no natural inclination to write nor any need to attract followers, there was no point in writing philosophy down. And we should not forget that others followed him in this. Some later prominent philosophers avoided writing, including Arcesilaus and Carneades,[39] or did not circulate their writings beyond a very narrow group like Plotinus. Longinus (in Porphyry, *VPlot.* 20), distinguishing between those who took care to write their thoughts down for the benefit of posterity and those who did not, included persons of widely differing philosophical allegiances among the non-writers of his day. Plotinus featured among the former since he did indeed ultimately make provision for wider posthumous publication (Porphyry, *Vita Plotini* 24).[40] Others who had occasionally written something like Origenes and Euboulus he nevertheless included as non-writers; nor he did he feel that poems or display-pieces that happened to have gone into circulation actually qualified as writings in this context. Longinus, who was seriously interested in the craft of writing, was here interested in those who provided for their *serious thoughts* to reach posterity, not those for whom it was a mere pastime.

6 Conclusion

It is obvious that even by the time of Longinus it was not writing that qualified one as a philosopher, and even less was it the release of one's thoughts into a wider market by something akin to 'publication'. Yet there had been many others, including Aristotle and Theophrastus, Epicurus, and prominent early Stoics who had written a great deal. In the early Hellenistic period, I believe, there were good reasons for this, only partly stemming from the number of competing schools and the inter-school polemic that would naturally have arisen. And I suggest that the main reason was the new realization that philosophical traditions endured beyond the death of their founder, and that the founder could make provision for his thought to continue in precisely this way. The founder's corpus provided a kind of template within which a school tradition could flourish. Early successors, like Theophrastus, Xenocrates, or

39 Carneades's professed reasons for not writing will soon become clear from new readings of Philodemus.

40 I omit the version of his writings made by his physician Eustochius, since this would also have been possible only late in life.

Chrysippus, fleshed out the parameters a little further. We no longer needed mere sound-bites to attract attention and win over potential students; the writing followed rather than preceded the success of the school.

To this we may oppose the Heracliteans criticized by Theodorus at *Theaetetus* 179e–180c. The riddling sound-bites (*rhêmatiskia ainigmatôdê*) characteristic of Heraclitean writing was all that they had learned, possibly because of Heraclitus's own recluse-like behavior, which presumably made him less interested in communicating with mere humans, and more concerned with the reaction of Artemis in whose temple he saw fit to deposit his work (Diogenes Laertius 9.5). The riddling darts of language, being all that these self-taught individuals (180c1–2) had learned, were also all they had to offer – thinking that to be the whole point of Heraclitean flux-mysteries; no clear explanation was ever offered; and no pupils were won over. They had forgotten that cooperative research in an instructive environment was what had set science and philosophy in motion. They had mistaken the means of self-advertisement for the real work that lay beneath the surface. They had mistaken the brief documents in which every word counted, almost in the manner of poetry, towards the revelation that could only be fully explained by on-going personal interaction. They had mistaken the written image for its serious reality and for the true work of the intellectual. We should not do likewise. We have to realize that it is merely a very cleverly constructed image, and bring all our hermeneutic resources to bear on penetrating beyond it to the thoughts of the author.

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CHAPTER 10

Metadiscourse

The Fabric of Early Greek Philosophical Prose

Gastón Javier Basile

The advent of Greek philosophy and science through the sixth and fifth century BCE entailed both a novel form of inquiry into nature, which initiated a new genre of literature (the *peri physeos* genre), and a new mode of discourse, continuous technical prose. Indeed, the prose treatise (*sungraphe*) was the material template that helped record and circulate early philosophical (and broader scientific) inquiries. While there are earlier records of public uses of prose in Greece through the eighth and seventh century in the form of graffiti, law codes and stone inscriptions, the sixth century witnessed an increasingly widespread use of prose, notably in the Ionian milieu, as a new medium to compose and disseminate new forms of knowledge and intellectual inquiries.[1] This new use of prose was not merely aphoristic – as the private record of graffiti in the public space – or apodictic – as was the case with public legislation engraved in stone, but was chosen as the medium to communicate the findings of an extended process of inquiry (and, accordingly, imposed new demands on language). If this choice was not unanimous (as shown, for example, by Parmenides', Xenophanes' and Empedocles' preference for metrical rendering),[2] it was by far the medium that early thinkers, irrespective of their

1 On the earliest use of writing in public inscriptions, legal statutes, decrees, treaties, religious rules, and curse tablets, see Detienne 1988, 10–21; Harris 1989, 45–64; Thomas 1992, 65–73; Thomas 1996, 9–31; Gagarin 2003, 64–72. On the use of writing in graffiti and archaic dedications, see Henrichs 2003, 45–50. The connection between legal inscriptions and the emergence of prose writing has been examined by Asper 2004; Sassi 2006, 3–26; Sassi 2018, 85–87.

2 On the *peri physeos* genre composed in epic hexameters, see Kahn 2003, 155–158. On the differences between the *peri physeos* texts in prose and hexametric poetry, see Rossetti 2006, 141–145. Whether the choice of Xenophanes, Parmenides and Empedocles is exceptional (Kahn 2003, 155) and is best explained as a deliberate rhetorical strategy that adapts the familiar and prestigious format and language of oral poetry to communicate a new doctrine (Wright 1998) or whether it is the default medium for archaic composers, philosophers included, to reach a large audience (Osborne 1998, 25–30) is difficult to settle.

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objects of study (mythography, philosophy, history, science, etc.), favored to communicate their individual inquiries to a (possibly) semi-literate audience.[3]

Far from being a natural, default occurrence stemming from the abandonment of meter as an expressive medium, the linguistic fabric of early Greek prose reveals traces of its 'constructed' nature. Non-metrical (*aneu metrou*) speech (as can be traced in law inscriptions, dedications, graffiti or what may have been *in vivo*, spoken, oral interaction) is not synonymous with the kind of continuous prose style used by the Pre-Socratic *peri physeos* writers. The evidence available, albeit sparse, reveals the constructed quality of early Greek philosophical prose. As such, early prose writing should be read as a new 'signifying practice' that not only departs from traditional poetic enunciation but is also closely related with the material and socio-pragmatic conditions of early Greek culture.[4]

This paper aims to look at the texture of some of these early philosophical prose texts in order to reveal traces of functional, pragmatic or sociolinguistic adjustments of language. I wish to argue that this adaptation to changing material conditions may have partly influenced the inception of prose (and technical expository form in particular) as the preferred medium to communicate philosophical knowledge.

1 The Historical and Material Conditions of Early Greek Philosophical Prose

A series of material and cultural factors in archaic Greece may have fostered the adoption of continuous technical prose by early Greek *sophoi*. For a start, the use of writing as a *techne* for recording and circulating knowledge (as a complement of the traditional oral medium of composition) remains a crucial

3 Cf. Kahn 2003; Asper 2007a, 2007b. The first prose book was reportedly written by Pherecydes of Syros. Cf. Schibli 1990. Contemporary with Pherecydes' theogonical work is Anaximander of Miletus' *peri physeos* treatise, which became the blueprint of a long-lived literary genre (Kahn 2003, 145; Graham 2010, 45). Robert Hahn (2001, 47–65) has persuasively connected the prose works of Thales and Anaximander with the technical handbooks produced by the Ionian architects. Kahn (2003, 152–153) argues that the broader literary prose texts may have evolved out of these technical handbooks and memoranda destined for specialists. The modern concept of "treatise", however, should be used with caution to designate these early prose writings (cf. Taub 2017, 14–15).

4 Cf. Gheerbrant 2019, 478. Drawing on the work conducted by Godzich and Kittay 1987, on the emergence of prose in the Middle Ages, Gheerbrant understands poetry and prose in philosophical discourse not as different modes of expression, but as more radically different modes of meaning-making ("modes de signification").

attainment of early Greek culture.[5] While the transformative impact of writing as proclaimed by Havelock, Goody and Ong has been significantly toned down in recent decades, it still holds true that writing plays an ancillary or instrumental role in bringing about psychological and social change by facilitating a series of cognitive operations. Literacy experts have argued that the very act of writing a certain type of script calls into consciousness certain properties of language that are otherwise largely overlooked, such as the awareness of the phonology of the language and lexis.[6] In other words, writing develops the recursive property of language, the property that allows language to be used to reflect on language itself.[7] The fact that in ancient Greece orality was paramount – and it certainly was in the case of early science and philosophy – does not preclude the fact that this knowledge was (often) recorded in writing – and particularly, in prose – and that the act of registering such knowledge must have contributed to its own genesis (at least in the form it has been handed down to us).

The book roll (papyrus scroll)[8] as the specific writing material where this knowledge was recorded is yet another material factor of early Greek

5 The transformative impact of writing as a *techne* has been sufficiently emphasized by the works of Goody, Havelock, Ong and followers, who highlighted the cognitive effects of the technology of writing in a preeminently oral culture. The scope of this technology-driven approach, however, has been significantly challenged as generally simplistic and reductionist (see the criticism in Thomas 1992, 15–28; Finnegan 1988, 1–14; Street 1984, 44–65; Olson 1994, 1–20, 36–40). The focus has gradually changed in favor of a broader and richer understanding of the role played by reading and writing (or literacy in a broader sense) in the inception of a variety of cultural and cognitive transformations. On orality and literacy in Greece, see *inter alia* R. Thomas 1989, 1992; 2009; Olson 1994, 20–44; Worthington 1996; Mackay 1999; Watson 2001. For a useful discussion of the interaction between orality and literacy in early philosophical thought, see Sassi 2018, 73–109. For an overview, see Junis 2003, 1–14; Olson 2009, 387–390.

6 See Olson 2009, 390–91. Phonological awareness (an effect of metadiscourse) is evidenced in the formatting of early Greek literary texts onto a book roll, as demonstrated by Johnson 2000. While the texts were written in *scriptio continua*, the words at line end were parsed according to syllabic rules, indicating a sound phonological and word awareness.

7 Writing allows the de-contextualization of speech and its re-contextualization (usually, a written record on a surface) but without the illocutionary/paralinguistic marks that accompany oral discourse. Thus, the focus automatically falls on the 'propositional content' – on the literal words (without speaker) – which fosters metalinguistic awareness. cf. Olson 2009, 398.

8 The physical aspects of the ancient Greek book are examined by Turner 1980, and Turner and Parsons 1987. More recent monographs include Capasso 1995 and Johnson 2004, who examines the typology of the papyrus book roll based on the literary papyri from Oxyrhynchus.

knowledge-making.[9] Special physical characteristics of the book roll, such as the undifferentiated script (*scriptio continua*), the absence of spaces between words, the lack of punctuation marks, paragraph breaks, running headers, and page or column markers, must have determined or helped shape some formal features of the texts themselves. Moreover, these physical characteristics of the writing material must have posed challenges to ancient readers and partly determined reading and writing practices. But, likewise, the papyrus scroll must have offered opportunities for continuous learning, providing a portable physical space for codification, preservation and socialization of knowledge.[10]

The literacy practices in early Greece, including the sociology of reading and writing, are also important factors in determining how texts were produced, circulated, and consumed in a specific subculture.[11] Reading in antiquity was primarily an elite phenomenon, restricted to the cultured few.[12] Even among the literate few, the production and socialization of knowledge must have been a preeminently oral-aural activity, which means that writing possibly played an ancillary part in preserving knowledge and lecturing on scientific matters. In this sense, the circulation of early prose texts should be understood in the context of private or tight-knit groups of readers (bound by a master/disciple relationships) or collegiate circles of intellectuals – often associated into families and involving a chosen few (e.g., Pythagoreans).[13] Read in elite settings, possibly in private (rather than public) contexts, by *sophoi* and their pupils,

9 For a survey of book production and circulation see Cambiano, Canfora, and Lanza 1992–1996, and Cavallo 1989. Dorandi 2000 describes the working methods of ancient authors.

10 Johnson 2010, 24 draws attention to the fact that, unlike modern texts, Greek and Imperial Roman book rolls lacked certain 'hints to the reader' such as word division, chapter headings and a consistent use of punctuation marks. This absence of marks in the text must have partly determined the kind of reading habits adopted in antiquity such as the oral performance of the written text. On the constraints of the writing process, see Tarrant's essay in this volume. For a critical reassessment of the literature on reading habits in Antiquity and new insights, see Heilmann 2020, 177–196.

11 On the concept of literacy, see Grillo 1989, 15; Street 1993, 12–13; Johnson 2000; Johnson and Parker 2009, 3–10.

12 Johnson 2000, 616.

13 It is likely that these texts were read privately or in small instruction groups, most probably aloud but also perhaps silently. cf. Sassi 2018, 80–81. Until recently, the prevalent view was that silent reading was a rare or nonexistent phenomenon in antiquity. However, recent studies have shown that the Greeks and Romans, especially fully literate and skilled individuals, must have been able to (and often did) read silently. Gavrilov 1997, 59 provides neurophysiological and textual evidence that silent reading was not only common, but rather a standard practice. Though focusing on broader sociological aspects of reading in antiquity, Johnson 2000, 593 admits that there was "no cognitive difficulty when fully literate ancient readers wished to read silently to themselves."

natural philosophy texts were, however, not immediately associated with oral performance or composition as other genres of epideictic literature. Indeed, as my discussion will show, certain linguistic features of these texts suggest that they were not designed to be performed (though they could have been vocalized or read aloud in instructional settings).[14]

Travel and cross-cultural interactions were also typical of the Ionian cultural milieu. Besides their propensity for multiple inquiries (*polymathy*),[15] these early *sophoi* were characterized by mobility. They were thinkers-on-the-go, both visiting Greek and foreign lands (usually through ritualized friendship ties with Greek *poleis* and non-Greek aristocrats) and embarking on a wide variety of activities.[16] Written documents acquire greater relevance in this context of knowledge diffusion and cross-cultural exchange, both because the knowledge is bound to be preserved beyond the embodied presence of the *sophos* and the more traditional oral channels of instruction, and because a written text is apt to be translated into a foreign tongue. Furthermore, early prose texts may have performed more specific practical functions – as handbooks to operate in practice (the case of architects, astronomers, geographers, physicians, etc.) or to disseminate knowledge among specialists or in specific instruction settings (as textbooks used for learning).[17]

14 In discussing prose performance texts, Thomas 2003, 166–167 makes the interesting remark that Plato portrays the work of natural philosophers as being read 'aloud' in contrast with sophists, who seem more prominent as speakers and performers.

15 On polymathy, see Hahn 2001, 82–85; Granger 2004, 238–241.

16 The doxographic tradition reports on the assiduous domestic and foreign travels of the early polymaths and *logographoi*, which aroused their interest in foreign peoples and cultures, the record of wonders (*thaumasia*), and natural oddities. cf. Granger 2004, 240. However, as noted by Wians in this volume, while most Archaic thinkers travelled, they did so in different ways. Thinkers who were landed aristocrats were a different category from itinerant *sophoi* in search of patrons like Xenophanes.

17 In fact, as noted by Hahn 2001, 135 the word *sungraphe* – the most widespread term to designate inscriptions in general and prose writing in particular – was also used to refer to the technical specifications in words and numbers that contained general and clear explanation of an architect's design. Kahn 2003, 148–52 links the inception of prose with the technical handbooks that appeared in the sixth century for specialists in astronomy, geometry, architecture, sculpture, and music. For the restriction of *sungraphe* to works in prose, see Dover 1997, 183–84; Kahn 2003, 148; Taub 2017, 14–16. The way these texts were read or circulated remains a matter of conjecture: Humphreys 1975, 100 claims that philosophical prose texts were read and lectured on in "sober meetings"; West (971, 5) stresses the value of written books as "aide-mémoire" for the authors themselves; Thesleff 1990, 112 suggests that they were "memoranda for his pupils". For an overview of these discussions, see Granger 2007, 412–17.

2 Metadiscourse in Early Greek Prose

The abandonment of metrical composition by most (though not all) of the early philosophers entailed not only an emancipation from the formal prosodic restraints but also a detachment from the traditional lore inspired by the Muses as well as the pragmatic aspects of in vivo performance.[18] Concurrently, the record of knowledge through writing onto a papyrus scroll, with its specific material constraints, a device that permitted both unlimited individual perusal as well as socialization of knowledge in relatively small instruction clusters, and also its dissemination outside the bounds of its original context of production, opened new avenues and imposed new challenges on language. Prose writing developed, enhanced, or fine-tuned a number of language components that were comparatively underdeveloped, negligible, or altogether lacking in situated, performative poetic composition.

Possibly one of the major consequences of the socio-pragmatic and material conditions outlined is the enhanced meta-discursive dimension of these early prose texts by comparison with other forms of traditional poetic composition. The record of philosophical inquiries onto a book roll in the form of continuous, sequenced, expository, and argumentative prose (the so-called *peri physeos* prose treatise) that was meant to be primarily 'read' privately or in small groups, and also circulated beyond the confines of the author's close community, expanded and refined the metadiscursive dimension of language.

While the notion of metadiscourse has been variously defined, most approaches highlight three key principles: (1) metadiscourse is distinct from propositional aspects of discourse; (2) it refers to aspects of the texts that embody writer-reader interactions; (3) it refers to relations which are internal to the discourse. In this description, metadiscourse provides "non-topical linguistic material" that is irrelevant to the topic development but key to understanding discourse as a whole.[19] Drawing on Halliday's meta-functions of language, most definitions of metadiscourse distinguish between the *textual* dimension, which helps organize a coherent discourse and features the capacity of language to refer to or describe itself, and the *interpersonal* dimension, which conveys the writer's attitude to the text and codifies social interactions with the readership. In what follows, I will illustrate the way in which this metadiscursive function of language has become enhanced in early prose texts by focusing on two fragments of pre-Socratic philosophers: a passage from

18 Cf. Laks 2001, 11–13; Sassi 2018, 83–84.

19 Lautammatti 1978, 226.

Anaxagoras of Clazomenae (B4a) and one from Melissus of Samos (B8), both of which provide a considerable stretch of continuous prose.

3 Metadiscursive Markers in Anaxagoras' Prose Writing (F.B4a)

Anaxagoras of Clazomenae, a philosopher that personifies the polymath spirit of his early Ionian predecessors, is reported to have written a single book.[20] According to Diogenes Laertius' *Vitae Philosophorum*, "Anaxagoras was also the first person to publish a book in the form of a treatise (βιβλίον ἐξέδωκε συγγραφῆς)" (b A1) 2.11. We learn from a passage in Plato's *Apology* (26d) that the works of Anaxagoras could be bought in Athens for a drachma, and in the *Phaedo* (97b) Socrates mentions someone reading from Anaxagoras' book (ἐκ βιβλίου … Ἀναξαγόρου), which was possibly of some length (or was subdivided into several parts).[21] From his book, there remain about twenty fragments of the first part, through preservation in Simplicius of Cilicia's commentary on Aristotle's *Physics*.

I will focus on Fragment 4a, which showcases a number of textual features of Anaxagoras' writing (highlighted in the text) and the way in which metadiscursive markers are developed in early Greek philosophical prose.

> *Fragment B4a*
> **τούτων δὲ οὕτως ἐχόντων χρὴ δοκεῖν** ἐνεῖναι πολλά τε καὶ παντοῖα ἐν πᾶσι τοῖς συγκρινομένοις καὶ σπέρματα πάντων χρημάτων καὶ ἰδέας παντοίας ἔχοντα καὶ χροιὰς καὶ ἡδονάς. καὶ ἀνθρώπους γε συμπαγῆναι καὶ τὰ ἄλλα ζῷα ὅσα ψυχὴν ἔχει καὶ τοῖς γε ἀνθρώποισιν εἶναι καὶ πόλεις συνημμένας καὶ ἔργα κατασκευασμένα, **ὥσπερ παρ' ἡμῖν,** καὶ ἠέλιόν τε αὐτοῖσιν εἶναι καὶ σελήνην καὶ τὰ ἄλλα, **ὥσπερ παρ' ἡμῖν**, καὶ τὴν γὴν αὐτοῖσι φύειν πολλά τε καὶ παντοῖα, ὧν ἐκεῖνοι τὰ

20 Diogenes Laertius 1. 16; 2.11. Also, Clement, *Stromateis*. 1.16.7 8.3–5.

21 For an analysis of Plato's passage, see Thomas 2003, 166–7. Sider 2005 argues that Anaxagoras must have written his text between 470–65, and that it probably reached Athens toward 465–64 BCE. The work remained available in Athens from 450–399 onward (*Apology*. 26d–e). Sider 2005, 15 speculates that approximately one seventh to one fourth of the book is preserved in fragments and that it may have originally included diagrams. The book is referred to as βίβλια in the plural (*Apology*. 26de), which may indicate that more than one work was attributed to Anaxagoras, or may refer to book parts or sections considered independently, or to several versions of the work produced throughout his lifetime. Lanza 1966, 12–13 claims that it is likely that Anaxagoras produced more than one single book in his lifetime.

> ὀνήιστα συνενεγκάμενοι εἰς τὴν οἴκησιν χρῶνται. **ταῦτα μὲν οὖν μοι λέλεκται** περὶ τῆς ἀποκρίσιος, **ὅτι** οὐκ ἂν **παρ'** ἡμῖν μόνον ἀποκριθείη, ἀλλὰ καὶ ἄλλῃ.
>
> *Since these things are so, it is right to think* that there are many different things present in everything that is being combined, and seeds of all things, having all sorts of forms, colours, and flavours, and that humans and also the other animals were compounded, as many as have soul. Also that there are cities that have been constructed by humans and works made, *just as with us*, and that there are a sun and a moon and other heavenly bodies for them, *just as with us*, and the earth grows many different things for them, the most valuable of which they gather together into their household and use. *I have said this about* the separation off, *because* there would be separation off *not only for us* but also elsewhere.[22]

Simplicius claims that this passage occurs "shortly after the beginning" of the first book (*Physics* 34.27–28). While it is hard to reconstruct Anaxagoras' cosmological theory consistently from the extant fragments, we should assume that at this point in his treatise he must have already alluded to the main tenets of his theory: the underlying Eleatic principle of no coming-to-be and no passing-away; the original mixture, where all things existed in a confused and indistinguishable form; the infinite smallness and largeness of things, and the everything-in-everything principle.[23]

From a discursive point of view, the passage reveals a number of textual features that may impinge on the construction of early scientific prose.

1. The genitive absolute construction (τούτων δὲ οὕτως ἐχόντων) that opens the citation – also found in fragment B4b.7 – is of great import. Fränkel (citing *Agamemnon* 1393) calls it a "formula of transition", which becomes remarkably common from the 5th century BCE; Sider (2005, 93) speaks of "old notebook style." From a discursive standpoint, however, this construction is best interpreted as a discourse marker with a specific function in the unfolding of an explanation. It functions as a meta-textual marker, recapitulating on the previous explanation and serving as a logical transition to the ensuing section (a procedure called 'endophoric marker').[24] This textual marker is used here to take up the previous explanation and introduce the opening statement in this section of the text (which is framed as the logical conclusion of the previous

22 I use the edition and translation of the fragment made by Curd (2007, 16–17).

23 Cf. Curd 2007, 42. For the problems posed by the exact interpretation of this section of the text, see Lanza 1966, 200–203.

24 Hyland 2005, 51.

explanation: "Since these things are so, it is right to think that all things were present in the whole").[25] At B4b the expression is used once again to resume the previous exemplification of the original mixture of things before *Nous* initiates the rotation and separation off. To the best of my knowledge, this metadiscursive function of the genitive absolute construction – used to establish causal links in the unfolding of an explanation – has no precedent in the earlier Homeric, Hesiodic, and lyric corpus, and may have been a distinctive feature of Greek technical expository prose.[26]

2. The impersonal construction χρή + infinitive following the genitive absolute (χρὴ δοκεῖν) occurs a few times in Anaxagoras' fragments (B4a, b; B5) and is regularly followed by epistemic verbs (*dokein / gignoskein*). This use of impersonal expression at B4a helps objectify the doctrine ("it is right to think / recognize", etc.) presenting the thesis ("that many and varied things are present in all objects") as a logical assertion derived from the previous evidence (which we unfortunately lack in the fragment) expressed via the genitive absolute formula.[27] Impersonal expressions with χρή / χρέων can also be found in Parmenides' poem (see, for instance, b1.29, b1.32, b2.5, b6.1, b8.11, b8.54), though not followed by an epistemic verb connected to the enunciator in the text.[28] Anaxagoras' use of the impersonal χρή to express an epistemic modality of necessity (namely, what is appropriate, fitting, right, etc.) based on the

25 On the use of the genitive absolute in Anaxagoras, cf. Sider 2005, 30–32.

26 See Ruppel 2013, 33–79. For the use of this absolute construction in the fifth century to indicate causal links within a narrative account, cf. Aeschylus, *Agamemnon* 1372; *Persians*. 159; Herodotus, 1.126; 8.144. The use of the genitive absolute construction in traditional oral poetry (Homer and Hesiod) is a comparatively limited phenomenon. On the other hand, there is a considerable development of the syntactic scope of the genitive absolute in classical Greek prose (Ruppel 2013, 20–21).

27 Epistemic modality refers to any modal system that indicates the degree of commitment by the speaker to what he says (cf. Palmer, 1995, 51). It has also been defined as the speaker's evaluation of the likelihood that a certain proposition has occurred or will occur. Epistemic modality can be divided into hedging and boosting, i.e., the respective weakening and strengthening of a claim (Hyland 2000, 179).

28 On the use of χρή / χρέων, see Redard 1953, 47–62 and Mourelatos 2008, 277–78, with further bibliography. Following Redard, Mourelatos contends that these expressions in archaic and classical Greek authors indicate an appeal to norms, whether of society or of ethics or of rationality – not to externally imposed 'necessity' or 'constraint' or 'need'. Mourelatos 2018 argues that the repeated χρὴ δοκεῖν in D12 and D13 and the χρὴ γιγνώσκειν of D16 are not jussive statements concerning what 'one must think' or what 'one must recognize' but the philosopher's proud claim as to what is the best and right way for judging the matters at issue. While this is admissible, a closer look at these examples shows a significant nuance – Anaxagoras' use in context signals a logical consequence – what 'should', or 'ought to' be inferred from the previous evidence.

foregoing evidence in a text (succinctly provided in the absolute construction) departs from the deontic modality that expresses a necessity stemming from *nomos* or divine rule, as appears to be mostly the case in Parmenides' usage where it is mediated by the goddess's voice.[29] In other words, the expression in Anaxagoras signals a logical transition in his exposition and works as a meta-discursive marker. This use of epistemic markers as indices of the degree of the author's commitment to the truth of his claims may be regarded as idiosyncratic of early Greek technical prose.[30]

3. ὥσπερ παρ' ἡμῖν. Regardless of the specific general meaning of the passage – the debate over the actual existence of parallel universes in Anaxagoras' theory or whether he is merely engaging in a thought experiment[31] – the expression ὥσπερ παρ' ἡμῖν is interesting per se in defining the deictic centre of the passage and as an instance of an interpersonal meta-discursive element. The use of the first-person pronoun begs the question: Who is 'us' specifically? And, likewise, who or what is the reference of the third-person pronouns and adverbials (αὐτοῖσιν / ἄλλῃ)? The passage establishes a contrast between the spheres of 'us' – whether inclusive or exclusive – and that of 'them', which are elusive categories to pin down in the fragmentary state of the text. Yet the expression 'among us' (παρ' ἡμῖν) indicates a collectivity – 'the imagined community' that is envisioned as the addressee of Anaxagoras' doctrine, however broad the reference may be conceived (the Ionians, the Greeks, humanity in general, etc.). The fabric of the 'scientific prose' text requires the establishment of both an authorized first-person voice – as is often laid down in the prologues or opening lines (*sphragis*)[32] – and the intended 'addressee', who becomes

29 Mourelatos 2008, xxxi and 277–278 states that the modal language used by Parmenides here suggests a "normative necessity" (right, due or proper necessity) rather than a blind inexorability. Coxon 2009, 285 writes that "the 'necessity' referred to in χρῆν ['should'] is that personified by the goddess herself, who is therefore best qualified to speak of it, and derives from that which determines reality".

30 χρή followed by an epistemic verb also occurs in Melissus three times (cf. b3, b5, b7, b8).

31 These lines suggest that there are other worlds like our own in Anaxagoras' universe. There have been a number of candidates for these other worlds: other places on our Earth, the moon, multiple parallel universes, worlds smaller than ours within our world (Curd 2007, 45). On the general meaning of this expression which depends on the overall interpretation of the kind of world Anaxagoras is postulating in this passage, cf. Lanza (1966, 205), who indicates, following Fränkel, that the expression points to the sphere of experience, as will become the standard use in Epicurus (*Epistulae ad Pythoclem* 96, 5; 97, 3, etc.)

32 The inclusion of a *sphragis* naming the author of the work and his birthplace was a standard practice in the literature of the fifth-century Greek compositions in prose and poetry. The earliest prose examples include the works of Hecataeus, Alcmaeon, and Herodotus. See in particular Porciani 1997, 3–78.

occasionally encoded in the textual piece through first-person deictic terms, and often via comparative structures (ὥσπερ) that bring out the similarities and differences between the two symbolic spaces in contrast. Such procedures are well attested in certain fragments of the logographers and in Herodotus in general. However, the idea of 'us' as an expected readership/audience which needs to be imprinted (that is, textualized or marked) within the text can be seen as a specific procedure of early technical prose. This use of the first person plural pronoun is an 'engagement marker', a metadiscursive device that explicitly addresses the readers either to focus their attention or to include them as discourse participants.

4. The closing sentence in this fragment beginning with ταῦτα μὲν οὖν μοι λέλεκται deserves a close examination. Several features here illustrate discursive procedures that may well be characteristic of early Greek technical prose.

For a start, the object argument of the sentence is topicalized: the demonstrative ταῦτα is fronted as an anaphoric term taking up the preceding explanation (possibly, the reference to the existence of other worlds where rotation and separation occur). In this regard, ταῦτα operates as a meta-discursive endophoric element, pointing at the content of the previous explanation. Strictly speaking, the demonstrative ταῦτα does not refer to any explicit antecedent in the previous text (as is often the case with anaphoras), but to a proposition whose existence is implied by the text, and one that presupposes a reader who has followed the correct steps in the unfolding of the explanation.

Second, μοι λέλεκται: the agent of the act of 'saying' is backgrounded as a dative agent in the passive construction.[33] The self-mention (the author's presence in the text) is mitigated by its dative form: this helps to confer greater objectivity to the unfolding exposition. Furthermore, the perfect tense emphasizes the resultative aspect of the action indicated by the verb ("it has been said", therefore, "is stated"). Indeed, the perfect tense originally lacked passive voice and had an intransitive and subject-oriented meaning; the dative μοι is therefore best understood – from the diachronic development of this

33 George 2005, 82–102 provides a full account of the usage of the dative of agent. Passive perfect verb forms often take agent phrases in the dative. Following the diachronic development of this construction, George argues that it originated out of the experiencer meaning of the dative at a time when the passive perfect did not have a real passive meaning, but indicated a state of the subject, similar to the active perfect which was in origin subject oriented. When the perfect acquired a patient oriented meaning, and a real passive became possible, the construction developed into an agented passive. For an analysis of the dative agent in Greek and other Indo-European languages, see Luraghi 2016, 26–36 (especially for Greek).

construction – as a dative of interest or point of view (*dativus judicantis*) rather than a true agent.[34]

The use of the perfect tense both highlights the actuality of what is stated by the enunciator on an interpersonal level and, on a textual level, the fact that the ensuing information follows 'what was previously stated'. This introduces a temporal dimension on the metadiscursive level, a careful monitoring of the ongoing expository discourse, which reveals a high degree of metatextual awareness, not only of the stages in the unfolding of the exposition but also of the textual recording of such content.

In sum, the topical prominence of ταῦτα, both as the thematic constituent of the clause as well as the grammatical subject, the backgrounding of the agent through the dative (agent), and the use of the third person perfect passive tense stressing the result/state, contribute to create a more impersonalized, objective diction that may be seen as prototypical of scientific or technical prose discourse.

The salience of these metadiscursive markers – both textual and interpersonal – in Anaxagoras' fragment is compelling. They can also be observed in several other textual fragments. Because Anaxagoras provides a reasonable number of direct citations it is a good starting point to begin a more extensive research into early Greek expository prose in general.

4 Metadiscursive Markers in Melissus' Prose Writing (B8)

Contemporary of Anaxagoras and Empedocles, Melissus of Samos (*floruit* during the 84th Olympiad, 444/40 BCE)[35] offers further evidence to examine the development of early Greek philosophical prose. Like Anaxagoras, Melissus was the author of a single book, as regularly transmitted by the doxographers (Diogenes Laertius 1.16: ἕν σύγγραμμα), and was counted among the writers of the *peri physeos* genre (Simplicius, *Physics* 70, 16; Simplicius, *de Caelo* 556, 35;

34 In this regard, Humbert 1960, 287 argues that the dative with perfect constructions and verbal adjectives should be interpreted as a dative of point of view. Hence, he notes that expressions like τὰ πεπραγμένα ἡμῖν cannot mean: 'the things that have been done by us,' but 'things that have been done as far as we are concerned.' Likewise, George 2005, 80 indicates that since the perfect tense does not refer to an action but a state, there is no "logical basis for referring to an agent."

35 While Melissus' chronology remains largely speculative, (Reale 1970, 8) suggests an earlier dating of the philosopher's works, as a nearly contemporary of Zeno. Reale argues that Melissus' birth date should be placed toward the end of the sixth or the early years of the fifth century BCE, and that his works should have been completed by 465 roughly.

557, 10 and Galen, *De elementis secundum Hippocratem* 1, 9).[36] Much of what remains of Melissus' philosophical treatise has been preserved by Simplicius in his commentaries on Aristotle's *Physics* and *On the Heavens*. The text, as far as can be judged by the remaining citations, provides an articulate prose rendering of Parmenides' poem with a piecemeal logical reconstruction of its key arguments. Melissus thus offers "the first critical reading" of Parmenides,[37] both clarifying and expanding on his master's obscurer diction, and providing a few doctrinal adjustments of his own.[38] Moreover, he provides the first prose argumentation on the question of being, precluding any speculation on natural phenomena.

In recent decades, scholars have rehabilitated Melissus' undue second-rate philosophical status in the Eleatic trinity, which had rested largely on Aristotle's indictment (*Physic* 1.2, 185b10–12). Besides its philosophical import, the specialized literature has begun to draw attention to the rigorous argumentative structure of Melissus' fragments, with keen attempts at reconstructing the successive premise-conclusion chain of argumentation in the Samian's account of what-is. By the same token, scholars have mapped out more largely the contribution of Eleatic formal thought in the birth of Greek formal logic and mathematics.[39] Equally important to our purposes is Harriman's (2019) contention that Melissus' remaining fragments amount to a higher proportion of his original book than is the case for any other Presocratic philosopher. Indeed, Melissus' longer fragments not only provide ample evidence of his formal argumentation strategies but also an invaluable glimpse of the metadiscursive dimension of the earliest Greek prose that has survived.

Unlike Parmenides, Melissus argues that what-is is 'unlimited' and numerically 'one'. In Fragment B7, Melissus states that, because what-is is unlimited, it must also be one (since if it were more than one it would have limits, that is, the boundaries between what-is and other entities). In his argumentation,

36 For a discussion of these testimonies, as well as the exact title of his work (later parodied by Gorgias), see Reale 1970, 280–282.

37 LM 2016, 229.

38 (1) Parmenides claims that Being is limited, while Melissus claims that it is wholly unlimited; and (2) for Parmenides, Being existed in a timeless Present, while for Melissus Being is eternal; cf. Curd 2004, 207. For a brief outline of Melissus' place in the Eleatic school, see Makin 2014, 126–158; more generally, Palmer 2004, 19–54, and Palmer 2009.

39 For Melissus' earlier rehabilitation as a rigorous thinker see Vitali 1973 and Barnes 1982. On the deductive structure of Mellisus' text, see Sedley, 1999, 113–35, at 125. Recently, Harriman 2019 offered the first monograph in English entirely dedicated to this oft-neglected Eleatic thinker, stressing his "rigorously deductive method of argumentation" (p. ix). See also Marcacci 2012, 70–80, and Rossetti 2017, v2, 113–147; 2020, 129–161.

Melissus is arguing for a radical form of monism, implicitly confuting post-Parmenidean pluralist or atomist theses, which admitted the rearrangement of what-is through the mixture and separation of things that are (as is the case of Anaxagoras' *chremata* discussed above) or the separation and combination of atoms.[40] In fragment B8 (transcribed below), Melissus sets out to disprove the plurality of ones (as an alternative model) and refute the reliability of the senses in pointing to how things really are. His argument is that the perception that things change, as well as the perception of the existence of many different things, is illusory.

In what follows, I will discuss the arrangement of the textual components and the metadiscursive markers that signpost the unfolding of the argumentative sequence.[41] According to Simplicius (*de Caelo* 558, 19), this fragment follows Melissus' characterization of what-is as one, ungenerated, immobile, and not separated by any void, but as a whole full of itself. Melissus constructs a complex chain of argumentation which rests chiefly on counterfactual reasoning:[42]

> (T) μέγιστον μὲν οὖν **σημεῖον οὗτος ὁ λόγος**, ὅτι ἓν μόνον ἔστιν, ἀτὰρ καὶ τάδε **σημεῖα**· (1) εἰ γὰρ ἦν πολλά, τοιαῦτα χρὴ αὐτὰ εἶναι, οἷόν περ **ἐγώ φημι** τὸ ἓν εἶναι· (2) εἰ γὰρ ἔστι γῆ καὶ ὕδωρ καὶ ἀὴρ καὶ σίδηρος καὶ χρυσὸς καὶ πῦρ καὶ τὸ μὲν ζῶον, τὸ δὲ τεθνηκός, καὶ μέλαν καὶ λευκὸν καὶ τὰ ἄλλα, ὅσα **φασὶν οἱ ἄνθρωποι** εἶναι ἀληθῆ, εἰ δὴ ταῦτα ἔστι, καὶ **ἡμεῖς ὀρθῶς ὁρῶμεν** καὶ **ἀκούομεν**, εἶναι χρὴ ἕκαστον τοιοῦτον, οἷόν περ **τὸ πρῶτον ἔδοξεν ἡμῖν**, καὶ μὴ μεταπίπτειν μηδὲ γίνεσθαι ἑτεροῖον, ἀλλὰ ἀεὶ εἶναι ἕκαστον, οἷόν πέρ ἐστιν. (3) νῦν δέ **φαμεν** ὀρθῶς ὁρᾶν καὶ ἀκούειν καὶ συνιέναι, δοκεῖ δὲ **ἡμῖν** τό τε θερμὸν ψυχρὸν

40 On the relationship between Melissus and the Atomist and Pluralist schools, see Curd 2004, 206–216.

41 On the logical formulation of Melissus' argument here, see Marcacci 2012, 73–74, and Palmer 2004, 32. Similarly, Harriman 2015, 20 says: "The work is deductive in structure; the conclusion of one argument acts as the premise for the next argument."

42 I follow the text as edited and translated by LM 2016. I have divided the text into five segments based on the unfolding of Melissus' reasoning. After the frame marker or transition (T), Melissus' argumentation develops as follows: (1) If many things existed, they would have to be like what-is. (2) If many things are like what-is, they should be permanent and unchanging. But (3) many things are not permanent and unchanging (as we perceive them), therefore, many things are not like what-is. This (1–2 and 3) entails a logical contradiction (4). Hence, Melissus concludes (5): i) The perception that things change is illusory; ii) The perception of the existence of many things is also illusory; iii) If there were many, what-is would cease to exist (not-being), therefore, only the One exists. For a slightly different reconstruction of the structure of the whole argument, see Graham 2010, 483.

γίνεσθαι καὶ τὸ ψυχρὸν θερμὸν καὶ τὸ σκληρὸν μαλθακὸν καὶ τὸ μαλθακὸν σκληρὸν καὶ τὸ ζῷον ἀποθνήσκειν καὶ ἐκ μὴ ζῶντος γίνεσθαι, καὶ ταῦτα πάντα [559] ἑτεροιοῦσθαι καὶ ὅ τι ἦν τε καὶ ὃ νῦν οὐδὲν ὅμοιον εἶναι, ἀλλ᾽ ὅ τε σίδηρος σκληρὸς ἐὼν τῷ δακτύλῳ κατατρίβεσθαι ὁμοῦ ῥέων καὶ χρυσὸς καὶ λίθος καὶ ἄλλο ὅ τι ἰσχυρὸν δοκεῖ εἶναι πᾶν, ἐξ ὕδατός τε γῆ καὶ λίθος γίνεσθαι, ὥστε συμβαίνει μήτε ὁρᾶν μήτε τὰ ὄντα γινώσκειν. (4) οὐ τοίνυν **ταῦτα** ἀλλήλοις ὁμολογεῖ· **φαμένοις** γὰρ εἶναι πολλὰ καὶ ἀίδια καὶ εἴδη τε καὶ ἰσχὺν ἔχοντα πάντα ἑτεροιοῦσθαι **ἡμῖν δοκεῖ** καὶ μεταπίπτειν ἐκ τοῦ ἑκάστοτε ὁρωμένου· (5) δῆλον τοίνυν, ὅτι οὐκ ὀρθῶς **ἑωρῶμεν**, οὐδὲ ἐκεῖνα πολλὰ ὀρθῶς δοκεῖ εἶναι· οὐ γὰρ ἂν μετέπιπτεν, εἰ ἀληθῆ ἦν, ἀλλ᾽ ἦν, οἷόν περ ἐδόκει ἕκαστον, τοιοῦτον· τοῦ γὰρ ἐόντος ἀληθινοῦ κρεῖσσον οὐδέν, ἢν δὲ μεταπέσῃ, τὸ μὲν ἐὸν ἀπώλετο, τὸ δὲ οὐκ ἐὸν γέγονεν. οὕτως οὖν, εἰ πολλὰ εἴη, τοιαῦτα χρὴ εἶναι, οἷόν περ τὸ ἕν.

(T) The greatest proof (*semeion*) that it is only one is this argument, but these following ones are also proofs. (1) For if many things existed, they would have to be exactly like what I myself say that the one is. (2) For if earth exists and water, air, iron, gold, fire, the living and the dead, black and white, and the other things of which humans say that they are true, if then all these things exist, and we see and hear correctly, then it is necessary that each thing of this sort be as it first seemed to us, and that it not change or become different, but that each one always be as it is. (3) But as it is, we say that we see, hear, and understand correctly, but it seems to us that what is hot becomes cold and what is cold hot, what is hard soft and what is soft hard, that what is living dies and that it comes to be out of what is not living, and that all these things [559] become different, and that what was and what is now are not at all similar, but that iron, although it is hard, is rubbed away by the finger and at the same time flows, and likewise gold, stone, and everything else that seems to be resistant, and that earth and stone come to be out of water, so that the result is that we neither see nor know the things that are. (4) Hence these [scil. statements] do not agree with one another. For although we say that they are many, eternal, that they possess forms and force, it seems to us that they all become different and change out of what is seen each time. (5) Hence it is clear that we do not see correctly, and that it is not correctly that these things seem to us to be many. For they would not change if they were true, but they would be just as each one seemed to us to be. For there is nothing stronger than what truly is; but if it changed, then what is would be destroyed, while what is not would come to be. In this way, therefore, if many things existed, they would have to be exactly like the one.

Melissus' lengthy passage is fraught with metadiscursive markers –and probably offers the most elaborate example of early Greek philosophical prose style. The opening line is worth considering in detail.

1. The opening section of this fragment (T) serves as a frame or transition marker, which is already an indication of the meta-discursive dimension of Melissus' prose. From a textual linguistics approach, it is quite a remarkable opening in that it uses concurrently two cohesive devices, which enable the reader to construe the relations existing between different discourse segments and incrementally construct a coherent representation of its content.[43] The opening line of the passage thus features two discourse-deictic markers (anaphoric and cataphoric respectively) that frame the ensuing passage within the broader discussion of what-is. This is an instance of endophoric marker in Hyland's model.[44] The expression οὗτος ὁ λόγος functions as an anaphora and directs the reader's attention to a previous textual segment, more precisely to the previous argument (referred to here as *logos*), which Melissus calls the "greatest proof" or "sign" (μέγιστον μὲν οὖν σημεῖον). This helps create textual cohesion and enhances readability. The following phrase τάδε (*ἐστι) σημεῖα has, conversely, a cataphoric function. The demonstrative pronoun directs the reader to the ensuing *semeia* (proofs) which will take up the rest of the fragment 8 (in the form of chained argumentation).[45] It is worthy of note here that the word σημεῖον in the sense of written sign (whence "written proof") is unprecedented in the early classical period, especially in a metalinguistic sense of argumentative proof as used here by Melissus.[46]

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43 The concepts of cohesion and coherence are defined by Halliday and Hasans 1976. On the processing of referring expressions, the connections of statements in text, and the encoding of knowledge-based inference, cf. Graesser, Millis, and Zwaan, 1997.

44 Hyland 2005, 51.

45 Reale 1970, 399–400 notes that the first *semeion* refers to the direct argument previously expounded which stemmed from the analysis of the concept of what-is, whereas the following *semeia* allude to the ensuing dialectical arguments – that will deal with the contradictory nature of multiplicity. At any rate, these *semeia* seem to indicate 'argumentative proofs', on a metadiscursive level. Interestingly, Melissus' *semeia* echo Parmenides' *semata* (B8, v2). However, whereas the former unequivocally perform a deictic function signaling a subsequent textual segment, the latter are best interpreted as predicates or attributes of the self. Coxon 2009, 314 states that Parmenides' σήματ᾽ are signs or monuments, which are enumerated in ll. 3–6 as predicates of Being (ἐόν).

46 The noun *semeion* originally had the meaning of 'countersign', 'signal', and 'identification mark', but also 'divine sign'. It began to be used very early in the more secular sense of 'proof', both as a starting point and as a verification of inferential reasoning (see Sophocles, *Oedipus Tyrannus* 712; *Elecktra* 23 and 85). The literature surveying the semantic component of the term *semeion* shows that its use became widespread in the medical and rhetorical *technai* in the fifth century, which relied on the identification and

2. Melissus' ensuing argumentation (segments 1–5 above) is not only rigorous from a logical point of view, but also displays an assortment of interpersonal and textual metadiscursive markers which enhance the readability of the text.[47] As far as the interpersonal level is concerned, Melissus' prose deftly combines first person singular and plural deictic markers together with third-person declarative statements. At (1) the expression ἐγώ φημι features a first person deictic marker followed by a verb of saying which is used to restate the main doctrine the text sets out to validate, to wit, 'that the one is'. The phrase also evinces an endophoric function in that it points the reader back to the core thesis previously developed. More importantly, the explicit use of self-mention (which does not occur again in the remainder of the fragment or elsewhere in Melissus' verbatim citations) underscores authorial identity and authority, sending the reader a clear indication of Melissus' core assertion, against which the following counterfactual speculation should be gauged. Indeed, the reasoning in (2) and (3) that follows is variously framed by the use of the inclusive "we", expressed via first person plural personal pronouns and conjugated verbs (ἡμεῖς ὀρθῶς ὁρῶμεν καὶ ἀκούομεν), the use of the dative first person plural with an impersonal verb (τὸ πρῶτον ἔδοξεν ἡμῖν / δοκεῖ δὲ ἡμῖν / ἡμῖν δοκεῖ)[48] or a dative participle construction (φαμένοις γαρ). This first person plural can be interpreted as the *author's we*, or *pluralis modestiae*, which is often interpreted as referring to a generic third person as we (instead of *one*). This inclusive use of 'us' creates an attachment between the author and reader, and is used by Melissus precisely when discussing the deceptive nature of sense perception – which appears to be common to all men (οἱ ἄνθρωποι). This interpersonal metadiscursive marker implies an assumed shared knowledge and thus helps shape an interpretive community (author plus readers), guiding the addressee (i.e., the reader) through an argument and toward a preferred interpretation. At the end of (2) the first-person plural as engagement marker

interpretation of signs as a way of making a case (or moving from the visible to the invisible). However, scholars concur that the knowledge obtained through *semeia* is largely uncertain, which makes Melissus' usage of the word here in the sense of logical argument all the more exceptional. On the meaning and use of the term in rhetoric and medicine, see Pender 2005, 50–51; Perilli 1991, 153–180. For a survey of *semeion* encompassing various genres, see Hankinson 1993, 1169–1187.

47 Current research indicates that the use of metadiscourse has positive effects on readability, especially, improved comprehension of texts (Crawford Camiciottoli 2003) and recall (Crismore and Vande Kopple 1997; Reitbauer 2001).

48 Cf. Smyth 1920, 344. The dative of point of view denotes the "person in whose opinion the statement holds good" and is semantically related to the dative of interest, cf. Goodwin 1894, 247–248; Chantraine 1953, 74; Moorhouse 1982, 84.

is combined with an endophoric marker in the comparative clause οἷόν περ τὸ πρῶτον ἔδοξεν ἡμῖν ("as it first seemed to us"). The temporal adverbial phrase (τὸ πρῶτον) functions here as a metatextual marker, that is to say, as an expression pointing not to a previous location in time but to an earlier reference in a textual sequence: Melissus' assertion that what-is is unchanging and permanent. Again, this endophoric marker guides the reader through the text by referring to earlier material, thus creating a highly cohesive whole that enhances readability and facilitates understanding in a complex argumentative sequence. Similarly, the demonstrative pronoun ταῦτα in (4) οὐ τοίνυν ταῦτα ἀλλήλοις ὁμολογεῖ ("Hence these do not agree with one another") is used as an indexical or endophoric marker: the reference of the pronoun is the two contradictory statements in the previous sequence. Strictly speaking, ταῦτα is a deictic expression which does not 'replace' a specific segment of text, but refers to the implications a reader may derive from the previous two argumentative steps, namely that the two propositions are logically incompatible or incongruous.

3. The fragment closes with Melissus' conclusion, which is signposted by yet another metadiscursive marker. Technically referred to as a 'booster', the expression δῆλον τοίνυν ("Hence it is clear") is a modality marker which emphasizes certainty while marking involvement, solidarity, and engagement with the reader.[49] This is reinforced by the transition marker (τοίνυν) which helps the reader interpret the remainder of the text as the logical consequence of the earlier discussion.[50] Melissus' conviction stems from the rigor in his previous argumentative chain, which makes his conclusion a logical necessity. The first-person deixis is abandoned; the re-statement that 'only the One is' in his final remark takes an impersonal, categorical phrasing: "if there were many things, they would have to be just like the one" (εἰ πολλὰ εἴη, τοιαῦτα χρὴ εἶναι, οἷόν περ τὸ ἕν). χρὴ thus implies a logical necessity: the multiplicity of beings has been refuted by counterfactual reasoning.

49 On boosters as interactional resources, see Hyland 2005, 52–53.

50 According to Denniston 1954, 568–69, τοίνυν is a connector that is common in Attic and Ionic prose, while absent from Homer and Hesiod, and rare in lyric. The particle is described as colloquial and conversational, and more frequent in direct speech. Its use as a conclusion of formal syllogisms is mentioned (p. 571), though this example from Melissus is not acknowledged.

5 Conclusion

The metadiscursive devices illustrated in Anaxagoras' and Melissus' fragments are distinctive features of early philosophical and technical prose. While the procedures of either author are not identical, and the individual styles are well in evidence, the metadiscursive dimension of the fragments stands out in comparison to other genres of philosophical (and non-philosophical) discourse. My suggestion is that the development of technical philosophical prose may have been prompted not only by doctrinal needs but also by the necessity to accommodate language to various shifting material and socio-pragmatic conditions. These conditions include the circulation of philosophical knowledge within elite circles of intellectuals increasingly acquainted with the technicalities of reading and writing, including their assiduous interaction with architects, astronomers, and geometers within the Ionian milieu, who produced hybrid texts combining diagrams, visual aids, symbols, and written text; the deliberate abandonment of metrical composition in certain discourse types (notably the *peri physeos* genre); and the practical limitations (and potentialities) imposed by the papyrus scroll as the preferred medium of transmission.[51]

As evidence in the fragments of Anaxagoras and Melissus, metadiscursive markers serve as visible linguistic traces of the adaptation of language and thought to these changing material conditions. Indeed, a number of the linguistic features identified in the fragments under study may have been prototypical of technical prose discourse more generally. Readability, for one thing, is enhanced by the use of textual markers to recapitulate previous explanations and to signpost logical transitions in increasingly complex expository or argumentative sequences. Epistemic markers often signal the degree of authorial commitment to the ongoing discourse. The addresser-addressee relationship is also often encoded via engagement markers that create an intellectual community in which readers are collectively incorporated as discourse participants. Finally, the fragments show traces of an increasingly objective and impersonalized diction, especially so in the case of Melissus' highly structured and formalized prose, which brings into sharp relief the *demonstranda* in the likeness of a mathematical proof.[52]

Regardless of the way in which philosophical knowledge was elaborated and reached its final form (possibly in contexts of instruction and oral conferencing), the evidence gleaned from the fragments suggests that these

51 Thesleff 1966, 94 uses the expression "early treatise style" to refer precisely to the prose texts composed by Melissus and Anaxagoras.

52 On the "Eucledian" style of Melissus' argumentation, see Rossetti 2020, 139–144.

philosophical inquiries were designed to be put into writing (*sungraphai*). Furthermore, the material on which they were recorded was papyrus scrolls, a device that imposed its own physical constraints but also permitted the accrual and re-elaboration of previous knowledge, unlimited individual perusal, as well as socialization of knowledge in relatively small instruction clusters. This writing material also allowed the inclusion of graphic or visual aids as paratexts, as well as the dissemination of knowledge beyond the bounds of its original context of production.[53] Finally, the heightened metadiscursive dimension of the texts suggests that they were chiefly recorded to be read (and, naturally, discussed thereafter) either aloud (or perhaps also silently) by a single individual or a relatively restricted group of intellectuals. Many of these texts could also perform practical functions, whether as memoranda, handbooks or material for instruction. Yet, by comparison with other genres, philosophical texts in prose did not lend themselves to memorization and oral delivery in front of an audience.

The metadiscursive dimension of early prose can be likewise seen, more largely, as an adaptation of language to buttress the texture of what has become disembodied, de-contextualised speech, following a deliberate attempt made by some early thinkers to abandon metrical composition, and as a strategy to facilitate the interpretation and enhance the readability of increasingly complex explanatory and argumentative sequences. Prose writing requires discursive strategies that may fill in the missing prosodic, paralinguistic and contextual features of situated, in vivo, speech acts that were naturally activated in performance. The speaker meaning of oral composition is thus largely supplanted by the enhanced textual meaning of written prose texts, which not only highlights the propositional content but also signposts the sequencing of information, makes transitions explicit and codifies writer-reader interactions in order to facilitate understanding of a disembodied text. While it is difficult

53 The inclusion of diagrams in prose handbooks may have been a fairly regular occurrence. Anaximander is famous for having composed not only the first prose book but also the first map of the world, followed by Hecataeus of Miletus (DK 12 A1, 6, 7). On these maps of the world, see D. Couprie, R. Hahn and G. Naddaf 2003, 32–33 and 48–55. The Ionian setting at the time of the earliest prose continuous compositions was a melting pot of intellectuals who relied on observation (*autopsia*) to conduct their inquiries (architects, geographers, astronomers, mathematicians, geometers, *physiologoi*, etc.). This makes it plausible that these prose handbooks and *historiai* also included maps, diagrams, or sketches of various kinds. Kahn 1983, 112–13 contends that the inception of prose is closely associated with geometry, architecture, and city planning. Hahn 2001, 47–66 explores the connection between *physiologoi* and architects as communities of shared interest and activities.

to generalize based on the meager evidence available, and considering that there must have been significant variations within the early Greek expository tradition, the case of Anaxagoras and Melissus discussed in this paper enables us to catch a glimpse of what seems to have been an increasingly technical, self-contained, and self-explanatory form of prose composition (*sungraphe*) aimed at recording and disseminating the results of a personal inquiry.

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CHAPTER 11

Materiality and Philosophy

The Ancient Greek and Chinese Experiences Compared

G.E.R. Lloyd

As Hahn and Wians explain in their Introduction, the focus of this set of studies is on what they call the 'matter' of philosophy. By 'matter' they understand not just the physical material support of written texts and the material circumstances of existence and social life, but also the manner in which philosophical ideas, beliefs, values, and practices are communicated in oral discourse as well, and even also the ways in which the philosophical life may be practiced by individuals in private and on their own. While that series of statements refers to 'philosophy' and to what is 'philosophical' as if these were unproblematic terms, it is clearly wrong to assume that we are dealing with a single well-defined and agreed, cross-cultural, phenomenon. On the contrary, what counted as philosophy was highly disputed in Greco-Roman antiquity, and remains so today, as a moment's reflection on the differences within and between differing western European philosophical traditions shows – to go no further afield. French existentialism, German idealism, British empiricism, post-modern deconstructivism, all have a claim to be philosophical, but the nature and justification of each of such claims differ profoundly.

That point can be extended, and I shall extend it, to other cultures where there is no indigenous term that is exactly equivalent to our 'philosophy'. The modern Chinese term for philosophy, *zhexue*, is a late borrowing from Japanese. In classical Chinese texts from the Spring and Autumn and Warring States, through the Qin and Han dynasties onwards, there is, however, considerable activity focussing on problems that we would think of as philosophical, debates on issues of morality, for instance, or on right and wrong, on justice and good government, on wisdom and intelligence, and especially on what they called the Way, the *Dao*. All of those interests give the lie to those who, in part misled perhaps by the lack of a single conceptual equivalent, have denied that the ancient Chinese had 'philosophy' and put it that they just had 'wisdom'. If the vocabulary in which they discussed ethical, political, cosmological, epistemological, and logical issues is distinctive, we can recognize the issues themselves well enough and accordingly investigate the characteristics of the various modes of philosophizing in which they engaged.

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The remit of this chapter is then to compare and contrast the Greco-Roman and the ancient Chinese experiences to see what light that can throw on the issues raised by this project. What were the aims and goals of those whom we can identify as engaging in philosophical inquiry? What were the media and means of communication they used and with whom, indeed, did they hope to communicate? How do the answers we can give to those questions impact on our understanding of their activities? What, in other words, can we learn about the matter of philosophy from such a cross-cultural comparison?

My tactic will be first to spend some time introducing elements from the Chinese experience since they will be less familiar to most readers of this book than those from the Greco-Roman world. Then cross-referencing that world I shall endeavour to spell out what I consider to be the important implications for our project. It will be simplest to begin with the relatively straightforward matter of our evidence for early Chinese written texts and the relevant genres into which they fall.

The earliest extant Chinese texts are the inscriptions on the so-called 'oracle bones' and turtle shells found at Anyang dating from the 12th century BCE. These record attempts to foretell the future and to determine which policies had the approval of the ancestors. We are dealing with issues of exclusive interest to the King or the State: the procedures were costly and elaborate and were no doubt tightly controlled. When more general (but still quite specialised) texts came to be written down, this might be on narrow strips of bamboo or less frequently on silk. We have extant examples found in tombs predating the unification of China by the first Emperor, Qin Shi Huang Di in 221 BCE, though he played an important role in the development of writing in that he made moves to standardise the Chinese script. By the time we get to the Han Emperor Wu Di in the next century certain key writings were selected for the educational curriculum of the Academy he founded. These were the so-called Confucian canons, the *Changes* (*Yi*), *Odes* (*Shi*), *Documents* (*Shu*), *Springs and Autumns* (*Chunqiu*) and *Rites* (*Li*).[1] The Academy had professors responsible for teaching these and a mastery of them was a prerequisite for anyone with the ambition to qualify as an official in the increasingly elaborate Chinese imperial civil service.[2]

1 The complex issues of the construction, transmission, and interpretation of these canons, and the extent of their indebtedness to any views that can be associated with the historical figure of Confucius (Kong Fuzi) are authoritatively discussed in Nylan 2001. Those labelled the *ru* were members of the literate elite whose allegiances to earlier masters varied substantially. To translate that term 'Confucian' is liable to mislead.

2 Entry to the Academy, and graduation from it, came to be controlled by a complex examination system, the history of which has been told by Elman, e.g., 1994, 2000. Success there

By the turn of the millennium serious efforts were being devoted to construct a bibliographical taxonomy of genres of writing. This was the work of the bibliographers Liu Xiang and his son Liu Xin charged with overseeing the increasingly impressive imperial library.[3] Their classification is recorded in the *Han Shu* and it exhibits some interesting similarities with and differences from our own Western categories. What we can call the study of the heavens fell into two categories, *tianwen*, the patterns in the heavens, and *lipu*, calendars and tables, although that division does not correspond at all precisely to the one we might draw between 'astronomy' and 'astrology'. In particular the ancient Chinese did not see the difference as being one between two modes of prediction, one relating to what happens in the heavens, the second to what can be deduced concerning events on earth.[4]

However, the simple statements I have just made about canons conceal several points that are of importance to our agenda. We know from extant examples of another important text, the *Daodejing*, that different versions existed already by Han times. In that case we have some texts that reverse the order into which the two main parts of the work are divided. If the form that became most common put the *Dao* (way) section first, in an alternative version the section dealing with the *De* (power, sometimes translated 'virtue') came first, a *Dedaojing* rather than a *Daodejing* in other words. We should not then presuppose that the main philosophical writings existed in just a single form. This applies to the *Lunyu* or *Analects* that was often attributed to Confucius himself, though nowadays it is thought more likely to be a composition by his followers over an extended period of time: the text refers to Confucius himself on many occasions in the third person. A second example of a similar complex provenance and multiple authorship is the *Zhuangzi* another text that was evidently put together over several decades from the fourth to the second century BCE.

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depended not on birth or wealth or connections, but on ability, though one should not ignore the non-egalitarian elements at work, since eligibility to sit the examinations was not just open to anyone. Compare the ancient Greek experience, where some philosophical schools, such as the Epicurean Garden, accepted a wider range of students, including women, than others.

3 The impact of their editorial activity on the extant texts of classical Chinese works is a recurrent motif in the detailed analyses in Loewe 1993.

4 Ptolemy already made just that contrast in the opening chapters of his *Tetrabiblos*, claiming that while the study he called astronomy could, thanks to its mathematical methods, aim at certainty, foretelling events on earth was inevitably based on no more than conjecture. It should be emphasised, however, that elsewhere in our Greco-Roman sources the two terms *astronomia* and *astrologia* – and their Latin equivalents – were used interchangeably.

So *our* preoccupation with the reconstruction of *the* original text of the *Iliad* say or of the *Oedipus Tyrannus* or of Aristotle's *Metaphysics* – a preoccupation we inherit from the ancient Greek philologists themselves – is inappropriate to the Chinese situation. There, different groups of teachers handed down their own versions of canonical texts. The term for such groups was *Jia* whose root meaning is 'family', and indeed the deference that pupils were expected to show to masters closely mirrored the filial piety that was a key virtue that every child needed to manifest to their parents. In some instances students were only admitted to receive instruction after a solemn ceremony of initiation, and in general their character and respectability were as important as qualifications for such as any intellectual talent they might manifest.[5]

Once admitted, students were expected to memorize the version of the text they were being taught and they in turn would be expected to hand on that text as they received it to the next generation. Although the written text was central to this process of transmission, instruction was basically carried on in the oral mode. But the authority of the text and of the teachers who interpreted it was paramount. The emphasis was on received wisdom and although we can certainly discern what we would consider to be modifications in the understandings of texts, they were regularly represented as uncovering the original meanings, not advancing new ones. Confucius himself famously disowned innovation: the *Lunyu* (7.1) reports him as saying that he did not create, rather he transmitted – that is the wisdom he saw as to be handed down from antiquity.

Concentration on an authoritative text is a feature not just of the core curriculum in the imperial Academy but also of more specialized writings, in mathematics and astronomy, and in medicine, for example, and across the board these canons attracted multiple commentaries and sub-commentaries. Once again it is difficult to assess this activity correctly. We have already seen that the assumption that the Chinese presupposed the existence of a single

5 Thus we have good evidence of the initiatory rituals that aspiring doctors might undergo. In the *Lingshu* recension of the classical medical text, the *Huangdi neijing*, (48.1: 396ff.) we have an account of how the pupil (in this case the Thunder Duke) underwent purification for three days, sealing his oath of allegiance by cutting his arm and smearing blood, before he received the text of the book from the Yellow Emperor. This is the stuff of legend, to be sure. But in the biography of the second-century physician Chunyu Yi that is reported in the first dynastic history, the *Shiji* (ch. 105), we are told that he first served one of his eventual teachers for several years before he was admitted for instruction, and when this happened he 'refused the mat' – a sign of his deference to his teacher – and venerated him. On the relationships that existed within the *jia* between pupil and master, see especially Sivin 1995a and Csikszentmihalyi and Nylan 2003.

authentic and original Urtext is often mistaken. We might equally be tempted to see the commentary tradition as no more than a merely scholarly, philological, exercise. Yet that too often miscues the situation, for the commentary may be the vehicle for new ideas even when they are presented as already implicit in the ancient texts. It is true that compared with the trumpeting of originality often to be found in Greco-Roman texts the Chinese are more reserved in their authorial claims. But there are plenty of examples of commentators improving on and correcting previous commentators. Two examples from mathematics are the correction that Liu Hui makes to the use of 3 as the value for the circle-circumference ratio (what we call π) and the improvement that a later commentator, Zu Geng, made in his turn to Liu Hui's work.[6]

Further afield there were important compendia that summarized useful knowledge in pretty well every department of investigation. One put together by the man who served as Prime Minister to Qin Shi Huang Di (though before he became emperor) was the *Lüshi chunqiu* from about 235 BCE.[7] This is a vast work running to two hundred thousand characters. The story was that the compiler, Lü Buwei, had a copy hung up at the gateway of the market in Xianyang, the capital city of Qin, and offered a reward for anyone who could 'add or subtract' a single character, in other words correct and improve it in any respect (*Shiji* 85). No one did so, though no doubt this was more out of fear for how Lü might react than from a sense of conviction that the compendium was indeed perfect and complete.

As remarked already, the ancient Chinese taxonomy of literary genres differs from our own, though they certainly distinguish between different types of prose works. Those I have so far mentioned are mostly treatises, handed on from master to pupil as we have said. That does not apply in quite the same way to a further genre or kind of writing that was to become increasingly important, namely historiography. The first great general history, which I earlier cited for the biography of Chunyu Yi and from which I have just quoted the story about Lü Buwei, is the *Shiji*, the work of Sima Tan and his son Sima Qian completed around 100 BCE. This is not just 'historiography' in our sense, since besides the section that outlines the Annals of major early Chinese dynasties, there are biographies of notable individuals and types of person (including

6 Liu Hui shows that 3 represents the ratio of sides to areas in a regular hexagon. Since the circle circumscribed round such a hexagon is greater than it, accordingly 3 must be incorrect as a value for π. Where Liu Hui has to admit he is defeated by the problem of determining the volume of a sphere, Zu Geng announces his successful solution. The texts are discussed in Chemla and Guo 2004, and cf. Wagner 1978.

7 I draw on the translations and commentaries in Knoblock and Riegel 2000.

even 'assassin retainers') and a set of treatises dealing with the calendar, water control, and other matters of importance for the state.

The *Shiji* served as a model for later Chinese historiography, though unlike Sima Tan and his son, later authors, such as Ban Gu, were explicitly commissioned to undertake their work. The Simas held a position as Chief Scribe, but acted on their own initiative in undertaking the history of China down to their own times. However, the important point remains, that Chinese dynastic histories were more than just reports and commentaries on what had happened. In addition to the lessons that could be learnt by reflecting on historical events, they provided a general resource for a good deal of technical information that would be needed to secure good order in the empire.

Thus far I have been dealing with works that served important educational purposes, some but not all taught in the imperial Academy, but all laying some claims to be conveying useful knowledge, sometimes for personal edification, more often for the correct management of affairs of state. But of course not all Chinese compositions were designed for publication in book form, not all intellectual exchanges were mediated by texts in the first place. I shall come back to debates in a moment, but an important and rather distinctive Chinese genre of writing that I should deal with first is the memorial to the throne. Advisers wishing to catch the Emperor's attention would produce a document setting out some recommendation on some issue of importance, the policy to adopt in relation to anything ranging from foreign affairs to the calendar. Sometimes the Emperor himself solicited such memorials, but often they were written on the initiative of ambitious members of the literate elite.

One such was the memorial attributed to Li Si when he was Chief Minister of Qin in which he produced recommendations for the censorship, indeed the destruction, of certain books. The first thing to remark is that our evidence for this episode comes from hostile sources, writers starting under the Han who were often out to denigrate the Qin dynasty that they were replacing. Then secondly the proposal as reported in the *Shiji* 87 was subject to certain qualifications and reservations. It was copies of the *Odes* and *Documents* and other works in private hands that were to be collected and destroyed, and that would not apply to copies in the imperial library. Moreover exemptions were explicitly made for texts dealing with medicine, divination, and agriculture.

Such memorials were written texts designed to be read by the Emperor himself, though they were quite often intercepted by officials fearful of their influence. But a memorial or a set of them could be the topic of an extended debate where rival would-be experts competed to persuade the emperor of the superiority of their particular point of view. We hear of debates on the calendar for instance, and on the question of the right policies to adopt on the issue of the

State monopoly of salt and iron manufacture.[8] Alongside the impressive literary skills that members of the literate elite, including many who were involved in what we should consider philosophical inquiry, had to show, they clearly needed to be skillful in discussion and the marshalling of arguments pro and contra a given policy.

Yet there is an important difference between the usual situation in which debates were held in ancient China and what we know about classical Greece. When Chinese philosophers attacked other philosophers, they were generally targeting long-dead rivals rather than contemporaries who were in a position to answer back. When, as in the examples mentioned in the last paragraph, viva voce debates were held, these were usually formal occasions, and more importantly the outcome was generally decided not by the debaters themselves, nor by a general public, but by the Emperor or Ministers acting on his behalf.[9]

Having sketched out some of the material circumstances of the situation in which Chinese intellectuals operated, let me turn now to some of the implications for our understanding of the nature of 'philosophy' and 'science' themselves. In both China and the Greco-Roman world many of the most prominent individuals who were responsible for giving a lead both in ethical and political affairs and in the understanding of the world we live in were strong independent-minded personalities. Yet there is this first broad difference in the organizations or institutions within which they worked. The Chinese imperial Academy was under the direct control of the Emperor. The Athenian philosophical schools, Academy, Lyceum, Garden and Stoa, were all initially private institutions. The Museum and Library at Alexandria depended on the patronage of the Ptolemies, of course, but they were keen to represent themselves as the true heirs of Athenian intellectual brilliance. It is true that patronage becomes an increasingly important source of support for Greek and later Roman writers from the Hellenistic period onwards. But it still remained the case that for many of the important philosophers, mathematicians, and medical writers patronage was unavailable and so irrelevant. They relied on teaching as a major source of livelihood, though the doctors could and did

8 The text known as the *Yan Tie Lun* purports to be an account of these exchanges (see Loewe 1993, 477ff.), though the extent to which it remains faithful to the originals is a matter of continuing controversy.

9 Cullen 2007 documents a number of formal debates on astronomical, particularly calendrical, issues. It is important to note that what was at stake was no merely technical scientific matter but one of deep concern for the good order of the state. In one case the proposals put forward by the defeated party were found treasonable and their proposers condemned to death, although the Emperor commuted the sentence.

also charge for their treatments and the astronomers for the horoscopes they cast. That makes a significant difference in the way you conducted yourself. Keeping in your patrons' good books was a matter of humoring, if not blatantly flattering, them. When your livelihood depended on your attracting pupils who would pay you for instruction, you were on more level terms with rivals who competed for their adherence. I shall return to the implications of this at the end.

Of course a concern for advising on good government is shared by many Greco-Roman as well as Chinese intellectuals, with exceptions on both sides. China produced some notable recluses. Where the *Zhuangzi* is concerned, that text deploys irony and paradox to suggest an ideal of individual self-fulfillment. Yet Zhuang Zhou (the man after whom the text is named) still remained in touch with those such as his friend Hui Shi who held official positions, and insofar as he advocated *wu wei* ('no ado') that still had relevance to how the ruler was supposed to achieve good order: I shall return to *wu wei* below. Where a second famous recluse was concerned, Wang Chong at the turn of the millennium, he at one stage certainly aspired to hold office though he never succeeded in getting anything but a very lowly appointment. Yet the text he wrote in self-imposed exile, the *Lun Heng*, still offered advice relevant to government. This was far from Greek-style *ataraxia* when that implied a total withdrawal from any political involvement at all.

Then a further important difference relates to the role of what the Greeks called the inquiry into nature and what are generally considered to be their most important contributions to scientific investigation. Chinese philosophical writers were concerned with certain cosmological questions. There are accounts of the origins of the cosmos (cosmogonies, in other words) in such texts as the *Huainanzi* which also offers accounts of many phenomena, included mathematically based analyses of musical harmonies (see Major 1993). But these views are rarely equipped with self-conscious epistemologies and methodologies, designed not just to justify the theories, but to show how they must be correct. By contrast already in the Presocratic period Parmenides drives a wedge between Reason, directed at what is and delivering Truth, and mere Opinion, that follows sense-perception and convention. Plato subsequently was to develop a profound contrast between perception and reason and to insist that (mere) persuasion is inadequate. It took Aristotle then to define strict demonstration and to contrast it with other inferior modes of argument.

It is important for our purposes to appreciate that all of this is not just testimony to Greek intellectual inquisitiveness. Rather it is in part a result of the competitiveness that existed between different Greek Masters of Truth, who,

in order to win out against their rivals, often felt a need for, or at least saw an advantage in, not just asserting their first-order claims to deliver the truth, but also backing those up with second-order arguments justifying those claims on methodological or epistemological grounds. Your own theories were reliable because they were based on the right methods. Those of your opponents were fatally flawed as they were not. That type of move is much rarer in the Chinese context. Rulers and their ministers were unlikely to be impressed by, indeed one might say they had every right to be suspicious of, individuals who claimed to be in possession of infallible methods to arrive at indisputable truths.

To be sure there was, as we said, plenty of rivalry between Chinese intellectuals too. But there the goal of gaining the attention and support of the Emperor or of the Imperial Authorities sometimes took precedence over the development of abstract intellectual arguments to show that your theories must be true. In particular the Aristotelian ideal of producing demonstrations that would not just show the truth of their conclusions, but their certainty, their incontrovertibility, has no counterpart in classical Chinese thought in any domain.

So we have plenty of evidence that shows that the typical circumstances in which Greek and Chinese intellectuals operated exhibit marked differences. Those circumstances included the audiences they targeted, their interactions with those in authority, patrons, other intellectuals, potential or actual pupils and followers, and the social and political roles they occupied or aspired to. Certainly these divergent factors had a substantial influence on the character of the intellectual products they were responsible for. The most striking example of this, that I have discussed elsewhere (Lloyd 1996a) is the effects of the development of the ideal of axiomatic-deductive demonstrations not just on one tradition of Greek mathematics, but further afield in Greek natural science, medicine, and even theology. The dissatisfaction that many Greeks felt with mere persuasiveness led them to aspire to a mode of argument that would deliver objective certainty. That depended on a combination of indemonstrable but self-evident premises and valid deductive chains of argument. While validity was certainly generally within reach, securing self-evident premises was often well beyond it. What were to be those premises where the understanding of physical elements was concerned? What could serve that role in medical practice? Galen appealed to the principle that opposites are cures for opposites. But the trouble was to say what counted as opposites. In practice the principle turned out either to beg the question or to be true but vacuous.[10]

10 A further axiom that Galen appealed to was that nature does nothing in vain. Yet he was well aware that that had been denied by the atomists and others. To claim that it was

At the same time it would clearly be mistaken to slip into assuming that either Greek or Chinese philosophy and science were *determined* by such social and cultural factors or by any other of the material circumstances of the world in which they flourished. We can best appreciate where any such suggestion is aberrant by reflecting on the variety *within* what we count as either Greek or Chinese 'philosophy and science'. Both ancient societies produced tough-minded, idiosyncratic, individuals who do not conform to the patterns we can observe among many of their contemporaries. That applies, in Greece, already in the Presocratic period, which after all encompasses figures as divergent as Pythagoras, Parmenides, and Heraclitus. It continues in the fourth century with very divergent views of politics and education not just in Plato and Aristotle but also sophists and writers such as Isocrates. While the main Hellenistic philosophers agreed on the importance of a focus on happiness, they disagreed fundamentally on how to go about securing that, with a particularly sharp contrast between on the one hand those such as both Epicureans and Stoics who had positive messages to convey, and on the other Sceptics of different persuasions who eschewed what they considered to be dogmatism. Nor was this heterogeneity just a feature of 'philosophy', for divergent methodologies and ideals continued to compete in medicine and mathematics.

Even though in China the reach of state-sponsored institutions is stronger, and the contribution of minority groups or interests is harder to recover, we cannot ignore the latter. At one stage the followers of Mozi competed on more or less level terms with other members of the literate elite, the *ru*. They developed a variety of interests in both logic and epistemology (the sources of knowledge) that set them apart from most other Chinese philosophical schools. On the one hand, this serves as a qualification to our generalization about some of the major differences between Chinese thinkers and Greek ones. On the other, the very fact that the successes of the Mohists were short lived, and their influence declined so sharply under the Han and subsequently, shows where that generalization still broadly holds.

So if facile deterministic arguments are always going to founder in the face of the heterogeneity in both Greek and Chinese traditions, that does not mean that all attempts at comparison are futile. On the contrary it is, I would argue, primarily if not solely by carrying out careful critical comparisons that we can uncover what is distinctive about the aims and end-products of either Greek or Chinese intellectual endeavours. Two key questions will enable us to focus, in conclusion, on what would appear to be significant divergences set against

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self-evident was to ignore how controversial it was. I have discussed Galen's views and practices of demonstration in Lloyd 1996b.

a background of important commonalities. The first concerns the relationship of the individual to society and the second to the limits of human aspiration.

But first let me rehearse some of those commonalities. Both ancient civilizations set great store by education, in both literacy was prized, both came to develop institutions where students could go well beyond their primary schooling in letters and good behavior. Both enjoyed an economic surplus, the fruits of which were distributed very unevenly, though the misery of the deprived had the effect of releasing the privileged from mundane tasks in order to cultivate whatever they fancied to be the good life, whether that was to be devoted to pleasure or virtue or the welfare of 'all under heaven'. For some at least learning was an important component in that, whether directed to individual self-fulfillment or to the welfare of society as a whole.

That takes me to the first of my two key questions, which relates to how individuals saw themselves in relation to the communities in which they lived. Picking up points from my earlier discussion, let me summarize a few salient issues. Both ancient China and the Greco-Roman world produced, as we said, strongly individualistic personalities who staked claims to be important leaders and guides to others on how to behave. However, many Chinese intellectuals pinned their hopes on the notion that the welfare of 'all under heaven' is to be achieved by the benevolent rule of a sage king, even though one prominent idea was that the way in which he achieved that was by practicing *wu wei*, 'no ado', in other words by minimal intervention. For that to work the king or emperor had to rely on loyal and wise advisers, including implicitly or explicitly those intellectuals who were advocating such an ideal. Political influence was certainly also a goal of many philosophers in the Greco-Roman world, and Marcus Aurelius is a striking example of a man who combined philosophy not just with political theorising but with ruling a vast Empire. However, as we have seen, many argued that freedom from anxiety, *ataraxia*, could be achieved whatever the circumstances. The claim was that with the right philosophy the sage could be happy even on the rack.

In both cases we have a mixture of a certain realism about the political scene combined with a particular mode of idealism about how to deal with that. Sage Kings were generally recognized in China to be mainly figures of legend, though important paradigms nevertheless. Yet many writers persisted in constructing an ideal that depended on the wisdom of the ruler. The retreat from any hope for securing a political utopia was more pronounced in Greco-Roman writers, even though so much effort was devoted to the dream of an ideal state. Yet when, as often, it was recognized that such ideas were hopelessly unrealistic, the focus was turned on how despite that, the happiness of the individual

could be achieved, namely by freeing oneself from dependence on external circumstances, indeed from any political or social ambition whatsoever.

But if we consider my second question, of the limits of what humans can attain, we see that some important qualifications need to be entered to the picture I have just sketched out. We drew attention to the prevalence of agonistic styles of debate across the board, from politics to mathematics and medicine, in the Greco-Roman world. We noted that the closer relationship that many Chinese intellectuals had to state-sponsored institutions not to mention imperial patronage carried both advantages and disadvantages. The patronage of ministers and rulers secured employment for many advisers, yet also acted at times as a constraint on their capacity or willingness to innovate.

A particular feature of much Chinese intellectual engagement enables us to nuance this point. Many texts emphasize that it is a prime responsibility of the good adviser to remonstrate with the ruler when he is advocating policies liable to damage the state or is simply misbehaving.[11] Those advisers did so at considerable risk to themselves, for there were many kings and emperors who responded not by following this advice but by punishing the adviser. Chinese history is punctuated by such cases.[12] On the one hand this certainly shows how Chinese advisers saw how important it was, on occasion, to reprimand their rulers. Yet on the other this practice cemented the tradition that the role of those intellectuals was precisely to advise. In Greece and Rome by contrast many philosophers operated at some distance from the seats of political power. They had accordingly more freedom to express whatever they wanted to. But the price they had to pay for that was often that their ideas were ignored by all but a tiny minority and their policies stood no chance of being implemented.

Yet we must come back to a further feature of the impact of the circumstances of intellectual exchange in Greece. We noted that a deep dissatisfaction with the modalities of persuasion led some – philosophers, mathematicians, and even medical writers – to develop a quite different ideal of what could be achieved, not mere plausibility, but indubitability. What this shares with the moral ideal of *ataraxia* is the idea that the goal can and should be secured independently of external circumstances of any sort. The truth can be attained

11 The primary evidence has been the subject of several studies, notably Schaberg 1997, cf. Lloyd 2005, Nylan 2010.

12 Among the Chinese intellectuals who fell from favor and paid the ultimate penalty were Lü Buwei and the king of Huainan, compilers of the *Lüshi chunqiu* and the *Huainanzi* respectively. The historian Sima Qian, who fell out of favor with the emperor Han Wu Di, chose the ignominy of castration rather than death precisely out of loyalty to his father, in order to complete his work.

irrespective of who was attaining it, irrespective of who might or might not be persuaded on the issue, irrespective of who was there to approve or disapprove.

What this suggests is that the embeddedness of Chinese intellectuals in the social and political circumstances within which they operated gives much of their output a more practical applicability than their Greco-Roman counterparts aimed for and achieved. The open public debates that are so prominent a feature of Greco-Roman society on the one hand fine-tuned the rhetorical skills that intellectuals and others had to develop in order to win the argument – even to secure their livelihood – but on the other had a quite different impact, when such persuasions served not as a positive model for argumentative exchange but as a negative one, one that served to emphasize that mere persuasion was quite inadequate. The goal, on this view, must be incontrovertibility. The end of a Euclidean proof was 'QED', quod erat demonstrandum – as if there was no person doing the demonstrating and no audience to question that it had indeed been achieved. Chinese philosophers engaged in critical analysis of the theories on offer and Chinese mathematics checked their results. But they were never tempted to aim for unqualified indubitability. On the argument I would propose it turns out that the typical contexts and styles of communicative exchange that obtained on the one hand in ancient China and on the other in the Greco-Roman world had a marked impact on the goals of their respective intellectual endeavors.

Our aim as historians is to investigate not just the surface contents of theories, suggestions, proposals, but to probe the underlying assumptions at work, the conception of reality, of the place of humans in the universe, the conceptions of what makes life worth living, in short the fundamental values expressed or implicit in those endeavors. It is by focusing on the similarities and differences I have drawn attention to that we can begin to hope to reveal aspects of the circumstances of the development of philosophy and science in China and in Greece that we might otherwise fail to appreciate. It has been the ambition of this contribution to take some first tentative steps in that direction, conscious of the considerable task that still lies ahead.

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PART 4

Philosophy and Ancient Embodiment

∵

CHAPTER 12

Thales and the Measure of Wisdom

Philip Thibodeau

Few Greek philosophers of note are as hard to bring into focus as Thales of Miletus. Some blame for this situation must lie with Thales himself, who left behind nothing in writing, despite living in a literate community. But the primary reason for his blurry profile lies in the distance from which ancient witnesses viewed him. Thales passed away in the 540's BCE. Three or four decades later, Heraclitus and Xenophanes said something about Thales in their work, but exactly what, we do not know. The oldest surviving texts that speak about Thales were written by Herodotus and Aristophanes in the last third of the fifth-century, more than a century after his death. Plato and Aristotle, who record several facts and colorful anecdotes about the thinker, were writing another half century later. The first scholars to make a concerted effort to discover and memorialize Thales' contributions to the fields of geometry, astronomy, and natural philosophy were Aristotle's students Theophrastus and Eudemus; unfortunately, their records survive only in late paraphrases. As we move into the Hellenistic and Roman eras, the corpus of testimony for Thales grows in size but decreases in evidentiary value the further on we go. The gap between Thales and the beginning of the ancient tradition about him means that, in a sense, we have no early sources for Thales; all are 'late'. As a result, our various bits of evidence are of uncertain credibility, and difficult to piece together.[1]

One tool we have to combat this uncertainty is *Quellenforschungen*: that is, the process of establishing a provenance for the various bits of lore that turn up in later witnesses and seeking to reconstruct their lost sources. Over the past two centuries this approach has yielded several results that illuminate the ancient tradition about Thales. Bruno Snell, for instance, has demonstrated

1 On this topic see especially Dicks 1959, who presents a powerful skeptical case regarding our knowledge of Thales which it is the purpose of this paper to overcome. The best comprehensive discussion of the philosopher in English remains that of Kirk, Raven, and Schofield 1983 (hereafter KRS), 76–89. The monograph by O'Grady 2002 suffers from implausible hypotheses, such as crediting Thales with knowledge of the earth's sphericity. The new collection of fragments by Wörhle 2014 is very useful.

I would like to thank Robert Hahn and William Wians for inviting me to contribute to this collection, and Jill Kelly for drawing the diagram for Thales' procedure.

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that Aristotle and Plato drew on an anthology of opinions assembled by the sophist Hippias which mentioned Thales.[2] Thanks to the work of scholars like Hermann Diels, Jaap Mansfeld, David Runia, and Leonid Zhmud, we now have a much better sense of the character and contents of Theophrastus' and Eudemus' histories of early science.[3] This paper seeks to build on that work in order to trace the provenance of several reports relating specifically to Thales.

Another way to address this problem is to lay foundations on the other side of the gap. This involves reconstructing the material and intellectual culture of the Greek world in Thales' day and trying to see which ideas were 'in the air', so to speak, when he was alive. We can learn quite a bit about the culture of Ionia during the sixth-century from the fragments of figures like Solon, Alcaeus, Anacreon, even Aesop. Herodotus and other sources, included some from the Near East, provide us with a basic outline of political and military developments. We also possess a wealth of evidence regarding art and architecture which, as Robert Hahn has show in series of fascinating publications, has the potential to shed valuable light on such things as the craft analogies which early Greek philosophers deployed.[4] Since the study of historical context can give us a sense of which matters Thales and his contemporaries would have considered salient, it can also be used to inform our reconstruction of the earliest phases of the Thales tradition, and guide our *Quellenforschungen*.

The discussion that follows takes a twofold approach, reconstructing both texts and contexts. I will start by considering how the form of intellectual expertise the Greeks called *sophia* was conceived of during the early sixth-century. Next, I reconstruct some of Thales' specific teachings involving navigation, astronomy, and meteorology. After that I will argue that Thales remarks about the earth resting on water originally belonged to an explanation of why earthquakes occur. Finally, I will make the case that a testimonium for Thales' doctrine of primary water preserved in the Aëtian tradition affords us a more accurate representation of what the Milesian taught than a commonly-cited passage from Aristotle's *Metaphysics*.[5]

This paper has an additional broad point to make. It will become clear as we move along that most of Thales' exposition focused on problems involving navigation and the use of astronomy and basic geometry to solve such problems. Now various sources allude to a document that preserved Thales'

2 Snell 1944.

3 Diels 1879, Mansfeld and Runia 1997, 2009, 2010, Zhmud 2006, Runia 2008 (a very accessible introduction to the topic).

4 Hahn 2001, 2010, 2017.

5 See the discussion on texts (50) and (52), below.

teaching, a didactic poem written in hexameters called the *Nautical Astronomy*, or *Astronomy for Sailors* (*Nautikē Astrologiā*). Although sometimes ascribed to Thales, one ancient scholar – almost certainly Callimachus – identified its author as a poet named Phocus who hailed from Samos, Miletus' Ionian neighbor.[6] As we shall see, a large portion of the authentic information that we possess about Thales can be traced back to this poem.

1 What Is Wisdom?

There are two words that turn up repeatedly in our earliest references to Thales: the adjective *sophos* and the noun *sophia*. Early stories about the so-called Seven Wise Men (*hoi hepta Sophoi*) make Thales the foremost member of this group. A statue in his hometown of Miletus bore an inscription praising his *sophia*; Herodotus has Thales aspiring to show off his *sophia*; Plato calls Thales the type of the *sophos* inventor; Demetrius of Phalerum asserted that Thales was recognized for his *sophia* at Delphi in 582 BCE; and Timon of Phlius called him 'the *sophon* astronomer among the Seven *Sophoi*'. The term is applied to him so consistently that the association can be traced back to his own day. It is also significant that when sources touch on the basis for his *sophia*, they allude, not to his ethical maxims, but to his skill in astronomy and practical invention.[7]

In authors from the fifth-century like Herodotus and Euripides the adjective and its cognates are regularly used to denote insight, sometimes of a positive kind ("wisdom, sagacity"), sometimes morally neutral ("shrewd, clever"). But texts dating to the period 630 to 530 BCE, which roughly encompasses Thales'

6 Diogenes Laertius wrote that "according to some [Thales] left behind nothing in writing; for the *Nautical Astronomy* that is attributed to him is said to be the work of Phocus of Samos" (1.23). Two considerations make it likely that the ultimate source for the claim about Phocus is Callimachus. First, as the cataloguer of the great library at Alexandria, Callimachus set himself the task of identifying pseudoepigrapha and tracking down their true authors; through his research he was able to identify the individuals behind works ascribed to Homer, Pythagoras, Ion, and Euripides (Blum 1991, 158/9). To claim that a poem ascribed to the famous Thales was actually written by the obscure Phocus of Samos would fit the same pattern. Second, Diogenes' statement is immediately followed by a reference to Callimachus and a quote from his *Iambi* where it is said that Thales invented Ursa Minor – an assertion for which the *Nautical Astronomy* must have been the source. See the discussion of passage (17) below; for the date, page 24.

7 See respectively Diogenes Laertius 1.34 (statue, astronomy), Herodotus 2.20.1, Plato, *Republic* 10, 600a4 (inventor), Diogenes Laertius 1.22 (Demetrius), and 1.34 (Timon, astronomy).

lifetime, show a word with a very different set of connotations.[8] The following gallery of texts contains all of the early instances of its use.[9] I have left the two words untranslated, and rendered *sophizomai* as 'to practice *sophia*', to allow their meaning to emerge from the contexts in which they are used.[10]

(1) Alcaeus of Mytilene, describing an unidentified man:
"he was *sophos* and with complex thoughts …" (fr. 39a.9 Vogt)

(2) Alcman of Sardis/Sparta, on Castor and Polydeuces:
"*sophoi* horsemen" (fr. 2 Davies)

(3) Anacreon of Teos/Samos, addressing a girl:
"Thracian colt, why do you eye me crosswise
and flee, so stubborn; do you think I know nothing *sophon*?
Be sure, I could easily put a bridle on you,
grab the reins, and make you turn at the end of the course." (fr. 417.1–4 Page)

(4) Archilochus of Paros, describing an unidentified man:
"good with a trident, and a *sophos* ship-pilot" (fr. 211 West)

(5) Chersias of Orchomenus, on Hesiod
"Hesiod, whose fame among humans is the greatest
if men are judged by the touchstone of *sophia*." (*Contest of Homer and Hesiod* 250–253 Allen, cf. Pausanias 9.38.9)

(6) Hesiod of Ascra, introducing his advice for sailors:
"I will show you the measures of the much-sloshing sea,

8 The discussion of the word in Snell 1924, 1–20 remains fundamental. Kurke 2011, 195–124, on *sophia* is very insightful, though the synchronic approach she adopts limits its usefulness for a historical exploration of the word's changing connotations.

9 I have omitted texts from Theognis of Megara, several of which do use *sophos* to mean 'insightful' (e.g., 120, 565, 682), on the grounds that his collection was still accreting material at the time of the Persian Wars, and thus it is impossible to tell at what date a particular epigram was composed. I have also left out a fragment of the Homeric *Margites* (Aristotle, *Nicomachean Ethics* 6, 1141a12) which speaks of a *sophos* digger or plowman because the date of the poem is uncertain.

10 For the translation of *sophizomai* as 'practicing *sophia*', see especially Aristophanes, *Clouds* 547.

having never practiced the *sophia* of sailing or ships at all." (*Works and Days* 648/9)

(7) Hesiod of Ascra, on Linus the cithara-player
"master of every kind of *sophia*" (fr. 306 Merkelbach-West)

(8) Homer, describing an evenly matched battle in a simile:
"But just as a measuring-cord (*stathmē*) straightens a ship timber
in the hands of an expert builder, one who knows well
all his *sophia* through Athena's instruction,
so their battle and the fight were stretched out evenly." (*Iliad* 15.410–413)

(9) Homer, describing wrestlers:
"And they gripped each other's arms with strong hands
like crossbeams which a *sophos* carpenter fits in place" (*Iliad* 23.711/2; text according to Aristotle, *On Philosophy*, fr. 8 Ross)

(10) Homeric Hymn, Hermes describing the virtues of the lyre:
"Any time
an expert questions it using art and *sophia*
it raises its voice and teaches him all sorts of mental delights." (*Homeric Hymn to Hermes* 482–484)

(11) Hermes, inventing the syrinx after giving Apollo his lyre:
"He in turn worked out the art for a second *sophia*,
and created the crying pipe, audible from afar." (*Homeric Hymn to Hermes* 511/2)

(12) Ibycus of Rhegium/Samos, on the Greek fleet that went to Troy:
"The Heliconian Muses who practice *sophia*
might embark on this account;
for no mortal man … could say in detail
how great is the number of ships which went from Aulis
across the Aegean Sea, from Argos
to horse-raising Troy." (fr. 151.23–30 Davies)

(13) Sappho of Lesbos, lamenting an unknown girl:
"I cannot imagine that any girl who has seen the sunlight
will be her like in *sophia* at any time whatsoever." (fr. 56 Vogt)

(14) Stesichorus of Himera on Epeius, builder of the Trojan Horse:
"an expert in measures and *sophia* by the will of venerable Athena" (fr. 89.7/8 Davies)

(15) Solon of Athens, describing a typical poet-singer:
"He has learned from the Muses the gifts of lovely *sophia*, understanding measure." (fr. 13.51/2 West)

In none of these examples, save perhaps (1), is the English word 'wisdom' the most natural translation. Whenever there is enough context to decide, the *sophia* which the person in question possesses is some kind of craft or skill. One such craft is construction: the shipwright builds a boat (8), the carpenter, a roof (9), Epeius, the Trojan Horse (14). Aristotle noted that in his day *sophia* could still be used to mean excellence in an art, citing several famous sculptors as illustration (*Nicomachean Ethics* 6.7, 1141a9). Poet-singers are also frequently credited with *sophia* (5, 7, 10, 11, 12, 13, 15) and from the Greek etymology of their name (*poiētēs*, 'maker'), one might conclude that the creation of things, structures or poems, was a characteristic feature of being *sophos*. However, *sophia* is not just used to describe productive arts: the helmsman guiding his ship (4, 6), and horsemen directing their horses (2, 3) are not making anything. What they are doing instead is holding tools in their hands, like rudders, or reins, to control their direction of travel, and manipulating them in an effective way.[11] This is a skill most *sophoi* exhibit. The shipwright holds the measuring-line (8) and the carpenter lines up his timbers (9); the pilot grasps and steers his rudder, the rider holds and manipulates the reins. The singer Linus (7) is expert at playing the cithara, and the *sophia* alluded to in the hymn to Hermes (10, 11) is displayed by playing the lyre or the pipe – a manual art.[12] Even in cases where *sophia* has something to do with the poetry (5, 12, 13, 15) but no instrument is named, the primary reference is arguably to skillful playing, the motion of an experienced hand. Archaic *sophia* thus seems to have primarily denoted deftness or precision in manipulating tools by hand.

11 Compare the *sophos* plowman or digger of the *Margites* (note 9, above). See also Ps.-Phocylides 130/1, which may reflect archaic usage: "the man who practices *sophia* is better than one who is strong; *sophia* steers fields and cities and ships."

12 Peabody 1975, 197: "The fact remains that from all over the world and from all periods of time we have indications that traditional composition has been associated with *hand activity*. [Italics mine] The aborigines of Australia and other areas often make string figures together with their songs. Other people manipulate beds on strings. Most descriptions of bards include stringed instruments or drums."

This reconstruction of the word's early sense allows us to make a conjecture about its etymology. Modern lexicographers treat the etymology of *sophos* as unknown, rejecting older attempts to link it to *Sisuphos* or *sapha*.[13] I would venture the suggestion that it is related to the Greek verb *hepō* 'to handle', with both words descending from a common ancestor. Many Greek words with a rough breathing /h/ before an initial vowel go back to proto-Greek forms with initial /s/; thus, the form **sepō* has been reconstructed for this verb, which is thought to be cognate with Latin *sepulio*.[14] The perfect form of **sepō* can be reconstructed by analogy with *legō* > *eilokha*, which would indicate a switch in the stem vowel from *e* to *o* and the replacement of *p* with the aspirated *ph*; but instead of an initial *ei* like we see in *eilokha*, the analogy of *sophizō* > *sesophismenos* would point to a reduplicated form: **sesopha*. It is this stem *soph-* that could have served as the base for nominal forms.

The semantic links between *sophos* and *hepō* are very strong. While rare in its base form, the verb is highly productive of compounds such as *amphepō* 'to caress on both sides', *ephepō* 'to wield a tool', 'to manage creatures by means of a tool', and *diepō*, which indicates management of a situation, typically by means of a staff; the rare noun *diepos* denotes a ship's captain.[15] From the same root we also get the noun *hoplon*, which can denote the rope and tackle of a ship, a metalworker's tools, or a warrior's armor.[16] To my mind this semantic overlap, combined with the phonetic match, secures the case for a connection between *soph-* and **sepō*. A *sophos* person would be someone who is deft, a 'skilled handler' in some relevant area of expertise, while an appropriate English translation of *sophia*, at least in these early texts, would be 'skilled handling'.

With that result in hand let us now return to Thales. At first glance the label *sophos* may seem like a rather poor fit for the Milesian – he was, after all, not known as a poet, musician, equestrian, or carpenter. Dicaearchus pertinently observed that the seven *Sophoi*, men like Solon, Pittacus, and Periander, were typically successful politicians or lawgivers – an extension of its meaning which makes sense when one considers how often the Greek compared their polises to ships, and their statesmen to ship-captains. Yet here too the label

13 Chantraine 1968, 1031: "Pas d'étymologie. Ni un rapprochement avec *sapha*, ni un rapprochement avec *Sisuphos* ne donnent satisfaction." Beekes 2010, 1374, "Unexplained. If *Sisuphos*, *sapha*, and *psephei* are related, this would point to a substrate word."

14 Chantraine 1968, 363.

15 S.v. Liddell and Scott 1940.

16 Chantraine 1968, 809/10. The name 'Epeius' (cf. 14) may also be related.

does not seem to like a good fit, since Thales' involvement in politics was limited to one or two occasions when he offered political advice.[17]

Nevertheless, our gallery of examples reveals other ways in which *sophia* could characterize Thales' expertise. As noted already, *sophia* is a general term for expertise involving boats (4, 6, cf. 8, 12), and many of the anecdotes told about Thales have some connection to sailing or navigation. In addition, *sophia* is frequently named in conjunction with measures or acts of measurement; the word *metra* is paired with it in passages (6), (14), and (15), and an act of measuring is implied in text (8).[18] Finally, in non-musical contexts, the goal of *sophia*, or of someone who is 'handling' (*hepō*) a matter, often involves straightness, as is evident from several passages in Homer and Hesiod where one steers horses straight, for instance.[19] As we shall see now, the quality most of Thales' insights share is a concern with measures and/or straightness in a nautical context.

2 Thales and the Bears

Like its Ionian neighbors, Miletus had an economy that was primarily maritime in orientation. The names of the various classes in a Greek city often pointed to the economic foundations of their members' wealth: Athens in Solon's day, for instance, had the Men of Good Families (*Eupatridai*), the Landowners (*Geōmoroi*), and the Craftsmen (*Dēmiourgoi*). At Miletus the leading class of citizens were called the *Aeinautai*, the Perpetual Sailors.[20] They were sailors and ship-owners who initiated so many trading voyages each year that it seemed as if they were always out at sea. Despite its small size – a population somewhere on the order of 50,000 souls – Miletus' trading network was truly massive. To the south, the city maintained a strong presence on the Nile Delta. To the north, in the Black Sea and the Sea of Marmara, Milesian traders and colonists established dozens of emporia, many of which, like those at Cyzicus, Apollonia, Olbia, Borysthenes, Trapezous, and Sinope, went on to become

17 Dicaearchus: Diogenes Laertius 1.40. The ship of state analogy: Page 1959, 181. Thales in politics: Herodotus 1.170.3, Diogenes Laertius 1.25.

18 For the importance of measurement in the Milesian philosophers, see White 2008.

19 In addition to passage (8), see *Iliad* 16.732, 24.326, and Hesiod, *Theogony* 220.

20 Plutarch, our source for this name (*Greek Questions* 32.298c/d), relates a just-so story to explain the label, saying that this class of citizens would sail out to sea to make their political decisions; this is obviously ridiculous – how would they make their decisions during bad weather? – and departs from the pattern for other class names. Hence the general interpretation that the word alludes to the basis for their wealth; see Robertson 1987, 382n62.

major cities in their own right. During Thales' lifetime Miletus' perpetual sailors were busy trading olive oil for linen in Egypt, or exchanging wine for slaves and metals along the shores of the Euxine. Thales reportedly commented on the ability of amber to attract materials like chaff to itself. Nearly all the amber that Mediterranean people came across originated from beds near the Baltic Sea, which means that the amber beads Thales had seen came to Miletus by way of the Black Sea trade.[21]

Against the background of this trade network the significance of one of Thales' achievements – the introduction of a new constellation – becomes more clear. As a general rule Mediterranean pilots preferred to sail within sight of the coast, hopping from one island or promontory to the next and seeking to make landfall before dark.[22] But when circumstances were favorable or a need for haste arose, a captain could save considerable travel time by sailing on the open sea at night. Homer alludes to night journeys several times, some short, some several days in length, and the practice was not uncommon, especially for long-distance voyages.[23] Traveling across the open sea from Crete to the coast of Africa, or from Sinope to Borysthenes, could save captains up to two weeks of travel time, compared to roundabout routes that followed the coast. Milesian sailors would thus have had more experience with such journeys than those from cities with less extensive trading networks.

One of the main challenges facing open sea voyagers was navigation. During the daytime a practiced sailor could steer by the sun; but what was he to do at night? The early poet Aristeas – who came from Proconnesus, a Milesian colony in the Sea of Marmara – hinted at the answer when speaking of sailors on the Black Sea: "they keep their eyes on the stars" (Longinus, *The Sublime* 10.4). To see what stellar navigation would mean in practice, we may turn to Homer's account of Odysseus' departure from Ogygia, at the start of an open-water voyage nineteen days long (*Odyssey* 5.269–277):

> (16) "Heartened by the fair wind, bright Odysseus spread his sails
> then sat, using the rudder to make straight (*īthūneto*) his course
> expertly, and sleep did not fall on his eyelids
> as he gazed on the Pleiades and slow-setting Boötes
> and the She-Bear, whom men also call by the name 'Wagon'

21 On Miletus's colonies and trade, see Gorman 2001, 47–71. For Thales and amber, Diogenes Laertius 1.24.

22 See Beresford 2013, 204–209, who refutes traditional scholarly assumptions about the limited scope of the Mediterranean sailing season.

23 *Odyssey* 2.434, 4.270, 10.28, 13.70, 14.252–258, 14.301/2, 15.292, 15.471–484, 16.366–368.

and who turns ever in the same place and eyes Orion
and alone has no share in the baths of the Ocean;
for Calypso, bright goddess, told him to keep the Bear
on his left hand while he fared across the sea."

The island of Ogygia lay somewhere in the distant west; Odysseus, who was setting out for his home, was heading east. The Pleiades and Orion and Boötes all rise roughly in the east, and Odysseus could steer by them for part of the night. But the only major constellation the Greeks of Homer's day knew that is always visible and always lies in the same quadrant of the sky ("who turns ever in the same place"), no matter the hour of night or the season of the year, is Ursa Major, the She-Bear, which circles the north celestial pole. Thus, by keeping the Bear on his left, Odysseus could be sure he was heading in the right general direction.

The seven bright stars of Ursa Major are a good rough guide for sailors because they are easy to find in the sky and are always visible. However, this asterism does not lie very close to the celestial north pole, and as the result it often stands closer to due northeast or northwest than it does to due north. In order to provide sailors with a more accurate guide Thales reportedly introduced a new constellation, Ursa Minor. Our oldest witness to this innovation is the scholar-poet Callimachus (*Iambs* 1.53–55, fr. 191 Pfeiffer):

(17) "Thales was a felicitous thinker in other regards,
and it is said that he measured with a line (*stathmēsasthai*)
the faint stars of the Wagon which the Phoenicians sail by."

In his *Phaenomena* Aratus, who was a friend of Callimachus, elaborated on this report, explaining why Ursa Minor ("Cynosura") is better at indicating direction than Ursa Major ("Helice") (*Phenomena* 36–44):

(18) "One Bear they call by the name of Cynosura,
the other, Helice. At sea the Achaeans use Helice
to mark the point where they should guide their ships;
Phoenicians cross the sea trusting in the other.
One of these is clear and easy to discern –
Helice appears in full from the very start of night –
while the other, though small, is more suitable for sailors,
the whole of it revolving in a smaller circuit;
by this the men of Sidon sail straightest (*ithūntata*)."

In Thales' day the heart of Ursa Major's seven stars lay approximately 32 degrees away from the celestial pole, which meant a sailor treating its stars as a guide to north might run off course by the same extent when it stood at its eastern or western extremes. Ursa Minor, by contrast, described a much smaller circuit around the pole, its center deviating no more than 8 degrees from true north. By using its stars as a point of reference a sailor could maintain a much tighter course during nighttime hours. Aratus may not mention Thales here, but he is certainly alluding to him, as the ancient commentators recognized: the description of Cynosura as a Phoenician innovation was meant to bring to mind Thales' boasts of his Phoenician ancestry.[24]

Now Callimachus was active some 250 years after Thales' death; was the information he was relaying accurate? Various indirect lines of argument suggest it was. For one, the timing of the introduction is right. Homer, as we saw, appears to have known only one Bear, Ursa Major; but in the *Hesiodic Catalogue of Women*, which probably dates to around 570 or 550 BCE, an etiological myth is given for *both* of the bear constellations: the smaller bear is identified as Arcas, eponym of the Arcadians, while the larger bear is identified with his mother Callisto.[25] Second, a description of Ursa Minor, perhaps under the name Cynosura, along with an explanation of its utility for sailors, would seem like a perfect fit for the *Nautical Astronomy*, given the title of the poem – and as noted above, Callimachus had access to the text.[26] Multiple late sources name Thales as the discoverer of this constellation, and no alternative candidates are anywhere mentioned. Despite the lateness of the source, then, we can repose confidence in it.

These considerations allow us to fit one more piece into our puzzle. When Callimachus describes the introduction of Ursa Minor, he specifically says that Thales "measured with a line" the stars in the constellation, using a verb, *stathmēsasthai*, whose cognate *stathmē* appears in the passage from the *Iliad* quoted above (8). Aratus, speaking of the "very straight" courses navigated by the Phoenicians with constellation's aid, used a word, *ithūntata*, which is cognate with the verb *ithūneto* found in (8) and (16). Now it could be that these two scholar-poets intuited a link between the sole passage in Homer's poetry where the noun *sophia* appears and Thales' introduction of the new navigational signpost. But to me it seems much more likely that terms for 'straightening'

24 See the scholia on Aratus' *Phaenomena*, 26/7. Strabo, *Geography* 16.2.24, specifically links the Phoenician 'invention' of astronomy to the demands of night sailing.

25 Hesiod fr. 163 Merkelbach and West. On the date of the *Catalogue*, see Fowler 1998, 114.

26 See note 6 above.

and 'measuring with a line' turned up in the verses of the *Nautical Astronomy*, and were meant to highlight, for a sixth-century audience, Thales' *sophia*.

3 Thales on the Nile

For centuries a trickle of goods had passed from Egypt to the Greek world, and sometimes back; but around the end of the seventh-century this trickle suddenly turned into a flood. The catalyst for this development was the decision made by the Egyptian prince Psammetichus I around 600 BCE to assemble a force of Greek mercenary soldiers in support of his successful bid to become pharaoh. The Greeks remained with him after his victory and were augmented; by 589 the Egyptian army included nearly 30,000 Hellenic and Carian hoplites, a large proportion of the Greeks hailing from the cities of Ionia. (The threat of an invasion from Babylon, in 601 and 567, was the driving force behind this unprecedented dependence on foreign troops.) Traders quickly followed the soldiers, eagerly taking advantage of their new access to the Mediterranean's oldest and richest civilization. The results can be seen in places like the foundation deposits of the temple of Hera at Samos – hundreds of objects of Egyptian provenance, including scarabs, bronze statues, model boats, and exotic seashells from the Red Sea, that were brought there during the early sixth-century.[27]

During this time the Pharaohs of the Saite dynasty engaged in personal acts of diplomacy and gift exchange with various Greek city-states. After defeating the Babylonians at Megiddo in 609, Necho II had the corslet he wore in battle sent to the temple of Apollo at Didyma, just outside of Miletus, no doubt in recognition of the part that mercenaries with Milesian ties played in the victory (Herodotus 2.159.3). Around the middle of the sixth-century Amasis established a working relationship with the tyrant Polycrates of Samos and dedicated two wooden statues of himself in the great temple of Hera (2.182.1). At Lindos on the island of Rhodes there was an ancient temple to Athena which, according to legend, had been founded by the Egyptian exile Danaus. In order to reaffirm the ancient ties between Egypt and Lindos, Amasis hired two Greek sculptors to craft a new cult statue for the temple; four cubits high, it was carved from green Egyptian granite or basalt and represented both Athena and her Egyptian counterpart, Neith.[28]

27 For an fine short introduction, with bibliography, see Kopcke 2009.

28 Francis and Vickers 1984a, b.

Amasis sent this gift to the ruler of Lindos, a man named Cleobulus who later came to be regarded as one of the seven *Sophoi*. According to Diogenes Laertius, Cleobulus "partook of philosophy in Egypt" (1.89). It is not hard to guess how the tradition of such a visit was preserved. Cleobulus' learning was enshrined in a collection of short poems, some that he authored himself, others composed by his daughter Cleobulina. Many of these took the form of riddles, like the following: "I saw a man use fire to glue bronze to a man,/ gluing it so tight that they were of common blood." (Athenaeus, *Sophists at Dinner* 10.452b). Another riddle poem ran like this (Diogenes Laertius, *Lives* 1.91):

> (19) "One father and twelve children, each of whom
> has twice thirty daughters, children with paired looks,
> some white to the eye, others who are black;
> although immortal, they all pass away."

Both of these riddles allude to Egyptian technologies. Cupping, which is described in the first poem, was an ancient Egyptian medical technique which was probably introduced to Greece at this time.[29] The second riddle alludes to a simplified version of the Egyptian calendar, which consisted of 12 months of 30 days/nights each, with 5 additional days tacked on at the end; these lines constitute the earliest unambiguous reference to a year of 12 months and 30 days in Greek literature. Cleobulus' acquaintance with 'Egyptian philosophy' must have been made clear by the various allusions to Egyptian science and technology in the riddles he and his daughter composed.

Two of the other *sophoi* were also connected to Egypt. In his poetry Solon described a journey he made to the Canobic branch of the Nile (Plutarch, *Solon* 26.1). The object of his visit was the trading emporium of Naucratis, which lay on the Canobic branch. Several Greek cities had a permanent presence there, including Rhodes, Miletus, and Samos; another Greek visitor to Naucratis was Rhoecus, the designer of the first great temple of Hera at Samos. As for Thales, the earliest reference to his sojourn in Egypt comes from Eudemus (cf. 26, below). Now it is conceivable that Eudemus had no reliable information about such a visit and was merely inferring one by relating Thales' geometric contributions to Herodotus' assertion that geometry reached Greece from Egypt (2.109.3). Yet even if this were so, it would not matter. In addition to Solon and Rhoecus, hundreds if not thousands of other Ionians sailed to Egypt, spent time there, and learned enough about the culture to engage in

29 Cupping is described in the Ebers medical papyrus, ca. 1550 BCE.

trade. Given Thales' Milesian citizenship and special interest in long-distance sea travel, it would be more surprising to learn that he did *not* visit Egypt than to learn that he did.

While visiting Naucratis Greek sailors would have become acquainted with the Nile and what, from a Greek point of view, is its paradoxical flooding schedule. The river reaches its peak during the summer, a season when most rivers in Greece run low or dry up, and is at its lowest during the winter, when rains cause streams and rivers in Greece to rise. Later sources credit Thales with the first explanation for this phenomenon,[30] an explanation Herodotus briefly alludes to (2.20.2):

> (20) One way to explain it says that the Etesian winds are responsible for the river's flooding, because they hinder the Nile from emptying into the sea.

This explanation, while incorrect, is based on two valid observations. The Etesian winds blow from the north, directly opposite the current of the Nile, and create waves that run against its surge. Secondly, the advent of the Etesians is roughly correlated in time with the beginning of the Nile flood.[31] One gets the impression that Thales was engaging in theoretical speculation, seeking the cause for a phenomenon of nature as part of a larger project to understand the world.

But there is more to the story than that, I believe. Both the onset of the winds and the inundation are roughly correlated with an important astronomical event: the annual summer solstice. Herodotus makes the connection quite explicit just three sentences before the text just quoted (2.19.2):

> (21) I was eager to learn from [the priests] why the Nile comes down in a flood *for a hundred days, starting from the summer solstice*, and once it reaches that day-count retreats again, its current diminishing, so that the river remains low all winter until the next summer solstice.

As it happens, one of the most securely attested of Thales' astronomical achievements involved the solstices: according to Eudemus, Thales was "the first to discover the sun's period relative to the solstices" or "was the first … to

30 Diodorus Siculus, *Library of History* 1.38.1, Aëtius 4.1.1.

31 For a good analysis of this passage and Herodotus' own explanation, see Graham 2003.

foretell the solstices".[32] If Thales was concerned to locate the Nile's flood and the advent of the Etesians within the yearly cycle, the coincidence of these events with the summer solstice could hardly have escaped his attention. For Greek sailors traveling to Egypt, knowing that these three things coincided would be of real value, since the strong northerly winds were what made it possible to journey southward in a relatively short period of time; once they arrived, the swelling of the Nile would affect navigational patterns within the branches of the river. Thales' theoretical observation about the cause of the flood was likely articulated in a practical context, a discussion of the sailor's calendar.

Just like Thales' discourse on Ursa Minor, mention of the triple coincidence would be right at home in the *Nautical Astronomy*. An older exposition of nautical lore, Hesiod's account of the sailing seasons in the *Works and Days*, invokes two of the same phenomena: the optimal time for sea travel, says Hesiod, is a period that begins with the summer solstice and lasts for 50 days, a time when "the winds are easy to read and the sea brings no pain," an obvious allusion to the Etesians (663–665, 670).[33] It is interesting that Hesiod prefaces his description of this season with the remark that he is about to "point out the measures of the sea" (*deixō … metra … thalassēs* 648). The "measures" in question have nothing to do with linear distance, but refer to the starting point and the length of the season. It is plausible that Thales also used the language of "measurement" to demarcate the sailing season, thus advertising the skill which his contemporaries called *sophia*.

While this overlap of solstice, flood, and winds may have been advertised by Thales, it need not have been his discovery. Papyrus Hibeh 27, a Greek language document from Egypt dating to ca. 300 BCE, consists in large part of an astronomical calendar that specifies the length of day and night for the various days of the year along with the rising and setting of major constellations and other astronomical and cultural events.[34] The author of the treatise states that it contain things he learned from an Egyptian 'sage' (*sophos*) in Sais – the capital of the twenty-sixth dynasty, which lay just a short distance from Naucratis. That its lore is primarily Egyptian in origin is evident from the text's use of Egyptian month names and deployment of Egyptian aliquot fractions. For the

32 Diogenes Laertius, Lives 1.23 and Theon of Smyrna, *Mathematics Useful for Understanding Plato*, 198.14–18. Since knowledge of the exact number of days in a solar year would allow one to track the number of days until the next solstice, these two reports, while they seem to describe different discoveries, are mutually consistent.

33 Thales' observations may have allowed him to better identify the precise day of the solstice, which it can be difficult to identify: see Hannah 2009, 5–12, on the challenges.

34 Grenfell and Hunt 1906; see also Lehoux 2007, 153/4, 217–223.

month of Pharmouthi, which corresponds roughly to our June, we encounter the following entries:

> (22) [Month of] Pharmouthi
> …
> [Day] 20: The night is 10 hours, the day 14, and the sun rises in the same place for
> three days.
> <21:> The night is 10 hours, the day 14.
> 22: The night is 10 hours, the day 14.
> 23: The night is 10 hours, the day 14.
> 24: *Summer solstice*, and the night becomes longer than the day by 1/45th of a
> twelfth of the day, and night is 10 1/45th hours, and day is 13 2/3 + 1/4 + 1/20 + 1/90 hours.
> 25: *The Etesian winds begin to blow, and the River begins to rise*.

The Egyptian sage's calendar brings the solstice, the Etesians, and the rising of the Nile into close proximity, just as we have speculated Thales would have done. The document is not of archaic provenance, but the Egyptian astronomical tradition from which it draws was famously conservative. To be sure, we cannot eliminate the possibility that the author's Saite informant was relying on a Greek astronomical tradition that included data popularized by Thales, in which case the direction of influence would run from the Greek to the Egyptian sphere; but a reverse influence is equally possible. At very least this document speaks to a permeability of the boundary between Greek and Egyptian astronomical lore which we may extrapolate back to Thales' own day, given the deep inroads which each culture was making into the other at the time.[35]

4 Compass and Straight Edge

Some of the most dramatic impacts that contact with Egypt had on the Greeks lay in the realm art and architecture, the statue at Lindos being just one instance among many. At Miletus, on Cape Posideion, a massive step-altar for Poseidon was built nearly identical in design to an altar at Naucratis that was itself a copy of an Egyptian form. At Samos the master-builder Theodorus oversaw

35 Vlassopoulos 2013, 44/5, presents some illuminating examples of fluid Greco-Egyptian identity from the archaic era.

the production of two statues of Apollo that embodied the Egyptian canon of proportions in their design. At Ephesus and Samos work began on temples, far grander than any built before in Greece, whose scale and double rows of towering columns were inspired by similar edifices in Egypt. The Samian temple was so large that it sank into the ground, and had to rebuilt by Theodorus. We will return later to the potential significance of this mishap.[36]

Along with new techniques and forms came new tools. One important introduction from Egypt was the A-frame level. This instrument consisted of two wooden pieces joined at a right angle with a horizontal brace; a plumb bob attached to the join would fall across the brace, and when it crossed the midpoint, indicated that the device was level.[37] Egyptian builders had been making use of this tool for at least a millennium when it was introduced to Greece. Theodorus is credited by Pliny with 'inventing' the level, which must mean that he introduced it to Ionia and popularized its use (*Natural History* 7.198). The Greek name for this device, *diabētēs*, is based on its resemblance to a man striding over a gap (*diabainei*).

Two plays of Aristophanes, both produced in the 410's BCE, mention Thales in connection with a *diabētēs*. In the *Clouds* we find the following account of Socrates' shenanigans (177–180):

> (23) Student: "He scattered ashes thinly on a table,
> bent a skewer, then, grasping a *diabētēs*,
> made off with a cloak from the gymnasium."
> Strepsiades: "Gee, who will still admire the famous Thales?"

In the *Birds* the *geometer-cum*-city planner Meton of Athens is described thus (1001–1010):

> (24) Meton: "So, I shall apply
> my ruler, place below it this bent *diabētēs* –
> you understand?"
> Pisthetaerus: "I don't."
> M. "– and measure with my straight ruler, applying it
> so that the circle, see, becomes square, the agora
> is in the center, and the roads lead to the same place
> at right angles in relation to the center, like a star

36 Stepped altar at Miletus, Hoffman 1952, 1953. Statues: Diodorus Siculus 1.98.5–9 and Davis 1981. Temples and styles inspired by Egypt: Hurwit 1985, 179–202.

37 See Lewis 2009, 27–39, for illustration and history.

> which is round and has rays shining in every direction
> at right angles."
> P. "This guy's a Thales!"

The device being described here differs from an A-frame in three ways: it is relatively small, since it can be made from a skewer; it is capable of being bent (*kampsās, kampulon*): and it is used for drawing rather than leveling. It is, in other words, an early version of the familiar drawing compass, that iconic tool of Greek geometers, which, Masonic imagery notwithstanding, was not an Egyptian invention.[38] It is surely no coincidence that in both cases the manipulation of a 'bent' *diabētēs* causes an observer to think of Thales – the instrument must have been seen as distinctly his. Similarly it may be no accident that variants on the verb *diabainō* turn up three times in the 'tall tale' about Thales that Herodotus relates (1.75.3–6):

> (25) Once Croesus reached the Halys river, he brought his army across (*diebibāse*) using bridges that then existed – or so I would claim, though a popular Greek tale has it that Thales of Miletus brought them over. The quandary facing Croesus was how to get his army across the river (*diabēsetai*) and in the story the bridges did not exist at this time. Thales, who was present in the camp, reportedly made it so that the river, which ran on the army's left side, also ran on its right … The river was cut in two and became crossable (*diabātos*) on both sides.

To what use did Thales put his compass? Our best evidence for his work in geometry consists of a series of statements made by Eudemus in his *History of Geometry*, our ultimate source for nearly everything that is known about geometry before Aristotle.[39] These statements are preserved for us by the Neoplatonist Proclus, who drew on Eudemus when composing his commentary on the first book of Euclid's *Elements*. Just as Eudemus' teacher Aristotle had made Thales the first Greek natural philosopher, so Eudemus himself would make Thales the first Greek geometer, based on techniques he supposedly learned in Egypt (*On Euclid's Elements Book One*, 65.7–11 Friedlein):

> (26) "Thales was the first to go to Egypt and bring back this science (sc. geometry) to Greece. He made many discoveries himself and led those

38 For more on its background, see Gladigow 1968.
39 Zhmud 2006, 166–213.

who followed him to many more, attending to some in rather general terms, and others in a more sense-based fashion."

Thales is specifically credited by Eudemus with four distinct geometric insights, which are listed below, Proclus' comments being followed with the Euclidean item in question for the sake of clarity:

(27) Proclus, *On Euclid's Elements Book One*, 157.10/11: "They say that the famous Thales was the first to show (*apodeixai*) that a circle is bisected by its diameter."

Euclid, *Elements* 1, Definition 17: "The diameter of a circle is a straight line drawn through the center and bounded in both directions by the circumference of a circle, which also cuts the circle in two."

(28) Proclus, 299.1–5: "So this theorem shows that when two straight lines intersect each other, the angles at the vertex are equal, something first discovered by Thales, as Eudemus says."

Euclid, Proposition 15: "If two straight lines intersect each other, they make the angles at the vertex equal to one another."

(29) Proclus, 250.20: "We owe thanks to ancient Thales for many discoveries including this theorem. For he is said to have been the first to understand and to say that in every isosceles triangle the angles at its base are equal; in archaic fashion, he called the equal (*īsās*) angles 'similar' (*homoiās*)."

Euclid, Proposition 5: "In isosceles triangles the angles at the base are equal to one another, and if the equal straight lines are extended further, the angles under the base will be equal to one another."

(30) Proclus, 352.14: "Eudemus in his *History of Geometry* traces this theorem back to Thales; for he says that one must use it to supplement the approach (*proskhrēsthai*) which, people say, he used to demonstrate the distance of ships at sea."

Euclid, Proposition 26: "If two triangles have two angles equal to two angles respectively, and one side equal to one side, namely, either the side adjoining the equal angles, or that opposite one of the equal angles,

> then the remaining sides equal the remaining sides and the remaining angle equals the remaining angle."

At first glance it may appear that we are dealing with four discrete theorems preserved by chance from a treatise ascribed to Thales which in its original form was much more extensive. However the existence of such a treatise is highly doubtful. As Reviel Netz has shown, Greek geometry in its classic, Euclidean form was defined by logical demonstrations, formulaic language, and above all by exploitation of the written medium, through the use of lettered diagrams.[40] The oldest Greek books to contain geometrical diagrams were the work of Oenopides of Chios (certainly) and Anaxagoras of Clazomenae (perhaps). That is to say, the tradition of what we think of as classic Greek geometry does not extend much earlier than 460 BCE. The idea that Thales, ca. 550, was composing treatises on geometry with proofs and diagrams is anachronistic. And of course it starkly contradicts the tradition that Thales left behind nothing in writing.

Careful attention to the wording of Eudemus' claims confirms that the insights he ascribed to Thales were not cast in the abstract form familiar to us from classical Greek geometry. The phrasing (30) shows that Thales did not articulate Euclid 1.26 but *assumed* it in the course of spelling out a procedure for determining the distance of ships at sea; one must "use it to supplement" (*proskhrēsthai*) that procedure. The equivalence of the angles at the base of an equilateral triangle is something Thales "understood and said" (29) – two forms of intellection simpler than proof, specified because Thales stopped short of proof. The geometrical symmetry described in (28) is visually obvious, making a demonstration unnecessary; the same is true of the insight in (27), a relationship so elementary that in Euclid it is expressed as a definition. Some have seen in the assertion that Thales 'showed' (*apodeixai*) the equality of two semicircles an indication that he offered a deductive proof, but this is a red herring, since the verb is an ordinary language word that could just mean 'to show', like *deixō* in Hesiod (6). Finally, the text of (26) speaks of Thales noticing geometrical relationships and expressing them either in general terms or in connection with perceptible objects, like ships at sea – once again, no sign of proofs. Thales' statements must have used some kind of geometric vocabulary – nouns like 'angle', 'line', 'circle', adjectives meaning 'equal', and 'similar', verbs meaning 'to draw', for example – and had some kind of rhetorical or didactic goal. It is charitable to assume that Eudemus observed similarities between Thales'

40 Netz 2003, 2004.

practice and that of later Greek geometers that were due to their belonging to a shared, continuous tradition. Yet there is nothing in these fragments that requires Thales to have been engaged in the abstract study of geometrical entities and their relationships.[41]

It is true that Eudemus could comment on the specific language deployed by Thales (29), as well as the general form of Thales' statements (26), which implies that Eudemus was relying on a written text that he thought represented Thales' contributions to geometry in their original form. Now this 'text' was either in prose or verse. If it was in prose, it must postdate the oldest works of Greek literary prose, which were composed in the 520's; if it was a prose work dealing with geometry, it should postdate the 460's, as we have already seen.[42] The problem then arises that a prose text from, say, the 450's could hardly claim to relate Thales' exact phrasing after one-hundred years of oral transmission. That leaves poetry; and as we have seen, there was a poem in circulation, the *Nautical Astronomy*, which seems to have circulated under Thales' name before Callimachus identified Phocus of Samos as its author.[43] What clinches the case for Eudemus' dependence on this poem is his ascription to Thales of a procedure for measuring the distance of ships at sea – an unusual bit of didaxis which would most naturally find itself at home in a work dealing with problems of navigation. I would concur with those scholars who have argued that the book Eudemus had before him was the *Nautical Astronomy*.[44]

One might question whether the medium of poetry would have the flexibility required to describe geometrical operations.[45] Yet the four insights that Eudemus identified can be combined to yield a single procedure whose articulation need not have taxed the capabilities of hexameter unduly. The steps in this procedure can be reconstructed like so. First, draw a circle. Homer describes Odysseus doing this when he lays down the plan for his boat, relying on a cord (*Odyssey* 5.249–251); perhaps Thales called for compass. Second, use a straight edge to draw a line through the center of the circle that cuts its circumference at two points. Such a procedure is very close to what Meton performs at the start of text (24) with a straight edge and compass. Next, observe that the circle has been cut in half – this is item (27). Semicircles are called 'lunes' (*mēniskoi*) in the oldest systematic treatment of geometry that we

41 *Pace* Zhmud 2006, 192–194. Gladigow 1968 offers a reading of the evidence similar to that presented here.

42 hibodeau 2019, 97.

43 Anaximenes of Lampsacus, who was a contemporary of Aristotle, thought that the Seven *Sophoi* had all written poetry (Diogenes Laertius 1.40).

44 Gladigow 1968, 265, and Gigon 1945, 55.

45 Zhmud 2006, 193n118.

know of, the *Elements* of Hippocrates of Chios (Proclus, *On Euclid's Elements I*, 66.4–8). 'Lune' language also turns up in connection with Thales in Herodotus: the channel which Thales ordered to be dug at the river Halys was to be "moon-shaped," *mēnoeidēs* (1.75.4). Moreover, Diogenes reports an assertion from an older source, probably Eudemus, that Thales "was the first to discover the sun's passage from solstice to solstice, and the first to declare that *the size of the sun, when lunate* (*to tou hēliou megethos tou selēnaiou*), is 1/720th part, according to some." This text is commonly supplemented with a nine-word addition proposed Diels, but makes good sense as it stands: it is referring to the lunate form of the half-risen sun, whose width is equal to the sun's diameter.[46] Since the sun is approximately half a degree across, it diameter spans 1/720th of a complete circle.[47] Given this convergence of indicators, the lunate terminology used by Greek geometers may well go back to the *Nautical Astronomy*.

The next step in our reconstructed procedure is to draw a second straight line that also passes through the center of the circle and its circumference. This will create two pairs of equal angles at a common vertex; the statement that one or both pairs are equal will have been the origin of item (28). The very idea that a 'corner' or *gōnia* could be treated as a quantity and put into relationships of equality or inequality with other 'corners' was a novel one, and represents one of the most important Greek contributions to geometry.[48] The drawing now has two pairs of 'triangles', at least if one goes by the etymology of the term *trigōnon*, which designates shapes with three corners, not three straight sides. Two of the corners in each triangle will appear similar in form, and the statement of this fact will have inspired (29). The reason why the angles were said to be "similar" rather than "equal," I would argue, is that they were similar *shapes*, not identical *quantities*. Later Greek geometers regarded these so-called 'horn angles' as a perfectly valid species of angle – another potential legacy of Thales' procedure text. Finally, some sort of claim would have been made which took for granted, but did not state outright, that the bases of two opposing triangles

46 With Diels' supplement the text reads: "he was the first to declare that the size of the sun is 1/720th part [of the solar circle, just as the size of the moon is of the] lunar [circle], according to some."

47 Apuleius, *Florida* 18.32, alludes to the same procedure: "As he was declining into old age, [Thales] came up with an inspired piece of reasoning, which I have not just learned about but proven by trying it out myself; the reasoning involves the number of times the sun measures the circle through which it travels as a multiple of its own size."

48 See Gandz 1929. Thales may well have been inspired by the Egyptian concept of the *seked*, or slope when he developed his notion of angles. Egyptian 'slopes' were always tied to specific ratios of royal palms to digits; Thales' 'corners' became, in Greek usage, quantities forming a unitless continuum.

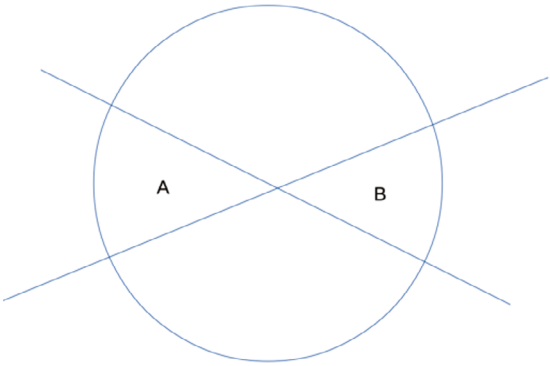


FIGURE 12.1
Thales' Basic Diagram
CREATED BY JILL KELLY

were equal; this would be the origin of item (30). The resulted diagram – simple enough that it did not need to be drawn – would look like this:

Let us now consider what functions such a notional diagram could serve in a poem on navigational astronomy. We know Thales described a procedure for measuring the distance of ships at sea, but have only one clue as to its form: that it assumed, but did not state, the angle-side-angle criterion for congruent triangles (30).

Now nearly all known procedures for measuring difficult-to-access heights, depths, and distances exploit the properties of similar triangles – in effect, one is reducing the ratio between two dauntingly large magnitudes to a ratio between magnitudes that are more easily measured.[49] So let us assume that we want to know the distance of a ship, with that distance being expressed as a multiple of the ship's own length. If the two straight lines in the drawing are aligned with the stern and the prow of the ship, then the distance-measure will simply be the ratio of either side of triangle A to its arc base; if one makes use of the relation implied in (30), one can take the ratio from triangle B. The only geometrical insight assumed in this procedure, beyond those mentioned above, is awareness of the properties of similar triangles; this insight can easily be ascribed to Thales, since a tradition that goes back to the third-century BCE held that Thales used similar triangles to measure the height of the pyramids (Diogenes Laertius 1.27).[50] That the *Nautical Astronomy* described a pyramid measurement does not seem very likely to me, but there is no reason why the procedure described in the poem could not have been adapted to a new application.

49 Cf. Euclid *Optics*, propositions 18–21.
50 Hahn 2017, 97–116.

Beyond its utility for determining the distance of ships, the lines-and-circle diagram has several other applications of potential interest to sailors, all of which involve identifying the circle with the *visible horizon*. If the four points where it is intersected by lines are identified with the solstice points on the eastern and western horizons – points which, as we have already seen, Thales made an effort to observe – one can give a precise definition for the four quarters of the horizon. The horizon arc to the east would be delimited by the sunrise solstice points; that to the west, by the sunset solstice points; a third, to the south, would fall between the two winter solstice points; and a fourth in the north would be defined by the summer solstice points. The ordinary language names for these directions in Greek – towards the sunrise (*pros anatolēn*), towards the setting sun (*pros dusin*), toward midday (*pros mesēmbrian*), towards the Bear (*pros Arkton*) – point to a rough-and-ready system for identifying directions; Thales' system could be used to give the distinctions more precise meanings, and resolve ambiguous cases.

The Aëtian doxographical tradition credits Thales and Pythagoras with dividing "the sphere of the whole sky into five circles, which people call 'zones'; one of them is called 'the arctic and ever-visible', one 'the summer tropical', one 'the equinoctial', one 'the winter tropical', and one 'the antarctic and invisible'" (Aëtius 2.12). Taken at face value, the claim about zones is highly anachronistic, since the five-fold division of the celestial sphere was first proposed by Eudoxus early in the fourth-century; Parmenides described something like zones, which applied only to the earth.[51] Nevertheless, if Thales divided the horizon in the manner just described, it is easy to see how such a description might have been interpreted, from an excess of charity, as showing insight into the later fivefold partition of the sky. If the entire horizon is divided into eastern and western halves, each half will contain three arcs separated from each other by two points. This makes for a total of five features: the arctic arc, the summer tropical point, the eastern arc, the winter tropical point, and the southern arc. Seeing those features named in a text that was ascribed to Thales may have led a doxographer to read them as precursors of the five zones or circles referred to in the Aëtian text, which have very similar names.

Once the horizon was demarcated in this fashion, it could be used as a framework for communicating other information that would be of practical value for sailors. Apuleius refers cryptically to discoveries Thales made using "small lines," i.e., lines in a geometrical diagram, that involved an assortment of astronomical and meteorological phenomena (*Florida* 18.30/1):

51 For Eudoxus' development of the five-zone model, see Goldstein and Bowen 1983; for Parmenides, Strabo, *Geography* 2.2.2.

> (32) [Thales] figured out the greatest things using small lines: the cycles of the seasons, the blowing of the winds, the motions of the stars, the noisy wonders of thunder, the slanting circles of the constellations, the yearly returns of the sun, the increases of the growing moon, the decreases of the aging moon, and the things that obstruct the moon in eclipse.

Of all the items in this list, the seasons readily lend themselves to geometrical definition due to their connection to the sun and the solstice points. Major stars and asterisms like Sirius, Orion, the Pleiades, and Arcturus all rise over certain fixed points on the horizon: Sirius close to the winter solstice point, Orion and the Pleiades nearly due east, and Arcturus over the summer solstice point. The moon, like the sun, comes up over different parts of the horizon depending on its phase and the time of year; the full moon is a very useful navigational aid at night because it goes through an annual cycle which is opposite that of the sun, rising near the sun's summer solstice point during the peak of winter, while coming up near the winter solstice point at the height of summer.[52] As for wind and thunder, it is hard to imagine Thales deploying geometry in order to explain their *causes*. However, a fourfold division of the horizon could serve as a helpful conceptual schema for *organizing* the various bits of lore about these meteorological events that circulated among sailors. So, for instance, by identifying each of the four basic winds Zephyrus, Boreas, Eurus, and Notus with a specific quadrant, and creating in effect a verbal compass rose, the link between direction and wind could be standardized.[53] Thales could then link other pieces of information to each quadrant, just the author of the Hippocratic treatise *Airs Waters Places* does when he identifies the winds, waters, temperature profiles, and ethnic types that characterize each quarter of the sky; tellingly, he calls this sort of reasoning *astronomiē*.[54] The Peripatetic treatise *Weather Signs*, which preserves a great deal of nautical folklore, relates that winds can be expected to blow from whichever direction on the horizon

52 Anaximander of Miletus noticed this phenomenon, which he called the *tropai* of the moon by analogy with the *tropai* of the sun; see Aristotle, *Meteorology* 2.1, 353b6, together with the commentary by Alexander of Aphrodisias, *On Aristotle's Meteorology*, 67.4–12. Anaximander associated eclipses of the moon with these *tropai* (Stobaeus, *Anthology* 1.26.1) – an association that held true for most eclipses during the period 525 to 509 BCE. I hope to have more to say about this topic in a future publication.

53 On ancient wind systems, see Thompson 1918. The *Ars Eudoxi* papyrus opens by identifying the point on the horizon where the sun rises during various times of the year using *wind names* like Apheliotes and Lips (Blass 1887, 1.10–2.20).

54 *Astronomiē*: ch. 2. For the quadrant system, which uses the solstice points to demarcate each portion, see chapters 3–6, 12, and 13.

thunder is heard, subject to certain qualifications (32); if Thales sketched out a rule of this kind, it would explain Apuleius' allusion to thunder. All of the phenomena referred to here thus have some connection to the cardinal points and the divisions of the horizon, save for the partial phases of the moon.

If these arguments are correct, Thales' geometry goes back to a procedure outlined in the *Nautical Astronomy* for drawing two straight lines through a circle, which included comment on the symmetry relations latent in the figure. The poem explained how this construction could be used to measure the distance of ships at sea. It also employed it to define the solstice points and the major arcs of the horizon, features which in turn served as a conceptual framework for organizing lore about the moon, sun, stars, and the weather. Elsewhere the poem also discussed the constellation Ursa Minor and the coincidence in time between the solstice, the Etesian winds, and the flooding of the Nile. All of this material would potentially have been of interest to sailors and the maritime community at Miletus, not to mention sailors from the rest of the Greek world. This poem will have predated the *Astronomia* of Cleostratus of Tenedos, another didactic treatise in verse, so that we may date it sometime after the middle years of Thales' life, and before the 510's BCE.[55]

5 When the Earth Shakes

We now pivot to a pair of teachings attributed to Thales that lie within the domain of natural philosophy proper: his propositions that the earth rests on water, and that water is the origin of all things. Aristotle alludes briefly to the first thesis in the *Metaphysics* (see 50, below) and describes it in a bit more detail in *On the Heavens* (2.13, 294a28–32):

> (33) Some say that the earth rests on water; for this is the most ancient theory we have heard of, one they say Thales of Miletus taught, the earth remaining in place because it is floating just like a plank or something else of that sort, for in fact none of these things is naturally able to stay still on air, only on water.

This information clearly came to Aristotle by way of an intermediary: "some" believe that the earth rests on water, and these same people cite Thales as an

55 Cleostratus' *octaeteris* was more sophisticated than anything attested for Thales, and he knew many more constellations; for his doctrine and chronology, see Thibodeau 2019, 267–273.

authority for this opinion. This means that someone besides Thales was associated with this idiosyncratic doctrine; and the most obvious candidate for that person is the only other thinker who made water the origin of all things, Hippo of Samos. Support for this assumption comes from the parenthetical remark that air, unlike water, is incapable of supporting the earth. This polemical remark cannot be Thales', since there were no natural philosophers before him to make the case for air, and it cannot be Aristotle's, since it was not his view that any of the elements held up the earth; the note ought instead to derive from his source. It would make sense chronologically for Hippo to have argued this point, since two philosophers from the generation before him, Anaximenes and Anaxagoras, maintained that the earth was supported by air; thus Hippo felt compelled to demolish their view before making a case for water. The upshot is that passage (33) is essentially a testimonium for Hippo, a summary of a text in which he laid out arguments for the earth's buoyancy.

Another inference one can draw from (33) is that Hippo referred to Thales' teaching on this matter – presumably to invoke the Milesian's authority, and perhaps to recapitulate his arguments. This is a crucial detail because it allows us to access further information about Hippo's text. A pair of passages in Seneca's *Questions about Nature* ascribe rather colorful theories about the relationship of the earth and the water to Thales (3.14.1, *6.6.1/2*):

> (34) For [Thales] says that the whole earth is held up by water, riding on it like a ship, and because of water's mobility it is bobbing on those occasions when we say that it shakes: so it is no wonder that there exists surplus moisture capable of pouring forth rivers, given that the whole world rests on moisture.

> (35) Thales of Miletus' opinion is that the whole earth rides or floats on water beneath it, which you can call Oceanus or the Great Sea or an even more basic form of water different in kind, a moist element. The world, he says, is supported by said water just as a large, heavy ship is supported by the water which it weighs down. It would be besides the point to record the reasons why he thinks that the heaviest component of the universe cannot be carried by something as subtle and fugitive as air; for our subject is why the earth moves, not why it remains in place. By way of argument he posits that water is to blame for shaking our round earth because in every large earthquake it is common for new springs to emerge. The same also happens with ships: if they are tipped to one side they take on water, and if they sink too far because their cargo is unusually heavy, water pours over or at least rises higher than normal on both sides.

Seneca was obviously acquainted with a text which purported to communicate Thales' doctrine. Now there are three candidates for the author of this text: Aristotle; Hippo; or an intermediary who knew one or both of the philosophers. The welter of detail here that has no parallel in Aristotle makes direct reliance on his text alone implausible. That Seneca had read Hippo's treatise is possible, but his error in ascribing a polemic against the air model to Thales rather than Hippo would be more understandable if his knowledge of Hippo was mediated by another writer. As it happens, there is a very good candidate for that intermediary. In his discussion of Homer, the Pergamene scholar Crates made a case for Homer as a natural philosopher by noting alignments between the poet's worldview and that of thinkers like Hippo (*Geneva Scholia on Homer's Iliad* 21.195, 197.19–198.13):

> (36) Crates in the second book of his *Homerica*, showing that Oceanus is the Great Sea, says, 'These things only make sense if they are said about the outer sea, which even now some people call the Great Sea, and some call the Atlantic … And he says in his third book that later natural philosophers concur that the water surrounding the earth in nearly every direction is Oceanus, from which drinkable water comes; for all waters come from the sea. Hippo in his writing on waters says: 'All drinkable water comes from the sea. For the wells which we drink from are surely not deeper than the sea; if they were, their water would not come from the sea but from some other source. As it is, the sea is deeper than well-water. So all of the waters that are above the sea come from it.'

Notice that passages (35) and (36) both start by adverting to the different names given to the primary body of water, such as Oceanus and the Atlantic; and both make inferences about this body based on the groundwater that comes from springs or wells. It would appear from (36) that Crates quoted a passage from Hippo – Homeric commentators did not normally quote verbatim from presocratic writers – and we have already deduced that Hippo mentioned Thales in his treatise. The simplest explanation for this set of facts is that Seneca was relying on a work by Crates in which the latter quoted and summarized a work of Hippo that in turn cited Thales as an authority; Seneca, in his doxography, cut out the middleman, and summarized what he thought he had learned about Thales. The theories Seneca ascribes to Thales thus came to him via two intermediaries.

Seneca's texts (34) and (35) are of value to us because they do a better job of conveying the character of Hippo's argumentation than Aristotle's does. If we

may trust Seneca – and Hall has found in favor of his general reliability[56] – the doctrine Hippo assigned to Thales did not say that the earth rests on water "just like a plank or something else of that sort," but centered around an analogy whereby the earth was compared to a large ship, the primary water to the sea on which the ship rides, and the appearance of new springs was akin to the flooding of a ship weighed down with too much cargo.[57] Hippo may have included further details in this comparison, since another Homeric scholium tells us that "according to Thales the earth rides on water, which is also why chasms (*khasmata*) are formed" (*scholia to Homer's Iliad*, 7.455). In isolation the transition from the first part of this remark to the second makes no sense; but if it goes back via Crates to Hippo's discussion, we might restore its sense by extending the ship analogy, e.g., the cracks that sometimes form in the ground after strong earthquakes are like the gaps that open between the timbers in a distressed ship.

The next question for us consider is whether this analogy goes back to Thales. But before we can address that, we must confront the rather striking discrepancy between Hippo and Aristotle regarding the underlying explanandum. Aristotle understood Thales and, by extension, Hippo, to be interested in the question why the earth remains in place and does not fall downward. But from Seneca's passages (34) and (35) it would appear that the puzzle Hippo wanted to confront was, why do earthquakes occur, which he solved by invoking a body of subterranean water on which the earth rides. To make matters even more confusing, when Aristotle discusses earthquakes in the Meteorology, he expressly says that only three of his predecessors developed explanations for the earth's tremors: Anaximenes, Anaxagoras, and Democritus. Neither Thales nor Hippo are mentioned, even though Aristotle must have known what Hippo wrote, since Hippo was his source for Thales' teaching in (33). Which source should we follow, then? Did Thales address the question of the earth's supporting element, as Aristotle says? Or was he concerned to explain earthquakes, as the material from Seneca/Crates/Hippo would seem to suggest?

In order to adjudicate this difference of opinion we need to have recourse to the doxography of Aëtius, whose thumbnail summaries of doctrines are ultimately based on a collection made by Theophrastus titled either *Doxai Phusikōn* ("Views of the Natural Philosophers") or *Doxai Phusikai* ("Views about Nature"). A section headed "On the Shaking of the Earth" (not necessarily Theophrastus' original label) briefly surveys the thoughts of early philosophers

56 Hall 1977, esp. 433–435 on the passages under discussion.

57 Lloyd 1966, 308/9, and KRS 1983, 93 cautiously accept this simile as Thales' own.

on the earth's movement. For the sake of clarity I have arranged these reports chronologically; I have also included a fragment of Xenophanes because it employs the same verb *kradainō*, 'to shake', that appears in the testimonia for Parmenides, Anaxagoras, and Democritus:

(38) Thales … links the cause of earthquakes to water. (Aëtius 3.14.1)

(39) Some [sc. Thales and Hippo] say it rests on water, like flat and plank-shaped objects do on water, and that is why it moves. (3.15.9)

(40) Xenophanes:

But without any effort, using the organ of his mind, he shakes (*kradainei*) all things. (Simplicius, *Commentary on Aristotle's Physics* 23.19)[58]

(41) Parmenides: because it remains at equilibrium, equally distant from every point, [the earth] has no reason to sink this way rather than that; thus it is only shaken (*kradainesthai*), not moved. (3.15.7)

(42) Anaximenes: the dryness and wetness of the earth are responsible for earthquakes, which are produced by droughts and downpours. (3.15.3)

(43) Anaximenes: because of its breadth the earth rides on air. (3.15.8)

(44) Anaxagoras: because of the sinking of air which encounters the density of [the earth's] surface, and, because it is not able to find an exit, shakes (*kradainontos*) what surrounds it with a tremor. (3.15.4)

(45) Democritus: because it remains at equilibrium, equally distant from every point, it has no reason to sink this way rather than that; thus it is only shaken (*kradainesthai*), not moved. (3.15.7)

(46) Democritus … link the causes of earthquakes to water. (3.15.1)

(47) Metrodorus: no body which is in its proper place moves, unless someone actively pushes it or drags it; thus not even the earth moves,

58 The language of the text is odd, but its general sense is clear; see Lesher 2002, 107.

> inasmuch as it is naturally at rest, but some of its locales return to their position with a jostling. (3.15.6)
>
> (48) Plato: there are six situations for every motion: up and down, right and left, front and back; the earth cannot move in any of these, lying in the lowest part; so it remains unmoved, having no special cause to sink in a preferential way; but its locales can be jostled due to their rareness. (3.15.10)

On the whole, this evidence is at odds with Aristotle's presentation of matters, while supporting that of Seneca/Crates. It emerges first that while Anaximenes may have been the first to present a credible account of earthquakes, he was not the first to address their existence or their likely cause. Parmenides maintained that the earth remains still but nevertheless does occasionally rattle, for reasons that unfortunately are not made clear in (41). Before him Xenophanes chalked up the shaking of the earth to the direct mental activity of the supreme deity (40). Thales also made some kind of statement that had the effect of linking earthquakes to water (38). It is very telling that text (39), which seems at first glance to reprise Aristotle's remarks about "plank-shaped" objects, uses that to explain the earth's mobility, not its stability. This connection actually makes more sense than what Aristotle claims in (33), since a plank lying on water is anything but stable. Unless something has gone terribly wrong with the Aëtian tradition, then, we should regard it as a more accurate witness to the thoughts of the early thinkers.

Another intriguing feature of this list are its doublets: along with its opinions about the causes of earthquakes, it also includes thoughts on the question, why does the earth remain still, for Parmenides, Anaximenes, Democritus, Metrodorus, and Plato:

> Why does the Earth Shake?
>
> | | |
> |---|---|
> | Thales: | because of water; because it rests on water like a plank |
> | [Xenophanes: | because of the mind of the deity] |
> | Parmenides: | ? |
> | Anaximenes: | because of extremes of wet and dry |
> | Anaxagoras: | because it obstructs the cosmic air |
> | Hippo: | because it rests on water like a plank |
> | Democritus: | because of water |
> | Metrodorus: | because of local slumping |
> | Plato: | because of local slumping |

Why does the Earth remain in Place?

Parmenides:	because it is equally distant from all points
Anaximenes:	because it is flat and supported by air
Democritus:	because it is equally distant from all points
Metrodorus:	because it is in its natural location
Plato:	because it is in the lowest part

The lumping together of these two different questions can be accounted for if one considers how close they are to each other conceptually. If one has identified a power or circumstance that produces the earth's stability, then any situation where that power or circumstance is absent can be invoked to explain the earth's motion, i.e. an earthquake. And vice versa: once a cause for the earth's movement has been identified, its stability can be explained as the absence of that cause. This assumes, of course, that earthquakes involve the motion of the entire earth; if earthquakes are local phenomena, then this symmetry no longer obtains. Arguably what makes the three theories picked out by Aristotle different from the rest is that they provide an explanation for local rather than global tremors; the accounts ascribed to Metrodorus and Plato here likewise touch on local causes. Xenophanes, Parmenides, and Hippo/Thales may have talked about earthquakes, but in a naïve fashion, either making it seem as if they involved the entire earth or leaving the issue unclear; also, like Xenophanes, they may not have adduced secular causes for the phenomenon. These considerations would have given Aristotle all the excuse he needed to ignore them.

The upshot of this discussion is that Seneca/Crates/Hippo, in combination with Aëtius, offer us a more accurate representation of Thales' doctrine than Aristotle does. It was Hippo, not Thales, who polemicized against the view that the earth is supported by air, and it was probably Hippo who argued, naïvely, that the earth rests on water like a flat piece of wood, borrowing the idea of flatness from his immediate precursors Anaximenes and Anaxagoras, but changing the nature of the substrate. Hippo invoked the authority of Thales for these claims in some fashion, and Aristotle took him at his word, with passage (33) the result. Yet it is very doubtful that Thales would have been looking at the issue in the same way. To start with, no one in Thales' day had proposed that the earth was surrounded on all sides by an emptiness that might allow it to fall. Secondly, contending that the earth rests on water is a very poor way to make an argument for its stability, as anyone who has crossed the Aegean in a boat would know.

It is much more credible that Thales spoke specifically about earthquakes, which were a source of genuine concern for the Ionians. It is also believable

that he drew an analogy between the shaking of the ground and the pitching of a ship at sea (34, 35). Contemporary nautical folklore spoke of islands drifting from place to place in the manner of sea vessels: Aeolus, master of the winds, inhabits a floating island in Homer; the Milesian geographer Hecataeus reported the existence of an island at Buto in Egypt that could float and sail about; in the Homeric hymn to Apollo, the island of Delos shares with Leto its worry that if her son is born there, he will sink the island to the bottom of the sea out of sheer contempt. Even in distant Babylon the prophet Ezekiel knew of the motif – witness his elaborate description of the Phoenician island city of Tyre, which he depicts as a glorious ship doomed to sink below the waves.[59] A ship analogy would thus have been especially suited to explain an earthquake that occurred on an island.

The record of earthquakes in the classical world prior to the Spartan quake of 465 BCE is rather jejune. Nevertheless, we know that the first monumental temple of Hera on the island of Samos suffered severe damage around 550, and had to be rebuilt on drier ground. No source speaks directly to the cause of the damage, but in the 540's, when the builders Metagenes and Chersiphron started work on the temple of Artemis at nearby Ephesus, they specifically designed the sub-foundation with the risk of earthquakes and ground fissures – hiatus in Latin, *khasmata* in Greek – in mind (Pliny, *Natural History* 36.95).

> (49) A true wonder of Greek magnificence is the temple of Diana at Ephesus constructed by all of Asia over 120 years. They built this on swampy soil. So that it would not be sensitive to earthquakes or fear chasms (*hiatus*) in the earth, or again, so that the foundations for such a large edifice would not be planted in something slippery and unstable, they laid a sub-foundation of crushed charcoal first, then wool fleece.[60]

This fear points to a lesson learned from experience, and the most obvious lesson was the recent experience of the builders at Samos. Now according to the historian Theopompus, the holy man Pherecydes, who died on Samos *c.*530 BCE,

59 *Odyssey* 10.3, Hecataeus FGrH 1.305, *Homeric Hymn to Apollo* 66–78, Ezekiel 27. For more on the folklore motif, see Heubeck and Hoekstra 1990, 43.

60 The received text is problematic. Eichholz 1962, the Loeb translator, renders the second sentence, "It was built on marshy soil so that it might not be subject to earthquakes or be threatened by subsisdences." This makes no sense, since building on soft ground would *increase* the risk of earthquake damage, not decrease it. Accordingly I have repunctuated, turning the comma after *fecere* into a period: *In solo id palustri fecere. Ne terrae motus sentiret aut hiatus timeret, rursus ne in lubrico atque instabili fundamenta tantae molis locarentur, calcatis ea substravere carbonibus, dein velleribus lanae.*

forecast an earthquake on the island after sampling well water there.[61] This is obviously very intriguing, since the earthquake would have happened in the right place and the right time to fit our scenario; unfortunately, some sources set this prediction on Syros, and the philosopher Porphyry charged Theopompus with rewriting an anecdote recorded by one Andron of Ephesus who had Pythagoras making the same prediction at Metapontum.[62] Yet even if transferred to Pythagoras, the story remains intriguing, since Pythagoras was a native of Samos and lived there until the 530's. Forecasting an earthquake based on the qualities of well water is a perfectly rational thing to do if one's 'science' holds that they are caused by the instability of the water on which bodies of land rest.[63]

There is another Samian who needs to be brought into the picture as well: Phocus, the mysterious poet who put Thales' lore into verse form sometime between, say, 560 and 520 BCE. For what we are discussing here are the contents of the poem with Thales' teaching that Phocus composed. Some sort of reference to an earthquake, new springs, and fissures in the ground, followed by a epic simile which compared the shaken island to a ship, would fit the *Nautical Astronomy* very nicely, and explain much of the evidence that follows.

6 Water Thou Art, and to Water Thou Shalt Return

We come now to the most famous of Thales' teachings, his claim that all things in nature derive from a single universal substance, namely, water. The most commonly cited text for this claim is a passage in the *Metaphysics* where Aristotle reviews his predecessors' attempts to identify some kind of basic principle (*arkhē*) (983b20–984a5):

> (50) (a) Thales, the *founder* of this style of philosophy, says that it [the *arkhē*] is water, which is why he declared that even the earth rests on top of water, perhaps making this assumption after observing that the nutriment of all beings is moist, and that warmth itself comes from water and lives on water – and that from which things come to be is the

61 Diogenes Laertius 1.116, Maximus of Tyre, *Philosophumena* 13.5.19; for the chronology of Pherecydes and Pythagoras, see Thibodeau 2019, 91–98, and 107–145.

62 Porphyry: Eusebius, *Preparation for the Gospel* 10.3.6. For a full presentation of the evidence, see Schibli 1990, 145–148.

63 "One of the most famous anecdotes about Thales also involves a well – albeit one that he fell into, while doing astronomy" (Plato, *Theaetetus 173a*).

> basic principle of all things – basing his assumption on this particular fact, as well as the fact that the seeds of all beings possess a moist nature, and that for moist things, water is the basic principle of their nature. (b) There are some who think that men in the very distant past held this kind of opinion, long before the current cycle of creation, as did the earliest theologians; for they made Oceanus and Tethys the parents of creation, and made the gods swear by water, which the same poets refer to as the Styx; for what is oldest is most respected, and the most respected thing is an oath. (c) Well, whether this opinion about nature is actually ancient and antique is not entirely clear; nevertheless, it is said that Thales made this kind of statement about the primary cause. (d) As for Hippo, no one would think that he deserves to be placed in their company, given the banal character of his thinking.

Aristotle's allusions to prior discussions of this topic ("There are some who think …" (b), "it is said that Thales …" (c)) invites us to consider whether we can identify his sources. Bruno Snell has demonstrated that the "some" in (b) must be Hippias of Elis, who created an anthology of competing opinions on various cultural and philosophical subjects.[64] This raises the possibility that Hippias was the source for the claims in (a) as well. However, several considerations tell against this. As we have already seen, Aristotle's informant for the notion that Thales made the earth rest of water was Hippo. Hippo argued that the universe began as a body of water which kindled a cosmic fire (Hippolytus *Refutation of All Heresies* 1.16.1), an idea which is reflected in Aristotle's reference to warmth deriving from water and being nourished by water. Hippo also maintained that the seed of living creatures is moist (Aristotle, *The Soul* 1.2, 405b1–3), another one of the observations ascribed to Thales. Furthermore, Aristotle clearly had Hippo on his mind when he composed this passage, since he goes out of his way to denigrate his abilities as a thinker despite not having mentioned him earlier. The most obvious conclusion, as Burnet and others have recognized, is that Hippo was Aristotle's source for (a).[65]

A second source for Thales-via-Hippo is a text on *arkhai* that descends from Theophrastus and is preserved for us by Simplicius (*On Aristotle's Physics* 9.23.21–28):

> (51) Of those who [Aristotle] calls by the special name *physikoi* and who state that the basic principle is one and in motion, some say that it is also

64 Snell 1924; see also the further reflections of Mansfeld 1985.

65 Burnet 1908, 49; KRS 1983, 91n1.

> finite, like Thales of Miletus, the son of Examyas, and Hippo, who was reputed to be an atheist; they said that the basic principle is water, coming to this conclusion based on things evident to the senses. For warmth lives on moisture and dying things turn dry and the seeds of all beings are moist and all nutriment is juice-like; and it is natural for individual beings to be nourished by that from which they are made; water is the basic principle of moist nature and tends to hold all things together. Hence they assumed water to be the basic principle of all things and declared that the earth lies on water.

Three of the phenomena cited here, warmth, seed, and nutriment, overlap with those cited by Aristotle, which might seem to support McDiarmid's thesis that Theophrastus was merely rephrasing what he read in the text of the *Metaphysics*.[66] However, it is a serious problem for this thesis that the example of dead things drying out does not occur in Aristotle, but is instead independently attested for Hippo in the Anonymous Londoniensis: "when it dries up, an animal loses sensation and dies" (11.27/9). The order in which the phenomena are cited is also changed – nutriment, warmth, and seed in Aristotle, warmth, seed, and nutriment in Theophrastus. Because the Lyceum had an excellent library, we can be sure that Theophrastus had access to any book Aristotle had used, and was in fact in a better position than his teacher when it came to texts, since he could consult volumes that joined the collection later. It is better then to regard (51) as an independent witness to the document Aristotle was drawing on, namely, Hippo's text. In the case of the earth's stability Hippo presented his arguments as somehow coming from Thales, and Hippo was presumably doing the same thing here. That would explain why Theophrastus ascribes these ideas to Hippo and Thales alike, while Aristotle, who held Hippo in contempt, ascribes them to Thales alone, albeit hesitantly, as his "perhaps" signals.

Now it is impossible to tell from these passages alone whether Hippo was communicating whatever information he had about Thales accurately. To answer this question, we would require a summary of Thales' teaching transmitted independent of Hippo. As it happens, such a summary exists, again descended from Theophrastus' doxographic compilation, but this time filtered through the Aëtian tradition (1.3.1):

> (52) Thales declared that water is the basic principle of existing things; for he says that all things come from water and into water all things are

66 McDiarmid 1976, 91–93.

> reduced. He makes this guess based first on the fact that the seed of all animals is their basic principle and is moist; hence it is plausible that all things have a basic principle composed of moisture. Secondly, all plants are nourished by moisture and bear fruit, and when they have no share of it they turn dry. Third, the very fire of the sun and stars is nourished by exhalations from bodies of water, as is the cosmos itself.

The broad similarities between (51) and (52) should not distract us from several crucial differences. Notice first that this doctrine is ascribed, not to Hippo and Thales, but to Thales alone. Second, in (50) and (51) the observations focus on different processes or qualities – the generation of heat, the desiccation of dying things, the wet nature of seed, the wet nature of foods – without reference to the beings involved. Here they are keyed to different categories of beings: animals, then plants, then celestial bodies and the cosmos. This way of sorting the observations is less abstract, and suggestive of an earlier stage in the tradition. Furthermore, the assertion about the fires of celestial bodies being nourished by vapor does not turn up in either (50) or (51). It too is an old doctrine, appearing in Anaximander and Xenophanes; and it is nowhere ascribed to Hippo.[67]

The language of (52) also indicates that the author had access to a written text: "he says" and "he makes this guess," in the present tense, are indicators of paraphrase. Now everything we have discussed so far would lead us to believe that the only written source for Thales' teachings besides Hippo that Theophrastus could draw on would be the Nautical Astronomy. I have already argued that his fellow Peripatetic Eudemus had access to it, and I would conjecture that Aristotle, when he was writing the *Metaphysics*, did not, since otherwise he would not have had to rely on the wretched Hippo. That written source was a poem composed in hexameters, which is significant, because the sentence, "for he says that all things come from water and into water all things are reduced" (ex hudatos gar phēsi panta einai kai eis hudōr panta analuesthai) bears a close resemblance to a hexameter from Xenophanes that also deals with the topic of arkhai (Sextus Empiricus, *Against the Natural Philosophers* 10.313):

> (*53*) *ek gaiēs gar panta, kai eis gēn panta teleutāi*
> For all things are from earth, and into earth all things pass away.

67 For the general idea, see Aristotle, *Meteorology* 2.2, 354b; for Anaximander in particular, Alexander of Aphrodisias, *On Aristotle's Meteorology*, 67.4–12. Xenophanes' doctrine that all celestial bodies are really burning clouds is a variation on this theme; see Mourelatos 2008.

If turned into direct statement, the sentence from (52) reads, *ex hudatos gar panta esti kai eis hudōr panta analūetai*, which can easily be rewritten as a proper hexameter mirroring Xenophanes', e.g., as:

> (*54*) *ex hudatos gar panta, kai eis hūdōr <anelūthē>*[68] *panta.*
> *"For all things are from water, and into water all things <dissolve>."*

Xenophanes knew Thales' astronomy and polemicized against certain of his ideas. 'Correcting' his predecessor's language in the manner which this reconstruction implies was precisely the sort of agonistic move poets and sages from this era would make.[69] Theophrastus frequently included short quotations from the texts he was summarizing that illustrate their authors' beliefs about *arkhai*, as he did with Anaximander, Anaximenes, and Xenophanes, for whom he quoted line (53).[70] We might expect him to have done the same for Thales, and the candidate text shows signs of being in hexameter. I would argue then that item (54) is a fragment of the *Nautical Astronomy* representing Thales' teaching on water. Perhaps located in a hymnic preface or digression that spoke about water and the sea, it would have been followed by observations about the watery origin of animal seed, plant life, and celestial fires. At very least, text (52) ultimately descends from a witness to Thales' teaching that was older than Hippo and thus provides us with a more accurate representation of Thales' discourse than (50), the better-known passage from Aristotle.

7 Thales the Wise Man

The achievements that Thales can be credited with – introducing a new constellation for navigation, attending to the triple coincidence of solstice, Etesians, and Nile flood, demarcating the horizon line, discovering a method

68 A gnomic aorist, to fit the meter; the original verb may have been different, e.g., *gegenētai*.

69 For Xenophanes' admiration for and rivalry with Thales, see Diogenes Laertius 1.23, 9.18. Griffith 1990 thoroughly documents the pervasiveness of contest and correction in early Greek literary culture.

70 For Anaximander, compare the near-quotation in Simplicius, *On Aristotle's Physics* 24.20–24, *ex hōn de hē genesis esti tois ousi, kai tēn phthoran eis tauta gīnesthai*, with the paraphrase in Aëtius, *ek gar toutou panta gīnesthai kai eis touto panta phtheiresthai* 1.3.3, both descending from Theophrastus. Anaximenes: Aëtius 1.3.4. For Xenophanes, see Stobaeus (*Anthology* 1.10.12) and Theodoret (*The Cure for Greek Maladies* 5.5), who are dependent on Theophrastus via Aëtius, and quote text (53), albeit with articles that spoil the meter. In Aëtius 1.3.8 there is a quotation from a poem dealing with numerology that is intended to illustrate the Pythagorean position on *arkhai*.

for measuring the distance of ships, inventing an analogy to explain earthquakes, and postulating that water is a universal reserve from which all beings must borrow and pay back – cannot help but impress us with their economy and insight. Using rather simple observations and uncomplicated mental tools, Thales developed a collection of teachings that would have proved striking to any Ionian who possessed a modicum of openness to new things. Because those teachings involved ships and navigation and measurement to various degrees, his contemporaries chose to award him the honorary title *sophos*. But in doing so, they also sparked a shift in meaning for the word. For in addition to being a capable technician, Thales was also – obviously – very clever. And by the end of the sixth-century, to be *sophos* meant to be like Thales, Solon, or Cleobulus, etc., which is to say, it meant being someone who was insightful and wise. This linguistic shift was helped along by the fact that the pronouncements of Thales and his fellow *sophoi* were not theoretical, but engaged directly with the material aspects of their contemporaries' lives.

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CHAPTER 13

New Insights into Pythagorean Women's Material Philosophy

Bella Vivante

Women's association with the physical, the body, and bodily functions is commonplace throughout ancient Greek thought.[1] It should therefore not be surprising that attention to material aspects especially of women's lives would characterize many of the writings by ancient female Pythagorean philosophers. And we immediately trip over the bump in the road caused by this last phrase, "writings by ancient female Pythagorean philosophers." That women were among the followers of Pythagoras and participants in the Pythagorean and Neopythagorean movements is well accepted from ancient through modern commentators.[2] Contested is whether these female advocates of Pythagorean ideas can be called philosophers, or, as Dorota Dutsch interprets some of the ancient evidence, as intelligent members of Pythagorean households.[3] More persistent has been the question of whether the writings attributed to these ancient female Pythagoreans were even written by women. The most compelling argument through the twentieth century was the anachronistic supposition that since the writings largely support male domination in family and social institutions, they must have been written by men in female guise in order to enforce their point. Unmasking the underlying misogyny of this argument has pretty much shoved it to the bottom of the pile. More significant is that the ancients who transmitted these writings believed they were written

1 See Dean-Jones 1996; also Butler 2017 and Spelman 2017.

2 Iamblichus, Stobi, Stobaeus, Athenaeus, Ménage 1690, Thesleff 1952, Waithe 1987, Henry 1994, Vivante 2008/09, Pomeroy 2013, Dutsch 2020, and increasing rapidly. For fuller review and analysis of ancient evidence and modern commentators see both Pomeroy 2013 and Dutsch 2020.

3 Dutsch 2020, 211 on calling these women philosophers. She observes that an account by Dicaearchus of Messana (fourth–third centuries BCE) "is the earliest explicit statement that … women, in fact, joined Pythagoras as his disciples and that Theano became so renowned for her intellectual prowess that she is known simply as 'Theano'" without the usual patronymic identifier. He "presents Pythagorean women as students of philosophy rather than practitioners of other kinds of *sophia* ('women wise in divine matters') and members of communities practicing the Pythagorean life style" (54–5). Dutsch 2020, does refer to these ancient female Pythagoreans as philosophers.

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by women, and often cited them for that very reason.[4] That the writings here discussed were written by women is well established. Whether they were philosophers may remain to be seen.

Who were these ancient female Pythagorean writers? According to the ancient biographical and pseudepigraphical traditions, notorious for their historical inaccuracies, the female Pythagoreans included Pythagoras's wife Theano, usually identified as Theano I in the writings, and his daughters Damo, Arignote, and Myia, entrusted with preserving and transmitting written records of their father's ideas. Perhaps as early as the late fifth century were Periktione I, possibly the same Periktione as Plato's mother, Phintys of Sparta, and Aisara of Lucania. And the Neopythagoreans, linguistically dated to circa third to first centuries BCE, Theano II and Periktione II.[5] Recent commentators have treated this ancient chronology differently. Despite linguistic and other contradictory evidence Waithe 1987 takes the provocative stance of accepting the validity of the ancient chronology; and she discusses the female Pythagorean writings as though dating from the late sixth through first centuries BCE. Pomeroy 2013 maintains some of Waithe's premise while making major emendations to Waithe's dates based on more careful reading of the linguistic evidence. Dutsch 2020 avoids this tangled web by focusing not on the authors per se but on the texts and the value of their presumed female authorship within the ancient social and philosophical contexts. "Far from being the work of identifiable individuals, the letters and treatises represent a school. Women's texts are firmly embedded in a tradition that deliberately obscures the writers' identity and dissolves authorship" (127). As such she concludes that there was a culture of acceptable female authority and authorship, that may however be limited to very specific female environments.[6] Since the linguistic forms date their writings to the late Hellenistic and Roman periods, the use of names like Theano, Myia, or Periktione is meant to impart authority to the writings, just as Pseudo Pythagorea and Platonea impart authority to these presumed male-authored texts. Thus Dutsch shows the values and limitations of these presumably female-authored texts while sidestepping the issue of who these actual authors were and when they may have lived.

This essay will look at how the writings attributed to ancient Pythagorean female authors treated the material issues that were frequently the subjects

4 Dutsch 2020, Ch. 1 on the extensive ancient references to female Pythagoreans and/or other female philosophers.

5 See Dutsch 2020, 123, 141, 172 on the validity of these names.

6 Dutsch 2020, 10–11 and *passim*.

of their writings. I continue the provocative thread begun by Waithe and Pomeroy while holding the awareness of Dutsch's groundbreaking work on the placement of these texts within the social and philosophical writings circulating in the background. By my stance I do not mean to argue that we can attribute these writings to historically identifiable women at certain times and places. What I do want to spotlight is the awareness that real women authored these texts, who can be placed alongside the real male authors of comparable philosophical texts, even at the same time that historical forces have imposed multiple clouds of doubt about the actual ancient women and their writings.[7] My acceptance of the names transmitted with these texts recognizes that an actual woman wrote for a larger or more restricted audience the particular texts that have survived despite the anti-female forces in the history of philosophy. That is, ironically, within the context of this essay, the actual historicity of the authors of these texts is immaterial for discussing the material aspects in their texts.

The texts here considered are of two types: treatises and personal letters. The treatises present the authors' ideas in a theoretical framework, while the letters reflect the epistolary genre of offering concrete advice to individual addressees.[8] That these works circulated in a largely female environment is strongly indicated by the opening of Theano II's letter of advice to Kallisto on her treatment of the household slave.[9]

> The right to manage household slaves is given by custom to you younger women as soon as you are married. Nonetheless, instruction by older women, who are always offering advice in everything that concerns domestic affairs, is necessary. It is proper first to recognize what you don't know and to consider the advice of older women most suitable. In these things a young mind must be educated from girlhood.[10]

Dutsch highlights the image this passage portrays of an environment that affirms the authority of older women instructing younger women. This rare

7 Dutsch 2020, too, even as she focuses on the texts as independent of their authors, still finds, like Waithe and Pomeroy, that her portrayal of "Pythagorean women highlights the female presence in the history of Greek philosophy" (67).

8 Dutsch 2020, 135. She also notes that women's "expertise is largely absent from fictitious philosophical epistles. In the vast majority of them, both the author-figure and the addressee are male. Only on rare occasions do philosophical letters address women" (174).

9 Stobi VII 174, 176, 178; Thesleff 197–8, text and trans., Dutsch 2020, 249–51.

10 Dutsch 2020, 250.

written expression of older women teaching younger women stands as a corrective to the more prevalent written comments by male authors advocating for older men to educate their young wives. Given the largely homosocial nature of ancient Greek society, it should come as no surprise that women talked to each other in their mostly female settings and that the older ones would advise the younger ones. Dutsch observes that "the Pythagorean letters … evoke a network of women who know about each other's lives and are eager to offer advice, both solicited and unsolicited" (178). That we have more male-authored expressions of this view than female is due not only to the historical suppression of female-authored texts, but also to the deliberate censoring of many female-authored texts by the male writers transmitting them.[11] On the other hand, John Stobi states explicitly that he is passing on as valuable the words of Theano, Phintys, and Periktione indicating that the women's ideas circulated not only for a predominantly female audience but were read and appreciated by (at least some) men as well.[12]

This essay will explore the treatment of three materially based topics in several female-authored texts. These topics fall into two of the three material categories the editors describe in their Introduction (p. 5). The display of wealth (in the treatises: Periktione I, *On Woman's Harmony* Fr. I, Phintys, *On Woman's Self-Restraint* Fr. II), exemplifies primarily the first theme, material objects. But it also overlaps with the second theme, the built environment, illustrated by the next two topics: treatment of slaves (Theano II's letter to Kallisto) and treatment of unfaithful husbands (Periktione I, *On Woman's Harmony* Fr. I and Theano II's letters to Eurydike and to Nikostrate).[13] To illuminate the distinctive gender-based ideas raised in these texts, I will compare these writings with those by male philosophers treating comparable subjects. The exclusion of the letters from the umbrella of "philosophy" for being about women's personal issues has often extended to excluding the treatises, whatever their subject matter, from the field as well. Although women were welcomed as intellectual participants in several philosophical movements, notably the Pythagoreans, Stoics, Epicureans, and Neoplatonists, the cultural biases, enshrined in Aristotle's political pronouncements, argued against considering the female-authored texts as philosophy. In her treatise *On Woman's*

11 Prince 2019 on Stobeaus; see also Dutsch 2020, 77–8.

12 Dutsch 2020, 1.

13 Dutsch 2020, 1 note 3 reviews the ancient and modern sources for the ancient female-authored texts.

Self-Restraint Fr. 11 Phintys advocated for the appropriateness of women philosophizing,[14] and Theano 11 begins her letter to Rhodope by situating themselves in a philosophical endeavor.[15]

> Are you upset that I have not yet sent you Plato's book, which is entitled *The Ideas or Parmenides*?[16]

Since many of the ancient men who transmitted these women's writings acknowledged them within the category of philosophy, and since, for the present essay, I am comparing the writings of the female-authored texts with those by male philosophers, my premise is that both these ancient men and women are writing within the same disciplinary field, and that the women's writings justifiably fit within the scope of philosophy.

One final point before I examine these texts: to look briefly at the general attitude to treating material subjects within the field of philosophy. Although ancients frequently promoted the field as an activity of the mind, material concerns were often treated in philosophical writings. Pythagoras, Plato, and Aristotle (collectively here, the big three) all treated issues of the body: how it functions, its proper treatment, foods to eat, value of exercise and the outdoors, etc. They all discussed the proper treatment of physical issues of daily life, notably husbandry and how to handle money or other possessions. At the same time that Aristotle disparages his need to treat what he calls vulgar matters such as the various means of wealth-acquisition, which he does at some length and detail (*Pol.* 1255b41ff.), he defends his doing so as a fitting subject of leisurely activity (i.e., philosophizing) – τὴν μὲν θεωρίαν ἐλευθέραν ἔχει (*Pol.* 1258b10). Regardless of the ethical or abstract discussions by the early philosophers of many schools, a sense of corporealism permeated their ideas (Kirk and Raven 1957: 216).

Scholars have not questioned the appropriateness of ancient thinkers treating these physically-based subjects, but have taken their discussions at face value as "philosophical" simply due to the authors' attributed status as male

14 Dutsch 2020, 165–8 thinks Phintys undermines this intellectual ability in women, by subordinating it to the fundamental importance of women's obedience to their husbands. "The program that Phintys' philosophical credentials authorize reduces the ideal woman's intellectual aspirations to an intimate understanding of the virtue of self-restraint" (167–8).

15 Stobi XI 182, 184; Thesleff 1965, text and trans.; Dutsch 2020, 257.

16 Dutsch 2020, 257.

philosopher. Thus, discussion of these topics by any of the big three is approved but comparable treatment by women philosophers is not. Sadly, despite Aristotle's views as they relate to women in philosophy being an extreme, atypical intellectual perspective, i.e., that women's reasoning ability was defective, hence incapable of and excluded from his school's philosophical pursuits, it is his views that set the parameters of the field and that encouraged such blatant misogynistic bias to flourish, and well into modern times. This gender-based exclusion of women from the field extends likewise to the appropriateness of certain ethical subjects: the education of children, the fitting behavior of men in the society, and the fitting behavior of women from a male point of view are all part of male philosophical writings. But when the ethical subjects are the education of girls, women's fitting behavior in the home and society, or men's fitting behavior from a woman's point of view, these subjects suddenly sit outside the realm of philosophic inquiry.

At the same time, a typical program of many philosophical writings that treated material concerns was to use such discussions as steppingstones in a more ethical or abstract trajectory. Thus, notably, Plato's ladder of beauty/goodness attributed in his *Symposium* to Diotima describes the physical as the first stage in the intellectual inquiry into the ultimate abstract nature of truth and the true reality. That is, the activity of philosophy is to transcend the physical in order to engage in philosophical activity. The views attributed to Pythagoras and those of the Pythagorean female writers who followed him also used their discussion of material issues as steppingstones for other considerations. The Pythagorean writings effected a double purpose in their extended discussions of the material aspects of the body and of daily life. On the one hand they demonstrate in careful detail how the ethical Pythagorean principles intended to guide human beings to a state of *harmonia* can be expressed through the minutest details of daily living. Thus the physical becomes the concrete proof of the actual functioning of Pythagorean principles in the reality of people's lives. While the physical thereby carries value in its own right in such a system, the ultimate goal is to transcend the physical to achieve total fulfillment of the ethical. This is the aspect emphasized by Plato's Diotima and in the teachings of the historical Aspasia, both of whom acknowledged the physical and advocated transcending it in order to attain a more intellectual or ethical goal (Henry 1995). And they both use the same language, transforming the connotations of *erōs* from the physical and sexual to the transcendent love of intellectual activity.

Theano II uses this same imagery in her letter to Rhodope to express her love for the philosopher Kleon:

> I am too much in love with his soul, both because it belongs to a philosopher and to a man who is determined to do good, and because it belongs to a man who fears the gods below the earth.[17]

Besides reiterating casually her rightful place within the philosophic realm, it is noteworthy that the eroticized admiration Theano II expresses for the soul of the philosopher Kleon is itself not the ultimate end of her regard. Rather, it leads first to the very Aristotelian praise of one who can not only think thoughts of the good but can also enact good deeds. To this convergence of intellectual and moral esteem Theano II adds Kleon's fear of the gods, notably those beneath the earth, i.e., those responsible for punishing wrongdoing. Theano II's profound esteem is for a man whom she describes as embodying the trifecta of human excellence: intellectual, moral, and spiritual – a man who can think good thoughts, do good deeds, and do so in attunement with the gods.

Not only the subject matter but the methodologies employed by ancient female philosophers places them well within the parameters of philosophy as it has been defined and practiced by its overwhelmingly male practitioners. Using Aristotle's *Nichomachean Ethics* as comparator, Vicki Harper draws four fundamental similarities in Aristotle's and the Neopythagorean women's theoretical approaches (123), focusing especially on ideas of practicality and flexibility, "that theoretical normative principles should be applicable in practice" (125).[18] As a result, whether or not they were familiar with Aristotle's approach to ethics – and all the more so if they were not – by employing an approach similar to his and simultaneously adhering to Pythagorean principles, the women brought innovative views to Pythagorean ethical approaches (124).

The underlying double purpose of Pythagorean writings – the value of the material fulfillment of Pythagorean principles and the goal of transcending the physical for fuller ethical and spiritual attainment – is evident throughout the Pythagorean women's advice in their letters and treatises.[19] This double purpose emerges whether the subject is infant care, childrearing, proper bodily care and presentation in dress, hairstyle or make-up, treatment of slaves, parents, or sexually unfaithful husbands, and ritual observances. Notably, from their consideration of these diverse daily details the Pythagorean women drew

17 Dutsch 2020, 257.

18 Cf. Waithe 1987: 34–35.

19 Dutsch 2020, 139, 194 notes that the women's writings reflect Stoic ideas as well as Pythagorean ones.

conclusions that differed in kind and depth from those of the male philosophers treating comparable subjects. Waithe, Pomeroy, and Dutsch all spotlight the personal, experience-based nature of the women's writings as compared to those by male authors. I intend to show how even when tackling the same subjects in similar ways to male authors, the Pythagorean women bring some distinctive interpretations to their discussions that may well be seen as bringing distinctively female perspectives into philosophic considerations. This is exemplified in the treatment of the three topics by both female and male philosophers now to be examined.

Complex notions underlie the big three's and the women's treatment of wealth. They are all members of the elite, wealthy class, which they acknowledge implicitly or explicitly with greater or lesser ambivalency. Pomeroy's 2013 description of the elite social conditions informing Pythagoras's ideas and the Pythagorean women's writings valuably conveys the cultural context that illuminates their discussions of material issues. At the same time that these philosophers rely upon and seem to assume the naturalness of their elite status, they all suggest or openly state that excess wealth, if not wealth itself, is a cause of wrongful behavior. Thus Pythagoras's injunctions to the Crotons to moderate their displays of wealth to achieve social *harmonia*; or Aristotle's approval of the amount of wealth acquisition fitting for successfully running a household and denunciation of wealth-getting for its own sake as not being useful to the individual, household, or society. For the guardian class in his *Republic* Plato's views are the most extreme as he would ban coinage for the harmful effects it would generate in the guardians – all the while assuming of course that his guardians would live an elite lifestyle. All three treat wealth-getting in excess or for its own sake as disruptive of a well-functioning individual or society. Except for Plato's outright ban for the rulers in his ideal society, the others invoke the concept of moderation as a way of properly treating wealth to prevent its harmful effects.

The treatise *On Woman's Harmony* attributed to Periktione I also treats the excessive attention to luxurious displays of wealth as harmful to the individual thus abusing material goods. She does so, as her title indicates, within the context of describing the harmonious woman:

> A woman filled with wisdom and self-restraint must set her mind on (achieving) harmony … When she controls her desires and will, holiness and harmony are born, so that illicit passions will not haunt her. … The woman must provide for the body food, clothing, washing, anointment, hairstyle, and adornment – in moderation, as nature requires. For those women who opt for all kinds of luxury in their food, drink, and

> surroundings, and wear what women wear, are ready to commit every kind of wrongdoing, pertaining to the bedroom and other forms of offense.[20]

Periktione I continues to describe in some detail what she calls the foolish extravagances of clothing and jewelry that weaken women. In contrast to the harmonious woman, this lack of wisdom and self-control opens the door to all manner of wrongful activity. In and of itself this is characteristic ancient Greek thinking: "wealth breeds violence" (Aiskhylos' *Agammemon* 776–8). But by articulating the direct connection between excessive displays of wealth and wrongdoing, Periktione I reveals how important a factor the personal dimension is in issues of social harmony or disharmony. She thereby makes specific the abstract concept of social disharmony seen in the male philosophers' discussions by expanding on the personal effects that form a critical component of the larger, abstract concept.[21] She also reveals the double purpose that characterizes Pythagorean women's writings: maintaining self-control in the minutiae of everyday activities enables a woman to be harmonious and serene. And rising above attachment to one's physical needs enables fulfillment of a Pythagorean lifestyle.

Periktione I also expresses her awareness of how her class standing impacts her discussion. The harmonious woman, even if born with wealth, should not consider wealth a necessity and pursue it for its own sake. Harper observes that Periktione I is clearly very familiar with an elite, wealthy lifestyle.[22] From her own experience Periktione I can distinguish between moderate and excessive uses of wealth; in this regard hers are perhaps not so different from Aristotle's distinctions between appropriate and excessive uses of wealth. But Periktione I goes further when she states that "It is only necessary to quench hunger and thirst, even if it is with something cheap, and to alleviate cold, even if it is with fleece or a goat hair cloak."[23] From her elite standpoint this proposal that all one requires are the absolute minimal material items to satisfy one's basic physical needs puts material goods into another perspective. Material items have no value in themselves, other than their fundamental function to satisfy a person's basic physical needs. This idea radically obviates the need to deal with such material items at all, though Periktione I does not push this idea into

20 Thesleff 142.17–145.6; Stob. *Anth.* 4.28.19, text and trans., Dutsch 2020, 230–1.

21 Dutsch 2020, 178 notes that a model for the philosophical move "from theory to practice can be found in the 'genuine Plato' of the 13 Platonic *Epistles*."

22 In Waithe 36.

23 Dutsch 2020, 231.

practice as did the philosophical Cynics.[24] However, her comments do show her awareness of such a class of penurious people and the value they may have, as people who can still live a worthwhile Pythagorean life even if they lack the material goods her class might consider essential.

In *On Woman's Self-Restraint* Fr. 11,[25] Phintys expands the scope of this discussion in her comparable advice regarding women's displays of wealth. When discussing women's appropriate dress she asserts that ostentatious displays in dress and jewelry would excite envy among the less fortunate:

> This is my advice concerning personal care. A woman should wear white clothing, simple, not extravagant. This will be so if she does not wrap herself in fabrics that are transparent, colorful, or woven in silk, but modest and white. In this way she will avoid being excessively adorned, will avoid luxury and adornment, and will not incite base envy in other women. And she must never wear gold or emeralds, because jewelry is expensive and shows contempt for the women of the people.[26]

Like Periktione I, Phintys' meticulous attention to specific aspects of dress and display of wealth aims at the personal well-being of the practitioner and the greater social harmony of the community. But Phintys expands the focus of who is affected by a vain woman's display of wealth by encompassing within her purview both the woman abusing wealth and the ones affected by such behavior. By drawing attention to the envy such displays would provoke in other women, Phintys exposes the personalized process that results in social disharmony: a direct cause-and-effect between one person's actions and the consequences in others' behavior. This is not a generalized or abstract notion of social disharmony, but one that shows how social disharmony arises out of the particulars of individuals' behaviors, individuals that begin with an elite woman's actions and spread from her to that of the non-elite women she encounters.

Phintys' awareness is one of class, the impact that the selfish, flaunting displays of the elite have upon "women of the people." In their comments regarding displays of wealth, both female authors show their awareness of the Other, whether other women or classes, due no doubt to their own status as the Other in male dominated Greek society. For these two Pythagorean women philosophers at least, attention to particular details of the material aspects of

24 Dutsch 2020, 99 on comparison with Hipparkhia and the Cynics.

25 Thesleff 1965, 153.8–154.11; Stob. *Anth.* 4.23.61a, text and trans., Dutsch 2020, 235–7.

26 Dutsch 2020, 236. See further Harper 2013, 129.

a woman's life opens new vistas of appreciating their own and others' stations in life.

Moving to examples of the second theme of material-based philosophy, built environments, Pythagorean women's writings emerge as more personal and more concrete than those by male philosophers in the other two subjects here addressed: slavery and adulterous husbands. Aristotle's treatment of slaves and slavery is consistently theoretical: whether slaves have virtue or reasoning ability and of what kind; whether slavery is a natural feature of human society or exists only by convention (*Politics* 1254a10–23, b15–1255b40). His discussion of the slave's ability approaches concrete practicality which he considers only from the perspective of the slave fulfilling the material needs of the master. Theano II's letter of advice to Kallisto on her treatment of the household slave begins as does Aristotle's – that the issue is a matter of household management.[27] Where Aristotle's is theoretical, Theano II's expands the kind of personal interpretation seen in Phintys' identifying envy as an effect of immoderate displays of wealth. Theano II's advice focuses on the household matron's personal treatment of the slaves and how that directly determines the slaves' actions within the household: good treatment leads to good feelings and actions, bad treatment to the opposite, all subsumed within Pythagorean notions of *harmonia*.

> The first domestic responsibility for women is the management of slave women, and the most important aspect in dealing with slaves is, my dear, their good will … [which] intelligent owners create … They are human beings by nature. Some women consider what is least profitable as a profit: the mistreatment of slave women [for which] they pay huge penalties: ill will and treachery of the worst kind. … It is worthy of a woman who is in control to forgive and cancel punishment for transgressions [Δεσποτικαὶ δὲ καὶ συγγνώμη καὶ χάρις ἐφ' ἡμαρτημένοις ζημίας ἀπαλλάττουσαι]; in doing so she shall uphold [what is appropriate for the household] decency in a way that is true to her character.[28]

Theano II's advice differs from Aristotle's similar one that states where relations between master and slave are natural, they are friends with a common interest, but where they rest on law and force, the reverse is true (*Politics* 1255b13). Aristotle is stating what appears as a general principle while Theano II

27 Stobi VII 174, 176, 178; Thesleff 2000, 97–8, text and trans., Dutsch 2020, 249–51.

28 Dutsch 2020, 250–1. I added the phrase in brackets as an alternate to Dutsch's "uphold decency": οὕτω δὲ καὶ τὸ πρέπον ἐπὶ τοῦ οἰκείου κατὰ τὸν τρόπον διαφυλάξει.

explores the direct, practical effects, psychologically and morally, upon both matron and slave of the matron's proper or improper treatment of the slaves. As we have noted in the earlier discussions, Theano II's comments encompass the conduct of both the subject woman and of those affected by her actions. Not only does she personalize the slaves, she explicitly affirms their human identity: they are not merely the living household property (*Politics* 1253b31) but human beings with feelings and sensibilities like those of Kallisto herself (Harper 132). Again the common thread emerges of close attention to material aspects of daily life intending to establish the personal and community minute and greater *harmonia* that is the goal of Pythagorean ideology and practice.

As we turn to the third built environment subject, the Pythagorean women's awareness of their status as the Other emerges most clearly in their multiple writings counseling tolerance of sexually unfaithful husbands – Periktione I, *On Woman's Harmony* Fr. I and Theano II's letters to Eurydike and to Nikostrate. Here again Aristotle treats the subject theoretically, and obliquely, when he claims that adultery is always wrong and has no place on the spectrum of moderation between defect and excess (*Nicomachean Ethics* 1107a10, 15). But he never discusses the actual activity of adultery by men, and especially not its effect on the wives of adulterous men. I have to wonder if, as an elite Greek male, he even thought that elite men's extra-marital sexual activity was adultery; if that were the case it would add another layer to my point here. According to Iamblichus (*Vita Pythagorea* 132, 152), the Croton women's appeals led Pythagoras to persuade their husbands to give up their concubines and resulted in his disapproval of adultery as morally wrong for both women and men and harmful to familial and social *harmonia* (Pomeroy 20). Highlighting this rare, counter-cultural stance regarding men's and women's sexual fidelity within marriage about seven centuries later Musonius Rufus (first century CE) advocated for complete sexual fidelity by both partners within marriage.[29] Against this background of overwhelming cultural approbation of elite men's extra-marital sexual activity, the writings of the Pythagorean women explicitly recognize the pain the women experienced from their husbands' infidelities (Pomeroy 60).

In contrast to Plato's social idealism in *The Republic*, the Pythagorean women's writings, like Aristotle, do not seek to change the social status quo (Waithe 28–29). Their arguments generally in defense of the status quo, though weaker than, are of the same type as Aristotle's by attributing the conventional behavior, in this case men's sexual infidelity in marriage, to the physical demands

29 Dutsch 2020, 199–200.

of nature. Consequently, they make no arguments against the ways of nature. Rather, just as the male philosophers stress the need to transcend what they deem the baser instincts of one's [i.e., a man's] human nature in order to achieve a morally satisfying life, the female philosophers use comparable arguments. Periktione I makes explicit this need to overcome these harmful inclinations:

> As for her own husband, she must live so righteously and honorably, that she thinks of nothing on her own, but preserves and protects his bed. For everything depends on this. She must bear everything that befalls her husband, whether he is unlucky, does something wrong through ignorance or disease or drunkenness, or lives with other women … She must tolerate anger, stinginess, constant complaints, jealousy, slander, and whatever else lies in her husband's nature, and, thanks to her self-restraint, arrange everything so that it is pleasant for him. For if a wife has affection for her husband and treats him honorably, harmony reigns.[30]

Periktione I's comments are couched within and aimed at achieving the Pythagorean ideal of *harmonia*. She also embeds a husband's adultery among his other possible failings or faults. Her intent is to steer a woman's likely, naturally angry and spiteful reaction, whatever the source or provocation, to focus on her higher and better self, which, for a woman, she defined as preserving and protecting her marriage bed. This is the pivot upon which rests the *harmonia* of the entire household and community, as she goes on to express. A woman who is hateful prays for ruin of her household and death of her husband just to consort with other men. But "a woman is harmonious if she becomes full of wisdom and restraint" – wisdom to understand the situation and her role in it, and the self-control to overcome any harmful urges.

Regarding the husband's adultery Periktione I states explicitly that "men are forgiven for this transgression, but women are not, and punishment is imposed on them."[31] Aside from any legal penalties the woman may incur for committing this social infraction, like Phintys Periktione I vividly describes the familial and social disharmony that result from a woman's adultery:

> For all women who become passionate for other men's beds turn into enemies of all the members of the household, both freeborn and slaves.

30 Dutsch 2020, 230–1.
31 Dutsch 2020, 231.

> Such a woman concocts falsehoods and treacheries for her husband and tells him lies about everyone else.[32]

Periktione I highlights the destructive consequences of a wife's infidelity upon her own actions and their deleterious effects upon her husband and others in her household. Her comments thus focus on the actual or potential human interactions resulting from a woman's adultery.

In *On Woman's Self-Restraint* Fr. 1,[33] Phintys takes this act of a woman's marital infidelity and its consequences to another level:

> The woman who breaks this law wrongs first of all the gods protecting her family … She also wrongs the gods that preside over procreation, upon whom she swore … along with her elders and kin … [and] her own country … It is unlawful and beyond forgiveness to sin and act insolently for the sake of pleasure. Every case of insolence inevitably ends in destruction.[34]

Phintys issues a heavy judgment against a sexually unfaithful wife. The destructive consequences of her actions now reverberate throughout the spiritual realm with their catastrophic cosmic effects felt by all her relations, living and dead, and by everyone, including the land itself, of the land where she lives. Hence an adulterous woman causes disharmony not only in her home and the community, but more profoundly in the spiritual order of the cosmos.

It is noteworthy that Phintys does not identify women's extra-marital sexual activity as unnatural but as unlawful. Phintys may thereby recognize implicitly that women may, like men, also be inclined to multiple sexual partners by nature. While the female Pythagoreans excuse men's adultery as activities that are within their nature, Phintys elides over the issue of nature in discussing women's sexual activity. She acknowledges the force of law and sanctifies this legal force by the weight of spiritual law. Phintys presents this description of the horrific consequences of a woman's adulterous activity as a negative model of a woman's immoderate behavior in order to more starkly impress upon her the necessity of her moderate conduct for the good of herself, her household and the whole community.

Theano II's two letters on the subject of a husband's adultery differ from Periktione I's and Phintys' treatises in that hers are personal missives to specific

32 Dutsch 2020, 230.

33 Thesleff 1965, 151.18–153.7; Stob. *Anth.* 4.23.61, text and trans.; Dutsch 2020, 232–5.

34 Dutsch 2020, 235.

women about their specific feelings in reaction to their husbands' infidelity. The specificity of her focus underscores the import of the general ideals conveyed. Theano II begins her letter to Nikostrate[35] by explicitly reiterating the points Periktione I had made regarding wisdom and self-control.

> I have heard about your husband's madness; he apparently keeps a hetaera and you are jealous of him. I have known, my dear, many men with this disease … You, however, despair night and day, and in your distress plot against him. Don't do this, my dear! … don't spend your life responding to hetaerae but distinguish yourself by your tactful behavior towards your husband, by care for the household … You should not compete with this woman.[36]

Completely echoing Periktione I, Theano II elides over the husband's conduct to focus on what the woman can do. Both emphasize that it is the woman's conduct that determines the well-being of the household and beyond.

> Certain transgressions, my dear, when examined are made even worse, but when passed over in silence instead they come to an end, just as they say that fire dies out when undisturbed.[37]

It is for the woman to maintain the high moral ground and not let herself get drawn down to her husband's deleterious conduct. A key factor that enables the women to thus elide over the man's wrongful conduct is that both attribute it to men's nature, which Periktione I states explicitly and which Theano II implies by saying she has "known many men with this disease." Pragmatists that they are, they waste no effort attempting to change what is, since what is exists by nature, but they seek to find what they can do that will be commendable and uplifting in the situational reality within which they live.

Theano II's short letter to Eurydike puts a musical spin on this notion of men's nature.[38] She compares a man's desire to seek pleasure from hetarae to the sense of hearing which enjoys the pleasure of different sounds from choral music to flutes to reed pipes. Recognizing this natural inclination should enable Eurydike not to be distressed by her husband's seeking bodily pleasure

35 Stobi VI 170, 172, 174; Thesleff 1965, 198–200, text and trans., Dutsch 2020, 245–8.
36 Dutsch 2020, 247–8.
37 Dutsch 2020, 247.
38 Stobi VIII 178, 180; Thesleff 1965, 197, text and trans., Dutsch 2020, 253–4.

from a hetaera. This recognition does not thereby entail her condoning this behavior. She concludes this brief missive by noting that

> For your husband has regard for your social standing, nature, and mind, and when he has had his fill, he will go and live with a hetaera a bit on the side. This is because there is some longing even for those unhealthy foods that contain some noxious flavor.[39]

Recognizing the naturalness of men's errant behavior does not signal acceptance of this behavior. Rather, Theano II's musical comparison offers Eurydike a concrete image that will allow her to better understand and therefore rise above her husband's conduct, however discordant, that is, disharmonious, this conduct is to him and from him upon his wife and household.

Theano II suggests in her letter to Eurydike that the latter's husband "has regard for [her] social standing, nature, and mind," implying that this regard will prompt the husband to perhaps reflect upon and even more perhaps adjust his behavior. Theano II's letter to Nikostrate elaborates this point by claiming that the wife's morally superior behavior will cause her husband to change his conduct.

> Called back to you, then, by a sense of fairness towards you … and unable to bear the contempt that comes with moral condemnation, he will soon change his mind.[40]

That is, by not letting herself be drawn down to her husband's level of injurious behavior, by keeping focused on upright, moral, and harmonious conduct, the woman will induce her husband to realize his moral errors regarding his wife and family, and it will compel him the more strongly to come home. Thus the ultimate aim and result of the woman's maintaining the moral center of her home is that it will bring the man to realize his higher, and truer, moral self. The process again illustrates the need to transcend physical demands in order to achieve a higher spiritual and moral plane.

The woman's superior moral conduct thereby creates multiple layers of *harmonia*: first within the woman herself and the radiating levels of *harmonia* she creates within the home and the community. And as important is the *harmonia* her conduct provokes *within* those with whom she interacts. We witnessed this intention of ameliorating the inner *harmonia* of others in the descriptions

39 Dutsch 2020, 254.
40 Dutsch 2020, 247.

of both the effect excessive wealth has upon less wealthy women and of how treatment of slaves affects their actions within the household. Most significant of this effect upon the inner *harmonia* of others is upon a woman's husband, as Theano II's words make clear. Her expectation that an adulterous husband can be shamed into doing the right moral thing in respect to his wife and family rests upon the double assumption that her husband shares his wife's moral concepts and that shame is an effective tool for shaping public conduct. Regarding the latter, given the primarily oral traditional nature that characterized ancient Greek society through most of its antiquity, E.R. Dodds' 1951 description of this role of shame in Homeric literature would still have been operative, to whatever degrees, throughout the ancient Greek period.[41] Theano II's letter to Nikostrate seems to underscore the cultural role of shame as a compelling incentive to ameliorate one's behavior without directly addressing whether this public shaming actually carries the weight her words imply.

However, as already noted for Aristotle's likely exemption of elite men's adultery from his basic ethical framework – just as American slaveowners could draft ideal documents that claim that "all men [sic] are created equal" – Theano II's assumption that her husband shares his wife's moral concepts when it comes to an elite male's extra-marital sexual activity was probably not as persuasive. In reality, the notion of both male and female marital sexual fidelity probably lasted only a few years in Pythagoras' Croton commune, if we may even trust that this putative ideal attributed to Pythagoras was actually realized. Although the Pythagorean women's writings invoked this ideal, the strength of this longstanding cultural practice that regarded elite male extra-marital sexual relations as normative probably overwhelmed any ideal, theoretical arguments Theano II tried to make. Regardless of whether these ideal expectations for the husband get realized, the focus remains on the woman's superior moral conduct in order to create the best possible outcome of an unpleasant situation.

At the same time the Pythagorean women explicitly acknowledged how their advice would provide the women the concrete means to rise above the pain they were experiencing due to their husbands' adulterous actions. These proto-psychological analyses provide a distinctively female perspective within the same type of philosophical discourse as might be found in Plato's or Aristotle's ethical discussions in which we can identify proto-psychological perspectives in the connections they make between self-knowledge and right action. Thus, one might view Sokrates' ideas that true understanding of the

41 See also Konstan 2003.

good naturally entails practice of right actions as a description of the integral connection between psychological self-awareness and one's resultant conduct, a cornerstone of modern psychological approaches. However unsatisfactory the Pythagorean women's advice may seem to many moderns, within their own time and cultural context their advice to other women was highly edifying for it offered women a respected and dignified source for their identity and status within their families and communities (Vivante 2008/09, 167). Thus the Pythagorean women offered their readers the same kind of uplift and edification that male philosophers offered to their followers. Rather than our viewing this focus on women's maintaining the high moral ground as a burden imposed on women while men are largely exempt, as most modern commentators do, the Pythagorean women present these ideas as establishing a respected role and status for women in Greek society. Countering both women's legal constrictions and Athenian dramatic portrayals of virulent viragos, the women's philosophical writings recognize women's intellectual capabilities, endow them with dignity, and emphasize their critically valued place in their household and community.

Throughout these three examples the Pythagorean women's treatment of material subjects corresponds in part to that by the big three in that all treat material subjects as steppingstones in their philosophical discussions. Moreover, they reveal their adherence to Pythagorean principles, especially that of *harmonia*. But they show their distinction from the male philosophers by highlighting the personal dimensions of their discussions, which often means they explore the concrete consequences of living out Pythagorean principles. And they recognize and valorize the status of the human Other, a dual perspective that reflects their awareness of their status as women in a male-dominated field within a male-dominated world. Thus the focus on the material functions as a way to concretely open new ways of approaching and addressing contemporary social issues. These writings show that beginning with Pythagoras, and expanded or transformed in the Pythagorean women's writings, attention to the material is intimately interwoven with ethical and other abstract intellectual discussions. Even when the intention is transcending the physical in order to achieve an abstract goal, daily attention to even the minutest details of physical life is invested with its own value that is an inseparable part of the process of aiming for the ultimate goal.

The Pythagorean women's writings counsel the wives of adulterous husbands to rise above any feelings of jealousy or revenge they may be experiencing to enact their better, morally sound nature. For the men, Theano II projects that their wives' maintaining this high moral ground will compel them also to fulfill their higher moral nature in their conduct. Like all these writings their

advice used Pythagorean principles to provide women with the means to best navigate the actual situations they faced in order to achieve a Pythagorean *harmonia* throughout their lives.[42] Moreover, they expand this specific advice to show that women's holding the high moral ground is central to the proper functioning of the family, household, and community, and even a whole nation for those countries where women rule.

Before concluding, I wish to examine one other area that complicates the foregoing discussion: Phintys' advice regarding women's proper ritual observances. In *On Women's Self-Restraint* Fr. 11 Phintys discusses this subject within the context of women's approved, temperate conduct. She first describes the ritual practices she considers appropriate:

> Women should leave the house who offer sacrifices during public festivals for the divine founder and protector of the city, on behalf of themselves, their husbands, and their entire households.[43]

Phintys' description demands attention for providing a rare, contemporary acknowledgment of the familial and cultural significance of ancient Greek women's ritual activity, which they performed in public, to civic deities, and intended to benefit themselves, their marriage, and their households. These Phintys approves as being fully within a woman's appropriate behavior.

After reiterating that a woman must perform her authorized ritual observances, Phintys condemns the sort of ritual activity she finds disruptive:

> She must … refrain from orgiastic celebrations for the Great Mother conducted at home. For even the common law of the city bars women from practicing such cults for many reasons, including the fact that such occasions lead to drunkenness and ecstatic states of the soul, and the mistress in charge of the house should be full of self-restraint and above all reproach in everything.[44]

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42 Like many modern interpreters of the ancient Pythagorean women's writings, Dutsch finds that at the same time that these texts emphasize women's intellectual abilities in the end "their ambition is not to emancipate women but to put them back in their place" as obedient and subservient wives to their husbands (Dutsch 2020, 172). As I note in this essay, I prefer to take the position that the treatises' authors acknowledge the customary and legal restrictions women must live under, but their emphasis on women's thinking capabilities highlights their positive rather than restricted role in their societies.

43 Dutsch 2020, 237.

44 Dutsch 2020, 237. Phintys states the same in Fr. 1: a woman must refrain "from orgiastic cults or those devoted to the Great Mother" (p. 234).

This condemnation of the centuries-old, culturally significant mystery rites is striking, all the more so since this attitude may not be characteristically Pythagorean.[45] The mystery rites offered transcendent spiritual experiences to their devotees. At the same time, they were based upon earth-centered deities, mostly goddesses, highlighted fertility concerns, and included various material or physical practices, including processions, eating of certain food and drink, ecstatic dancing, and sexual activity. The mystery rites developed out of ancient rituals that venerated sensual, earth-based female powers; these rites celebrated the sensual aspects of the female body and movement, typically through ecstatic dance, as portals to experiencing spiritual fulfillment. At initial glance, as Phintys states explicitly, her advice accords with the female Pythagorean writers' general emphasis on moderation and sexual restraint, since she sees engagement in such rites as leading to licentiousness. It also accords with Pythagoras's own practices that seemed to establish new ways of ritual observances that "minimized the ritual and stressed the symbolic character of the religious formulations,"[46] a perception that supports the transcendent emphasis of the philosophic inquiries.

But Phintys' goal is complicated here in that these mystery rites were a fundamental feature of women's religious observances that established their positive sense of identity and valuation as women within the culture. These rites recognized the value of their physicality as women to be culturally significant in multiple ways. Phintys' counsel in this case would remove a centuries-old, physically based, powerful source of women's identity and substitute a new rationale for her positive self-identification. One might argue that by taking away this long-standing cultural vehicle for affirming a positive notion of female identity, women are left resourceless within the patriarchal restraints of ancient Greek society that would erase her cultural value as a physical human being. It is to these women who, if they follow the female Pythagorean writers' advice, are bereft of their traditional source of positive self-identification that Pythagoreanism offers a consolation prize: an affirmation certainly of women's positive identity and social status, but one now fully situated within prevailing patriarchal social norms. Furthermore, it is devoid of the concepts of elemental female power inherent in the older mystery rites and their spiritually based appreciation of the female body. By denouncing the mystery rites,

45 Dutsch 2020, 169 notes that Phintys seems to deliberately set herself against acceptable Pythagorean practice regarding the mystery religious practices and that Phintys is constructing a "'Pythagorean' identity that is purely Greek and Doric – exclusive of any foreign mystical elements."

46 Wheelwright 1966, 201.

Phintys elides out the traditional, potent, physically-based sources of women's power within the culture. Instead she uses Pythagorean philosophy to provide an outline of women's potential power now fully inscribed within the parameters of patriarchal ideology – precisely analogous to the transformation of the power of the ancient earth-based goddesses Erinyes by the end of Aiskhylos' *Eumenides*.

This establishment of a patriarchal social context, even as certain Pythagorean precepts may aim at transcending its limitations, sets the context for all further discussion by the Pythagorean female philosophers on various topics. Thus, by denouncing the mystery rites, Phintys does not merely use the physical as a steppingstone to transcendent ideas but seems to suggest what to her probably appears as a legitimate way to elide over what may now loom as problematic female body issues. Hence we may observe a three-stage process. The mystery rites initially celebrate the female body as a source for spiritual transcendence. But there is now a perspectival shift from using the body as a steppingstone to transcendent ideas to eliding out the female body in order to engage in the transcendent. This radical denigration of powerful religious custom with its consequences for the cultural perception of the female body and of femaleness fully accords Phintys' advice with prevailing ancient Greek patriarchal ideology. The Pythagorean emphasis on moderation provided a formidable framework within which to condemn the ecstatic practices of the mystery rites. Yet in the end, even with this denigration of these rites, the Pythagorean women provided valuable counsel to women, and sometimes men, on how best to live a Pythagorean life through the small and large challenges, material and ethical, of their actual daily lives.

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CHAPTER 14

Xenophanes the Sophist? Material Realities and Philosophical Innovation

William Wians

1 Xenophanes the Philosopher?

For Aristotle, philosophy requires leisure. It begins only when material needs are satisfied (*Metaphysics* A.1, 981b13–25; cf. A.2, 982b22–28). Aristotle implies that those who engage in commerce and attend to material needs are not properly or not fully philosophers.

Such a judgment has frequently been passed on one of the earliest thinkers on philosophical topics. Almost from the beginning of the reception of his thought, the status of Xenophanes as a philosopher has been questioned. Xenophanes was probably the earliest of those thinkers active before Socrates to position himself explicitly as a critic and rival of Homer and Hesiod – criticisms that may have shaped Plato's own response to these two poets in the *Republic* and elsewhere.[1] In his only (and perhaps ironic) mention of Xenophanes by name in the dialogues, Plato labeled him the founder of the "Eleatic tribe" (*Sophist* 242d4–6; = DK 21A29; LM III.R1).[2] A century after Plato, Timon of Phlius dedicated a series of satirical dialogues called *silloi* to Xenophanes, casting him as his interlocutor and guide to skeptical predecessors (Diogenes Laertius 9.111; = Timon fr. 1 DiMarco). What Timon intended by this casting is disputed.[3] Going back as far as Heraclitus and Aristotle,

1 Xenophanes' possible influence on Plato is widely noted. See for example Wright 2021, 474; Tor 2020; Wians 2019, 72; Laks 2017, 18; Warren 2013; Lesher 1992, 72, 74.

2 In citing ancient passages pertaining to Xenophanes and other early Greek thinkers, I list first the familiar Diels/Kranz citation, followed by the citation in Laks and Most 2016 (cited hereafter as LM), including volume in Roman numerals, chapter number, the letter P, D, or R (or T in the appendix in volume IX) and passage number. Readers should be aware that the material included in a DK passage does not always precisely coincide with that in an LM passage, especially in LM's R (Reception) materials; see further the preface in LM vol. I: "Introductory and Reference Materials," pp. 9–13.

3 What did the Pyrrhonian Timon intend by making Xenophanes his main character and guide? Long asserts that "Xenophanes played a role in the *Silloi* comparable to that of Virgil in Dante's *Inferno*"; Long 1978, 69. For Tor (Tor 2020, 34–35), Timon's use of Xenophanes points to the earlier thinker's attitude toward human epistemic arrogance. Lesher 1992, 194,

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Xenophanes has been subject to derision and dismissal. He was mocked by Heraclitus for his *polymathia*, broad learning that brought no understanding (DK 21B40; LM III.8.D20), and may have been regarded as superficial by Empedocles as well.[4] When Aristotle came to Xenophanes in his survey of predecessors in *Metaphysics* Alpha, he dismissed him as an unsophisticated thinker who said nothing clearly (*Metaph.* A.5, 986b21–27 = DK 21A30/LM III.8.R12; cf. *De Caelo* 2.13, 294a21–24 = DK 21A47/LM III.8.R13).[5] Many centuries later and coming from a very different perspective, Friedrich Nietzsche was equally scornful in his *Philosophy in the Tragic Age of the Greeks*, calling Xenophanes a religious mystic, a rhapsodic "teacher of ethics," and a forerunner of the Sophists.[6]

Questions about Xenophanes' philosophical status arise both from the wide range of topics he addressed and from the poetic forms in which he expressed his ideas. Xenophanes wrote on a much wider range of topics than is ascribed to any other thinker from Ionia. Along with a radically non-Homeric theology and striking remarks about human knowledge and observations about natural phenomena, Xenophanes addressed many non-philosophical and more conventional topics. Fragments address customs of dress, offer political commentary, engage in historical reflections, and comment on rival poets. And unlike his Ionian near-contemporaries Anaximander and Anaximenes who adopted the new medium of prose, Xenophanes expressed his ideas in poetry, in a variety of forms and meters. His diversity of subjects and retention of traditional forms led both Burnet and Cherniss to doubt whether Xenophanes should be

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compares Timon's use of Xenophanes to the broadly satirical characterization of Socrates by Aristophanes, where scholarly accuracy was not the intent. It is uncertain whether Xenophanes himself called any of his writings "Silloi" (rendered "mockeries" in LM, and "lampoons" by Mourelatos 2002), or whether the label is in fact due to Timon.

4 Aristotle reports that Xenophanes was the target of Empedocles' criticism that those who hold the Earth extends infinitely downward as one "who have seen little of the whole" (*oligon tou pantos idontôn; De Caelo* 2.13, 294a21–24 = DK 31B39; LM V.22.D113).

5 Aristotle's criticism is specific to whether the ultimate *archê* of things was one or many; see Kurfess 2021, 274. Kurfess also argues that Aristotle depended on Theophrastus's account of predecessors, not on his own reading; Kurfess 2021, 272–275. Aristotle sounds a more respectful note in three passages in the *Rhetoric* that refer to Xenophanes' ideas about piety: *Rhet.* 1.15, 1377a19–21 (= DK 21A14; LM III.8.P18), 2.23, 1399b6–8, and 2.23 (= DK 21A12; LM III.8.P16), 1400b5–8 (= DK 21A13; LM III.8.P17).

6 Nietzsche 1962, 74–76. On Nietzsche's attitudes toward the Presocratics in general, see Laks 2018, chapter 2. In the portion of Nietzsche's *nachlass* translated into English by G. Whitlock (Nietzsche 2001), 76–80, Nietzsche treats Xenophanes at greater length and in less strident tones, but his overall characterization is consistent with his remarks in the *Tragic Age*.

considered a philosopher at all.[7] Kirk, Raven, and Schofield concluded he was primarily a literary critic and sage, though one whose opinions deserve philosophical attention.[8] At least one scholar has said that at a time before anything like a specialized notion of the philosopher emerged, Xenophanes should be regarded as a sage, a *sophistês* in the original sense of the term.[9] The combination of poetic form and (occasional) philosophical content is widely noted, though perhaps nowhere as elegantly as by Guthrie: "He is a poet, the only one whose genuine writings find a place both among the Presocratic philosophers of Diels and in the lyric anthology of Diehl."[10]

In this paper I will sketch a somewhat novel portrait of the "enigmatic poet-philosopher" Xenophanes.[11] I will do so by taking into account the variety of topics he addresses and poetic forms he employs – both his philosophical and his non-philosophical poetry, and his use of epic but also non-epic meters. Central to my approach will be the material context of his activities. By these I mean the lived circumstances that conditioned Xenophanes' career – why and where Xenophanes traveled, those to whom he spoke and for whom he wrote, what he said and how he said it, and especially his intended audience – those auditors most likely to be receptive to his message and the strategies he adopted to make himself persuasive to that audience.[12] Drawing attention to the performative context of his poetry will produce a more coherent picture than many typical accounts of his poetic forms and philosophical ideas. In the process, I will ask several questions I won't be able to answer, and the answers I give to other questions will sometimes be speculative, based on evidence some of which is circumstantial. But I would maintain the circumstances of his career are just what need to be taken into account, so that my portrait will gain credibility by the sorts of evidence I consider.

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7 Burnet 1930; Cherniss 1970, 18.

8 Kirk, Raven, and Schofield 1983, 167–68 [Cited hereafter as KRS].

9 Nightingale 2007a, 29–30. See further Lloyd 1987, 93 n. 153. The absence of clear disciplinary boundaries at this time and therefore of fixed labels is widely noted.

10 Guthrie 1962, 361. For a concise summary of the origins of Xenophanes' devaluation as an original thinker, see Mourelatos 2002, columns 628–32, nearly a quarter of which he devotes to rebutting the grounds for the devaluation.

11 So called by Algra 1999, 59.

12 A stimulating anticipation of my position can be found in Sassi 2018, 93–98, who draws attention to the "communication strategies" adopted by the itinerant poet. Adkins 1960, 74, saw Xenophanes as an innovator who cloaked his attack on traditional *aretē* in conventional terms. See also Lesher 1992, 54 and 73.

I say my portrait is somewhat novel because long before Nietzsche more than a few late ancient and medieval readers regarded Xenophanes as a forerunner of the Sophists.[13] Likening Xenophanes to the Sophists should not be taken to imply that his ideas about the gods, knowledge, or nature were facile or disingenuous, connotations I think any association with the Sophistic movement still carries. The point of my comparison is not to highlight some set of shared doctrines – Sophists were not united by doctrines in any case – but to draw attention to similarities in the material conditions surrounding their roles as traveling educators. The most important material similarity can be seen through a non-controversial definition of a fifth-century Sophist meant to describe Protagoras: "someone who lived by transmitting his learning and who traveled from town to town doing so".[14] The definition applies equally well to Xenophanes a century earlier. Fifth-century Sophists served, and were dependent upon, a new wealthy elite in the cities of Classical Greece.[15] Xenophanes, I will suggest, filled a similar role as educator in post-Homeric Archaic Greece. The most important similarities with the Sophists derive not from shared doctrines but from the material realities that conditioned their careers, particularly with regard to their intended audiences. These are similarities which tend to be overlooked when the peripatetic Xenophanes is viewed mainly as a natural philosopher in the Ionian mold. And just as these similarities can be overlooked, dissimilarities with other thinkers born in Ionia may be obscured. Some resemblance with ideas associated with particular Sophists will be suggested toward the end of the chapter, but these will be secondary to my main argument. Like Nietzsche, but without derision or dismissal, I will argue that Xenophanes was indeed a forerunner of Sophistic educators, and that the diversity of his topics and forms of expression are best understood with the material circumstances of his career in mind.

13 Texts reflecting this later tradition are collected in Strobel and Wöhrle 2018. See especially their summary of citations on p. 452 and 499, which reference more than thirty ancient texts, especially 83–85, 115, 173, 190, 218, and 240. While parallels with Plato are much more often remarked on, anticipations of the Sophists have been noted by some recent scholars; see for example Dherbey 2000, 725; de Romilly, 1992, 105.

14 The definition by Dherbey 2000, 721.

15 Standard treatments of the Sophists include Kerferd 1981; de Romilly 1992; Guthrie 1971. The material realities of the Sophists' activities are often noted, though at times with at least a hint of snobbery or condescension: see Cassin 2000; Dillon and Gergel, 2003, ix–xiii. By contrast, Kerferd, 15–23, and De Romilly, 1–29 treat the Sophists without condescension as a social and political phenomenon important in their own right.

2 Xenophanes the Colophonian?

I will start with a question that can't be answered. When did Xenophanes become Xenophanes? Though it is impossible to answer, the question of his apprenticeship is still worth asking.

Xenophanes' written remains amount to about forty fragments. With one valuable exception, it is impossible to assign any of the fragments to a particular period of his long life. And while certain fragments seem to cohere as if they were part of a larger argument, putting them into any sort of continuous sequence (including an alleged work *On Nature*)[16] is fraught with uncertainty. Were the fragments that speak of the limits of human knowledge early declarations of a philosophical prodigy, a pre-Socratic Hume, starting an epistemological revolution in his 20s? Was his new theology the result of decades of rumination, an ancient Kant awakened from dogmatic slumber in his 50s? We cannot say. As Barnes memorably puts it, "his intellectual biography is a tract of darkness some eighty years across."[17] We cannot, in other words, say when Xenophanes became Xenophanes.

The most commonly accepted dates for the life of Xenophanes are from about 570 BCE to as late as 475, a span of up to 105 years.[18] By his own testimony – and this is the valuable exception referred to above – he left Colophon and Ionia at about the age of 25, probably to escape advancing Medes under the command of Harpagus, who conquered his city in 546/5 (DK 21B8; LM III.8.D66, embedded in DK 21A1; LM III.8.P1). This is why the year 570 – about twenty-five years earlier – is so often given for his birth.[19] Assuming these dates are more or less accurate, they place Xenophanes firmly in the Archaic period (roughly 700–480 BCE), though much less firmly in Ionia. If one places his *floruit* in good ancient biographical fashion forty years after his presumed birth, it would imply an *acme* around 530, which is to say fully fifteen years after leaving his homeland and its intellectual milieu. Put differently, though

16 Scholars disagree over whether or not Xenophanes wrote a unified work 'On Nature' as many Presocratics beginning with Anaximander are said to have done, though the current tendency is to doubt that he did.

17 Barnes 1979, 82. That being said, Lesher 1992, 159–160, plausibly argues that B34 is a "master fragment" looking back on a significant body of teaching.

18 These dates are confirmed by the most recent study of the chronology of pre-Socratic thinkers: Thibodeau 2019, 99–107.

19 This fragment implies that Xenophanes was 92 when he spoke or wrote these words. Against Lesher 1992, 70–71, who questions whether the old man correctly recalled his age upon leaving Colophon, one should place B22, which seems to speak of an indelible memory of a life-transforming event.

typically styled "the Colophonian," Xenophanes spent roughly three-quarters of his long life far from the city and region of his birth.[20]

The age of twenty-five is not too young to attain prominence as a poet, though few philosophers have done so. It is plausible that already as a young man he had begun to formulate his moral objections to Homeric literature, a poet of a new more moralistic age reacting to his poetic forebears.[21] But surely for a thinker so original, one can presume many decades of post-Ionian intellectual activity. It seems unlikely, therefore, that the young man who left his ancestral home and region in his mid-twenties had already become the mature thinker known to us through modern textbooks. If he began as a singer of poetry composed by others, Xenophanes may not have become a philosophically interesting figure until many years after he left Ionia.

It can certainly be said that after leaving Ionia Xenophanes traveled widely. Again based on his testimony in B8, upon leaving Ionia he began roughly seven decades of travels as an itinerant poet.[22] Some scholars believe he visited Naucratis in Egypt.[23] He may have spent time in Elea in southern Italy after its founding in 540 (he is said to have written a poem celebrating its founding: DK 21A1; LM III.8.D1).[24] Eventually he landed in Zankle (Messina) and Catania in Sicily – which prompts the following bit of speculation. According to a biographical testimonium (DK 21A11; LM III.8.P13), Xenophanes spent time in Syracuse at the court of the tyrant Hieron. Heiron's reign began in 478, when Xenophanes would have been in his 90s. If the anecdote preserves an historical

20 Jaeger would strongly disagree with what I am implying: "The mere fact that Italy was the region of their chief activity [sc. Xenophanes, Pythagoras, and Parmenides] tells us nothing about their real intellectual antecedence, which was determined far more by their ancestral background"; Jaeger 1947, 38. I would respond that Jaeger does not consider the material implications of Xenophanes' relocation.

21 See further below. Xenophanes is said to have written a poem celebrating the founding of Colophon. If he did so prior to leaving the city, it would seem that he was already a creative poet in his twenties. See further Rangone 2005. But it's also possible that the poem was written in response to the Persian invasion as a patriotic or nostalgic gesture after its fall.

22 There is some controversy, relevant to the question of his apprenticeship, as to whether Xenophanes was a rhapsode, properly understood as a professional reciter of Homer. Burnet 1930, 115, firmly rejects labeling him as such, claiming the rhapsode's profession was of a higher status than that held by a singer of elegies like Xenophanes. KRS 1983, 165, deny that Xenophanes was a Homeric rhapsode specifically. LM 2016, III.2, 3, refer to Xenophanes as a rhapsode without comment or apology. Perhaps to avoid the issue, many commentators refer to him as a bard or minstrel.

23 Naddaf 2005, 99.

24 KRS 1983, 164–66, doubt the connection to Elea. See also Burnet 1930, 113. For current assessments, see the papers in Bugno 2005.

fact, one can't help but wonder if the elegiac lines of B8 were written by the 92-year-old Xenophanes to introduce himself, *a la mode Odyssean*, at a reception hosted by Hieron upon the distinguished poet's arrival at Syracuse.

So long a life lived over so wide a geographical area means that Xenophanes overlapped with most of the important figures of the Archaic period, including both philosophers (including both those who wrote in prose as well as other poet-philosophers) and non-philosophers, primarily poets. Though overlap does not imply either direct contact or indirect influence, surviving evidence suggests that Archaic figures had a fairly high degree of awareness of one another.[25] Though saying so isn't controversial, it reinforces my point that speaking of "Xenophanes the Colophonian" risks obscuring the intellectual climate – and with it, the material conditions of travel, dissemination, and competition – in which Xenophanes conducted most of his career.

Consider first those we call philosophers. While general characterizations are necessarily imprecise, based on standard chronologies (and if he lived for more than ninety years) Xenophanes would have overlapped to at least some extent with every major pre-Socratic thinker before Democritus.[26] If he was born around 570, he would have been a generation or two younger than Thales and Anaximander and about 20 years younger than Anaximenes.[27] Xenophanes could have been a near contemporary of Pythagoras, another immigrant to Magna Graecia (though the latter's dates are more conjectural; birth *c.*570–550). As for the thinker one might call "the enigmatic prose cosmographer" Pherecydes of Syros, though the evidence is slight he seems to have been active in the 6th century and may therefore also have been a near contemporary. Younger by at least a generation were Heraclitus (b. 540?, *fl.* 500) and Parmenides (b. 530?, *fl.* 490). Heraclitus, as we saw, knew of Xenophanes well enough to mock him. Parmenides may have met Xenophanes, though the

25 Barnes's caution regarding the possible influence of one thinker on another is worth bearing in mind: "often the assessment of one scholar nicely balances the contradictory assessment of another". Barnes 1979, 83. See also Mourelatos 2002.

26 The dates in this paragraph are based on those in the relevant chapters of KRS 1983 and Graham 2010.

27 In a controversial reassessment of what he calls the standard "Olympiad-first" approach to chronology, Thibodeau 2019 argues that the dates of Anaximander and Anaximenes fall significantly later than typically placed. According to Thibodeau, Anaximander was almost exactly contemporary with Xenophanes, and was in fact born a few years after him. Anaximenes is younger still, born in the 520's, long after Xenophanes left Ionia. If Thibodeau is correct, the links between Xenophanes and other Ionians could be even weaker than I suggest. See in particular Thibodeau 2019, 57–76. The implications of rejecting the standard chronology are profound and go well beyond the scope or needs of this paper.

old tradition that he was Xenophanes' student finds few modern adherents. The later pre-Socratic thinkers Empedocles and Anaxagoras were born around the beginning of the fifth century, with Empedocles also having been said to have been Xenophanes' student. While just possible chronologically, this mentor-disciple relationship is now widely discounted.[28] Democritus was not born not until around 470, close to the end of Xenophanes' lifetime. There are no firm dates for Diogenes of Apollonia, often called the last of the pre-Socratics. Like Democritus, he may have been born a century after Xenophanes, though his doctrines seem to place him earlier than Democritus, and thus may overlap to a degree the activities of Xenophanes. Another Milesian prose-writer (though not a philosopher) often mentioned in connection with Xenophanes is the geographer Hecataeus of Miletus. Hecataeus may have been born as early as 560 and is identified by Diogenes Laertius as an auditor of Anaximander along with Xenophanes. However, Hecataeus seems to have conducted his *epigeis* around the years 510–490, many years after Xenophanes began his own peregrinations. Finally, given my title and intentions, mention should also be made of Protagoras, the oldest of the first generation of Sophists. Protagoras was born in Abdera around 490. He may have come to Athens around 450, where he stayed for many years, enjoying the special patronage of Pericles.[29] Though his activities clearly post-date the death of Xenophanes, I shall return to Protagoras toward the end of the paper.

Along with the first philosophers, the other important figures for my purposes are the (non-philosophical) Archaic poets.[30] While generalizations are necessarily imprecise, one can say that Archaic poets often spoke in a more personal voice (even when that voice was a constructed presence), and that they favored a variety of shorter poetic forms.[31] A conspicuous feature of much Archaic poetry was its moral tone. Though Xenophanes is celebrated as the first philosopher to criticize Homer and Hesiod on moral grounds, he was in fact part of a larger moralizing movement in the Archaic period that included several major poets.[32]

Again being mindful that dates are at best approximate, one can say the following about Xenophanes' poetic contemporaries, each of whom exhibits the more personal and moralizing tone of the Archaic age. Among poets born in the century before Xenophanes, mention should be made of Archilochus

28 The report in Diogenes Laertius is based on Hermippus (DK 21A5; LM III.8.P12).

29 See further De Romilly 1992; Kerferd 1981; Guthrie 1971, 262–264.

30 Dates are based on those given in Lefkovitz 2012; Kivilo 2010; Hazel 2000.

31 Whitmarsh 2004, 57.

32 Lesher 1992, 73–77, is especially good in bringing this out.

(fl. 648, almost a century before Xenophanes), who wrote in a variety of meters on a wide variety of subjects; the Athenian political reformer and elegiac poet Solon (639–559); and two symposiast poets, i.e., poets who wrote in elegiac meter: Alcaeus (b. 620) and Theognis (mid-6th c.). Two Archaic poets younger than Xenophanes were Simonides, perhaps fifteen years younger (*c.*556–468) and Pindar, about fifty years younger (518–438). Like Xenophanes, the poets Alcaeus, Simonides, and Pindar were itinerant. Finally, though he was a tragic and not an epic or elegiac poet, the playwright Aeschylus should be mentioned. Aeschylus was born in 525, at about the midpoint of Xenophanes' long life. Xenophanes' influence has been detected in some lines in the *Supplicants* (96–103), and given the fact that Aeschylus traveled to Syracuse (though well after the older poet's death), some contact at least with the earlier poet's ideas is possible.

In this connection, another date becomes relevant, that of the first philosophical treatise in prose. The Milesian philosophers were innovators not just in their approach toward nature, but also in the material forms by which they communicated their ideas to others. Along with Ionian architects, historians, geographers, and physicians, they took part in a revolutionary turn toward prose. There is general but not universal agreement that the first philosopher to write in prose was Anaximander, likely influenced by local monumental architects with whom he could easily have been in contact.[33] Standard chronologies going back to Diogenes Laertius place his treatise at around the time Xenophanes left Ionia in the early 540s. If the standard dating is correct, then the young poet *could* have encountered philosophical prose while still in his homeland.[34] Even if Xenophanes left Ionia before Anaximander's book was "published", Diogenes also suggests that the young Xenophanes heard the presumably elder Anaximander firsthand. Given their geographical proximity and based on the standard chronology, such direct contact cannot be ruled out.[35]

33 Though Anaximander's "book" may have been the first prose work of philosophy (see Kahn 1994, 240), it was not the first work of any sort in prose, and was likely to have been influenced directly by non-philosophical prose predecessors; see Hahn 2001, 55–66. The earliest Greek book in prose may have been composed by Pherecydes in the 6th century. As Kahn says in a later piece: "Accepting the ancient view that Pherecydes' theogonical work is the oldest Greek prose book, we can say that the tradition of prose as a form of literature begins around 550 BCE." (Kahn 2003, 143–144).

34 The dating of Anaximander's *Peri Phuseos* goes back to Diogenes Laertius, who in separate entries gives the 60th Olympiad as the period for both the publication of Anaximander's book (DK 12A1) and for Xenophanes' departure from Ionia.

35 Naddaf 2005, 98–99, defends the tradition of direct contact with Anaximander. Of course the earlier one places his birth (Barnes suggests 580), the easier it would become that Xenophanes was acquainted – perhaps at first hand – with the speculations of his close

However uncertain the dates, they point to a crucial question of influence and reaction. Xenophanes was a poet. He wrote poetry rather than prose, and wrote in several forms and meters. His doing so sets him apart from Ionian thinkers in a non-trivial way. His use of traditional poetic forms are, it seems to me, facts which any appraisal of Xenophanes must address.[36] Did his use of poetry reflect a rejection of the new medium of Milesian prose in which other Ionians expressed their ideas? This is another question that cannot be answered. We cannot say based on surviving evidence that Xenophanes *deliberately* rejected the innovation of prose. If my previous point about the dissemination of texts and ideas is correct, he must have known of prose as a medium for recording new and complex ideas, whether as a young man through contact with Anaximander's book or later with prose works over the course of his life. But no criticism of prose by Xenophanes has come down to us. Rather than rejecting prose, he may simply have felt that prose was not appropriate for his purposes. But to say that requires that we ask what those purposes were.

3 Xenophanes the Symposiast?

It is not hard, in fact, to come up with a motive for composing and performing his own verse at almost whatever age the itinerant poet may have begun to do so. Graham makes the point indirectly, which is to say without having the material conditions of Xenophanes' career mainly in mind: "A wandering poet and minstrel, Xenophanes does not fit the mold of other early Greek philosophers, who mostly stayed at home, were independently wealthy, and wrote in prose."[37] Graham's observation points to a striking truth without emphasizing what I think is crucial. Most early philosophers were landed aristocrats. If they traveled, it was mostly for what might be called short-term learning tours – a mission to see for themselves, at the end of which they returned home. Thales was a leading citizen of Miletus, which he advised on matters of policy. He is said to have traveled to Egypt but certainly returned to his home city. Anaximander, who "evidently had the Ionian taste for travel", reportedly founding the Milesian colony at Apollonia on the Black Sea.[38] The aristocratic

neighbors in Miletus. Thibodeau, in sharp contrast, places Anaximander's birth *after* that of Xenophanes, with the publication of Anaximander's treatise fully fifty years later, precisely in 498, when Xenophanes would have been about 70.

36 See further Sassi 2018, 93–98; Grainger 2007.

37 Graham 2010, 95.

38 Guthrie 1962, 75.

Heraclitus seems never to have left Ephesus. Pythagoras left his native Samos and migrated (or perhaps was driven)[39] from one side of the ancient Greek world to the other, but he did not become itinerant, instead founding a school in the southern Italian city of Croton. Anaxagoras, like Xenophanes, seems to have fled Ionia in the face of a great invasion. Like many later intellectual figures (including the Sophists) he was drawn to Athens, where he came to enjoy the patronage of Pericles and remained until he became collateral damage in a political campaign against his sponsor.

Xenophanes by contrast left his home never to return, and never to settle in any one place. His migrations were forced upon him. Calling him a traveling bard or wandering minstrel obscures the fact that Xenophanes, "tossed up and down Hellas" for some seventy years, was a refugee. This, I would say, is the fundamental fact of Xenophanes' material condition. In his dispossessed status we find a sufficient material motive for his writing. In contrast to many of the pre-Socratics, but like fellow traveling poets Alcaeus, Pindar, and Simonides, Xenophanes was in regular need of a paying audience. Xenophanes needed patrons.

Just as his writing poetry is the fundamental fact of his material output, the need for patronage is the fundamental material circumstance of Xenophanes' career. Xenophanes was not – or at least after 545 was no longer – a member of the landed aristocracy. This fact is more than a bit of unfortunate biographical history. Properly considered, it gives us a way of unifying and understanding his disparate pronouncements and forms of expression over so many years, regardless of when they were set down.

The question to ask here is, for whom did Xenophanes write? A brief comment in KRS points us in the right direction. Xenophanes was, as they put it, "honourably received" in aristocratic households.[40] As with Graham's observation, this is correct as far as it goes, but it obscures another aspect of Xenophanes' material circumstances. It conceals the struggle and – for lack of a better phrase – the business calculation that must have been needed to gain "honorable reception." Patronage was not a given. Like Alcaeus, Pindar, and Simonides – and like Protagoras and other Sophists of a later age – Xenophanes was competing for and dependent upon the patronage of a wealthy clientele. Indeed, competition for patrons was a characteristic feature of the lives of Archaic poets.[41]

39 DK 14, A8; LM IV.1.P23.

40 KRS 1983, 165.

41 For discussion and extensive bibliography of the competition for patronage, see Fearn 2018, 93–113; also Collins 2004; Griffith 1990. Lloyd 1987, 58–59, calls Archaic poets

His honorable reception implies that Xenophanes competed successfully. But more should be said about the nature of this competition and the competitive environment in which he worked. One thing that can be said with confidence is that Greek poets wrote for a listening audience, not a reading audience, and that poetry whether in epic meter or elegiac was meant to be heard. The most visible public venue was provided by the several Pan-Hellenic festivals at which competitors would vie with one another in recitations of Homer (by rhapsodes such as Plato's Ion) or of their own poetry. But such formal contests were relatively infrequent. Much more often, poets displayed their skills not in face-to-face competitions, but in symposia, the social and intellectual setting favored by their hoped-for aristocratic patrons. These were, in the words of one critic, "the festival environment, writ small."[42] Though social in their nature, symposia had a competitive dimension. One may detect some direct evidence of Xenophanes' competition with other sympotic poets in two of his surviving fragments. In B6/D69, Xenophanes seems to criticize a rival poet (perhaps Simonides), while in B21/D68, he insults Simonides by name. Such direct insults are fairly rare, as indirect allusion was a prized skill and sign of refinement, making it the fragment all the more valuable as evidence of competition.[43]

Elegiac was preferred poetic form at symposia. Indeed, "almost all surviving archaic elegiac poetry, including the poetry of the 'philosopher' Xenophanes, was written for the symposium."[44] Elegy can be characterized both in terms of meter and content. An elegiac couplet consists of one hexameter line followed by one pentameter line, as opposed to the hexameter lines of epic meter. Ancient elegies varied widely in content, ranging from longer poems on political themes to shorter love poems. According to Whitmarsh, sympotic elegies present "an almost exclusively human world, largely dominated by material realities: love, death, class, politics, war."[45] Relevant to my purposes, symposia

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beginning with Hesiod "aggressively innovative", emphasizing their strongly individuated competitive voices; about Xenophanes specifically he notes that in B34 "he makes us aware that it is he who is talking". Sassi 2018, 93, makes a similar point about the highly personalized tone fragment B8: "*his* reflection (*phrontis*)" was tossed about for sixty-seven years.

42 See further Martin 2015, 17–30, who provides much valuable information about the Archaic competitive environment. For a recent general study of the institution of the symposium, see Hobden 2013.

43 Martin 2015, 25–26.

44 Osborne 1997, 33.

45 Whitmarsh 2004, 57.

served as avenue for the promotion of philosophical ideas, including those of Xenophanes.[46]

Two fragments in elegiac meter offer clues as to Xenophanes' intended audience (B1/LM D59; and B2/LM D61).[47] Each looks like something meant to be delivered at the beginning of a *symposion* (though I will qualify that statement in due course). B1 appears to come just after the opening lines of a larger proemium (note the post-positive contrastive *gar dê* in the first line). B2 begins with an adversative conjunction (*all' ei*) and so would seem to have come later in the symposiast's preamble.[48] Each fragment is over 20 lines in length; combined they equal nearly 40% of the roughly 118 lines that make up Xenophanes' surviving fragments. Neither is obviously philosophical in a modern sense. Indeed, they are preserved by the decidedly non-philosophical "anthologist of food and drink" of the second or third century CE, Athenaeus, in his *Deipnosophistae*.[49] Though there are no independent grounds for taking the two fragments as parts a single longer sequence, they express a similar attitude of moral restraint and probity. Rather than quote them here, I will provide a brief summary of each fragment, with the hope that doing so will be sufficient to make my larger point.

B1/D59 describes appropriate behavior at a *symposion*. It describes the freshly cleaned chamber and the washing of hands, the donning of garlands, and the fragrance of ointments and wine. Bread, cheese, and honey are at hand, and a flower-decked altar stands in the center. In the midst of this pure setting, Xenophanes instructs his audience to pour a libation and sing the praises of the gods with equally pure speech.[50] Such songs should tell of noble deeds done in the pursuit of virtue, and shun old tales of divine strife. B2 amounts to a promotion of the poet's own *sophiē*, claiming honors at least equal to those awarded to victorious young athletes from good families of the sort celebrated

46 For the competitive settings of early Greek philosophical poetry beginning with Xenophanes, see Benzi, 2016. Such competitions give rise to yet another description of Xenophanes: in the words of Glenn Most, he was a "polemical rhapsode"; Most 2011.

47 I have examined the ethical import of the two fragments in Wians 2022, on which the next several paragraphs are based.

48 See further Bowra 1953, who discusses the two fragments in the context of elegiac poems sung at the beginning of a symposium.

49 The description of Athenaeus comes from KRS 1983, 2. The almost century-old Gulick edition has now been replaced by the eight volumes of Olson 2006–2012.

50 As Lesher 1992, 51, notes, the repetition of *katharon* at lines 1, 8, and 14 "sets a tone of uncommon purity or cleanliness."

by Xenophanes' younger rival Pindar. Wisdom, Xenophanes sings, is better than strength when it comes to governing cities.[51]

Until fairly recently, the two fragments received little serious attention from philosophers. Fairly typical was Guthrie's dismissal of them for what he calls their "cheerful conventional piety."[52] The neglect isn't hard to understand. While the poetry is attractive, with stately cadences and vivid images, the two fragments seem philosophically unpromising. Neither seems part of a systematic ethics; each has a ready-at-hand quality; both make Xenophanes sound more like a moralist than a moral philosopher.[53] Everything in B1, except perhaps for the three concluding lines asking that ancient *muthoi* about divine conflicts not be aired (ll. 21–23), sounds like (well crafted) rhapsodic boilerplate, ready to be used by the wandering poet upon any appropriate occasion. Fragment B2, with its claim on behalf of the poet's own *sophiē*, strikes a more personal, even polemical note; but it too has a ready-at-hand quality, sounding less like a philosophical declaration than a self-promoting calling card.[54]

In describing the two fragments in this way, I want to make a serious point about how one should approach Xenophanes' material circumstances. The first question that needs to be asked is this: Why were these passages written down? A traveling poet or rhapsode would presumably have had a prodigious memory. Xenophanes would not have needed notes, much less a script.

If this is correct, it leads to a second, related question: for whom were these lines written? We can dismiss several possibilities. Unlike Pythagoras, Xenophanes did not found a school or community, and unlike Parmenides seems not to have had followers. He did not, in other words, write for disciples,

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51 One should also note that depending on the occasion and audience for which they were composed, these lines could amount to a sly solicitation by the poet for a state subsidy.

52 Guthrie 1962, 361 and 364–65. Guthrie continues, "This claim [criticizing the over-valuing of athletes] is characteristic of a poet at the time, and would have been made equally by Solon or Theognis." He is undoubtedly right to a point: see Theognis 145, 331, 335; Solon 4; Anacreon 356; and from the next century Euripides' *Autolycus*, quoted by Athenaeus 10.413c (DK 21C2; LM IX.43.T73). Guthrie does not ask how Xenophanes' instruction fits into his larger purpose.

53 I borrow the phrase from Lesher 1992, 73, who deserves much of the credit for showing to the contrary that the two fragments have philosophical interest. He directly rebuts Guthrie's judgment several pages earlier: "In setting the scene as he has, Xenophanes gives voice to a conventional piety but is also attempting to deepen his audience's understanding of the demands of true piety" (Lesher 1992, 51). I would add that the wry wink at human foibles at B1.17–18, including perhaps the aged poet's own, should suffice to show he was not at least an unsmiling moralist!

54 For the "promotional motif" sounded in B2, see Sassi 2018, 95–96. An insightful discussion of B2 as a revaluation of the traditional notion of *aretē* can be found in Reid 2011, 22–31.

for whom written texts would serve a clear function. And in sharp contrast to the victory odes of Pindar, neither passage shows signs of commemorating a specific event. The passages are general, ready to be used on multiple occasions.

When one considers the competitive realities of an itinerant career, such ready-at-hand self-promotion could be expected. The need for patrons made Xenophanes and other Archaic poets contestants in two different but related competitions. I've already spoken of one of them, the competition between Archaic poets for aristocratic patronage. The competition between Xenophanes and other Archaic poets was an implied contest over who had the better claim to wisdom. This contest has been strikingly expressed as a competition between contenders for the title of Master of Truth.[55] The moralizing pronouncements of Archaic poets have to be understood from this perspective, as well as specifically B2's promotion of the poet's own wisdom and its value to the *polis*.[56]

This leads to the second competition. Wisdom in Greek culture was measured in comparison to its two founding poets. Xenophanes and other Archaic poets were engaged in what might be termed a cultural competition between themselves, on the one hand, and Homer and Hesiod on the other. This was in his case a competition Xenophanes himself provoked. Xenophanes set himself as both successor and rival to Homer and Hesiod. His criticisms of his two great predecessors are written in epic meter (not in the symposiast's elegiac), practically demanding comparison with their targets.[57]

Just as the competition for patronage was implied, so too were many aspects of Xenophanes' claim to be a successor and rival to Homer and Hesiod. Along with the direct criticisms of his poetic forebears, Xenophanes employed many Homeric constructions and metaphors, creating echoes of the founding poets' language for those able to hear them. This leads to my final question. What

55 See further Lloyd 1987, 85–86, on "more or less formalized competitions in 'wisdom' … between different types of claimant to excellence."

56 A point made by Broadie 1999, 212: Xenophanes' aim was not to expound a new theory of physics, but was to speak "as a matter of moral and civic leadership."

57 Though the use of hexameter in these fragments obviously demands a comparison with Homer and Hesiod (see for example Most 1999, 335), it complicates an easy division between the subject matter of the hexameter fragments and the fragments in elegiac meter. KRS 1983, 167, claimed that nearly all of the extant theological and physical fragments are in hexameter, and Laks 2017 saw the difference in meter as an anticipation of the difference between physics and ethics. But these are our divisions. The concluding lines of B1 suggest a thematic and philosophical connection, if not a metrical one, between the theological and the ethical.

sort of listener would have been able to take the implied point of his lessons? Answering this question will bring me to the conclusion of the paper and an answer to the question posed by my title.

4 Xenophanes the Sophist?

As noted previously, Archaic Greek poets wrote to be heard. This implies that instead of writing for a more limited specialist audience in the new medium of prose, Xenophanes wrote for a wider, traditionally educated elite attuned to poetic forms. By traditionally educated, I mean an audience that would of course know the poems of Homer and Hesiod. But as also was noted, while the professional Homeric rhapsode retained a high degree of respect in Archaic culture, new poets practicing a more personally expressive craft enjoyed wide popularity. Put differently, audiences in the sixth and fifth centuries were not the same as those for the original rhapsodes who first performed what became the Homeric epics.

Many members of the Archaic poet's audience belonged to a newly enriched mercantile class and had their own motives to question heroic Homeric values.[58] One cannot, of course, presume that all Archaic audiences shared the same interests and motivations. Some may have sought validation for their newfound status in traditional stories. Pindar found patronage serving those more conservative interests. Others listeners would be drawn to new ideas then in circulation about the gods and nature. It may have been such newly enriched audiences that drew Xenophanes and other poets to newly founded cities like Elea and to powerful cities like Syracuse.

It is from this perspective that Xenophanes should be viewed as the forerunner of traveling Sophists like Protagoras. Plato's Protagoras, who clearly had come to Athens in search of paying clients, has attracted a fawning circle of wealthy prospects. He is made to say that forerunners of the Sophists concealed their intentions by writing poetry (Protagoras names Simonides, not Xenophanes, as one of these predecessors). Plato's purposes in having his character do so go far beyond the scope of this paper. My point is that in writing for a similar audience in Western Greek cities – wealthy, leisured, steeped in traditional learning, interested in novelty and attracted by celebrity – Xenophanes would have found more than a few appreciative ears for his trenchant criticisms

58 The literature on the Archaic age and its values is very extensive, dealing with innovations in ideas, politics, art, trade, and coinage. See for example Nightingale 2007b; Power 2016; Osborne 1997; Lloyd 1987; Boardman 1982; Snodgrass 1980.

of Homeric anthropomorphism along with its validation of the traditional heroic code, and his implied rejection of inspired poetic wisdom and consequent skepticism.[59] So too the poet's *polymathia*, mocked by the aristocratic Heraclitus, might have attracted an Archaic audience similar to later auditors who delighted in displays of the breadth of skills and interests by Protagoras's occasional companion Hippias and of the Sicilian Gorgias of Leontini.

Plato's *Protagoras* displays one further aspect of the pursuit of clients: selective withholding of doctrines. Upon being told by Socrates – though tantalized might be a better descriptor – that young Hippocrates is looking for a teacher, Protagoras makes it known that he offers a full course of private instruction – for a fee, of course – beyond what he is ready to display to the assembled aristocrats. Such selective withholding was in fact a common practice.[60] It allows me to make one more suggestion about B1 and B2. As already noted, the two fragments are general, rather than specific. They suggest but do not state the precise nature of the virtue Xenophanes promises to instill. I would suggest the passages were indeed a particular kind of self-promotion, written to attract paying patrons, promising (in effect) to deliver something more specific to interested parties. The fragments are a preview of the sort of content a patron could expect, not a record of what had been delivered on a specific occasion. Xenophanes, in other words, is advertising his ability to instill virtue. Their content is dictated by the material circumstances of an itinerant poet looking for patrons.

In closing, I want to repeat the caution expressed at the beginning of the paper. Likening Xenophanes to the Sophists should not be taken to imply that his thinking was philosophically superficial or insincere. I see no reason to suspect that Xenophanes did not speak genuinely to the audience that he sought and that supported him, or to doubt his claim to be a more pious if also a more fallible poet. There is no doubt that Xenophanes displays a critical spirit similar to the Milesian natural philosophers, especially with regard to the explanations of various natural phenomena (see for example B27, B29, B30, B32, B33; also A33, A40, A46). But these similarities should not obscure my main point: Xenophanes the symposiast poet can be seen as a forerunner of the traveling sophistic polymaths who lived by catering to an educated and culturally

59 Here it is worth quoting the opening line of Protagoras's treatise On the Gods: "About the gods, I am able to know (*eidenai*) neither that they exist nor that they do not exist, nor of what kind they are in form: for many things prevent me from knowing (*eidenai*) this, both its obscurity, and the brevity of human life." (B4) Translated in LM, slightly modified.

60 Here I am drawing especially on insights derived from the chapter by Tarrant, elsewhere in this volume.

critical elite. Xenophanes in the Archaic period anticipates, whether by intent or effect, the coming Sophistic revolution in classical aristocratic education.[61]

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Ever since Thales fell into the well, popular imagination has pictured philosophers as abstracted from everyday reality. *Materia Philosophiae: The Material Dimensions of Ancient Philosophy*counters that view. Philosophy in ancient Greece grew out of and remained closely connected to the material realities around it—difficulties of travel, reliance on cumbersome scrolls, learning acquired literally at the foot of a master; but also the spread of coinage, contemporaneous achievements in technology and engineering, and contact with everyday household objects. By resituating philosophers in their material contexts, *Materia Philosophiae* opens research avenues that have not previously been explored in a single volume.

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