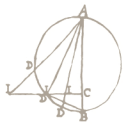

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Science Writing and Its Settings: Some Ancient Greek Modes

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ABSTRACT This paper presents six cases in ancient Greek cultures of knowledge, which make it possible to posit a connection between certain modes of presentation and institutional context. Among the texts looked at are the Hippocratic Epidemics, Aristotelian discourse, Hellenistic mechanics, and theoretical mathematics. While historical reconstruction of the institutional contexts involved is impossible, each of the cases leaves room for observations concerning an interdependence of knowledge-presentation and 'setting', understood as standard social context of reception. The paper describes resulting modes (collective, epideictic, school mode, how-to mode, analytical, and esoteric modes) as responding to and possibly emerging from certain contexts, but also as registers that later became per se possible choices for science writers, each catering to specific functions within the transmission and presentation of knowledge. With respect to Greek science, it remains an open question, whether and how one can separate a style of reasoning from a mode of presentation, that is, separate epistemic from rhetorical structures.

Introduction

This paper is about aspects of a question that has led me into the field of ancient Greek science some years ago, namely how science writing and its social contexts interact, especially with a view towards the emergence of differentiated genres.[2] In the case of ancient Greek science writing, any record of knowledge-related practices, from collecting over observing to writing-up, as well as a precise picture of the social

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[2] While much work has been done on genre in ancient science writing in recent years (e.g., van der Eijk 1997, Kullmann e.a. 1998, Netz 1999 and 2001, Asper 2007, Taub 2017, to name but a few), the problem put forward above has, usually, not been at its center.

structures in which these people were working are lost. All that we have in the case of most of ancient Greek and Roman science is the polished textual product (cf. Cooter & Pumphrey 1994, 255). These products exhibit a range of literary features, the functions of which vis-a-vis their addressees and their respective situations of reception remain often unclear. For a certain group of such features that often go together, I have preferred the term 'mode' to, e.g., 'genre' or 'style', because they are more voluble and more elusive than genres and because style is open to misunderstandings, such as being mistaken for a personal literary style of a given author or a 'style of reasoning' (see conclusion). I understand 'mode' as a certain way of literary expression less dominant and visible than the factors the conjunction of which constitute a genre, but less dependent upon an individual's taste or education and thus more easily generalized than the features we describe as a given author's style. That is, a 'mode' would be a shared way of presentation in-between the two. The term 'setting' tries to capture those receptive situations that are somehow standardized for a certain field of knowledge. I have chosen the term 'setting' in order to indicate some reserve towards the term 'institution' with its potentially anachronistic associations and the burden of theoretical approaches that usually come with it.[3] Some of these settings, however, might have met modern expectations as to the features of what we would call an 'institution', e.g. 'schools';[4] others perhaps might have not, e.g., somehow established or anticipated 'reading communities'.[5] Many historians of knowledge nowadays think that ancient Greek knowledge structures and conventional modes of representation were, in comparison with ancient Egyptian or Near-Eastern cultures, at least initially rather independent from institutions, certainly when compared to modern academic

[3] See now the discussion in Strohschneider 2001, 3-7; Cancik-Kirschbaum & Traninger 2015, 3-6. I still think that Peter L. Berger and Thomas Luckmann gave the best working definition of 'institution': "Institutionalization occurs whenever there is a reciprocal typification of habitualized actions by types of actors. Put differently, any such typification is an institution." Berger & Luckmann 1966, 72.

[4] A catalogue of features in Cancik-Kirschbaum & Traninger 2015, 4 ff. Of course, it all depends on how 'institution' is defined; see, e.g., Shapin & Schaffer 2011, xvii-xxi on "institutional settings" in the history of science.

[5] As for "reading communities" see Johnson 2010, 11 f.; and now Oikonomopoulou 2015, 182.

settings (e.g. Netz 2002, 215 f.). Furthermore, this is one of the reasons of why they were so incredibly adaptable in terms of later appropriation and transformation.

In order to show some of the chances and problems that come with such an approach, I am going to present first two early fourth-century BC medical texts (1). After a short discussion about possible connections between knowledge, setting, and text, I will further present three typical cases of later ancient Greek science writing and confront them with the same questions. These cases will be Aristotle (2), Hellenistic mechanics (Hero, (3)), and third-century theoretical mathematics (4). Six distinct modes of representations will emerge that invite cross-cultural comparisons.

(1) Two Hippocratic Modes: *Epidemics III* and *De flatibus*

Apart from occasional artifacts of earlier times, e.g. surgical instruments, our knowledge of Greek medicine begins with a host of writings usually called the Hippocratic corpus. This corpus, a collection of about 50 autonomous works, ranging from short treatises to rather huge handbooks, is diverse, both in terms of content as of form. Despite the traditional belief that all or most of these texts are related to the Hippocratic school, situated on the island of Cos, we do not know anything about the features of that institution. The only real setting of medical knowledge in practice that occasionally emerges from the corpus, is the one of an itinerant medical expert, that is, a physician who does not usually work within a school setting. We are especially ignorant with respect to the production and actual use of these texts as part of medical or pedagogical practices. In order to illustrate at least two prominent registers of the Hippocratic corpus, I have selected two very different, albeit somewhat typical, passages. Both date to the years around 400 BC, both exhibit a specific mode of presentation.

(a) The ‘Collective Mode’ and *Epidemics III*

Among the most influential works in the Corpus are the so-called *Epidemics*, seven books that collect two sorts of data: first, descriptions of the weather and prominent diseases in a given place throughout a given year; second, and of more interest to modern readers, many short case histories of named individuals. The *Epidemics* are

obviously trying to argue for a connection between the former and the latter, but this connection is never articulated. The c. 140 case histories in the *Epidemics* are obviously the product of a selection from a much bigger corpus of case histories that is now lost (Asper 2011; Smith 1989). One of the shorter cases, taken from *Epid.* III 8 (3.56 Littré), will illustrate the peculiar ring of these medical narratives (my translation, Greek in appendix #1):

> Fever took the young man who lay at the Liar's Market as a result of over-exertion and running more than he was accustomed to. On the first day, bowels were disturbed with bilious, thin and copious stools; urine thin, quite dark; he did not sleep, thirsty. On the second day, everything exacerbated; more stools, more unfavorable. He did not sleep, his mind was disturbed, he sweated slightly. On the third day, he was uncomfortable, thirsty, nauseous; much tossing around, distress; he was delirious; extremities were livid and cold; tension of hypochondrium, quite soft underneath, on both sides. On the fourth day he did not sleep; deteriorated. On the seventh day he died, his age about twenty years.

When we read through dozens of these, the rhetorical effect is even more impressive. Apart from all the issues raised by the *Epidemics*, ranging from retrospective diagnosis to the purpose of such collections,[6] it is both the accuracy and the impersonality of these accounts that has intrigued modern readers. Treatments are usually not mentioned, that is, the physician who collected the data remains as invisible as the author (Holmes 2013). All theory that has guided the collection of these data remains implicit, e.g., the assumption that fevers develop over a given span of days, the tenets of humoral pathology, or deep-seated notions of balance (as in the case above: it is *over*-exertion that brings death, not exertion itself).

This case history is part of a series of 12 such texts, mostly longer ones, and then there follows the so-called *katastasis*, a description of the weather and of the epidemic diseases of that year (undated, of course). I will not quote a passage from that description: the text describes in detail summer, autumn, winter, and spring according to rain, wind, temperature. This patient apparently died in a year wet and mild (*notiou kai hugrou kai malthakou*), which led to fevers in that spring. Similar to the case

[6] For the first see Mattern 2009, 29, for the second Graumann 2000, esp. 133-159.

histories, the *katastasis* presents a collection of data that completely effaces the collector and the intentions and assumptions that have guided him.

As for the structure of the knowledge concerned, a couple of inferences seem obvious: first, this is an instance of large-scale research output in the sense that a group of people must have retrieved the data over a great span of time and in many different places. Nothing is known about the logistics involved, but it must have been quite complex in that it involved travel, techniques of record over sometimes several months, and storage of the data over about up to a century. Second, the group involved must have shared the assumptions the collective work rests upon: again, we do not know anything about the testing and tradition of such hypotheses. Third, it is very probable that these collections were geared towards an inductive process, which could, for example, have yielded insights into individual variation of epidemic diseases and, thus, have improved prognosis. Unfortunately, the text hardly ever hints at its theoretical intentions.[7] The text suppresses the individuality of the observer to the degree that it passes over the patients' therapy in silence. Since it would be preposterous to assume that these patients actually did not receive any treatment, this silence obviously was self-evident for the addressees and its suppressed objects were considered beyond the text's focus. To write out the physician is, I believe, a rhetorical strategy meant to better bring out the inherent course of the disease. I call this rhetorical stance the 'collective mode', not only because its medium is the collection, but also because it speaks to and thus about a collective of anonymous, choreographed co-workers (Cf. Shapin & Schaffer 2011, l). The typical features of the *Epidemics'* representation of knowledge will become clearer when held against another mode of Hippocratic writing, almost a neat opposite to that collective mode.

(b) The 'Epideictic Mode' and *De Flatibus* (On Breaths)

Unlike the *Epidemics*, most of the Hippocratic texts that became popular in later reception engage in speculative constructions of the causes of diseases. At the same

[7] Some personal remarks in *Epidemics* III that end the first *katastasis* (III 16,3.100-102 Littré) and are thus *not* part of the case histories, touch upon observation, collection of data by writing, and inference from large-scale observation.

time they exhibit a profound awareness of how striking knowledge-claims and personal reputation interact. One example may suffice: The anonymous author of *On Breaths* ambitiously claims to be able to explain where all diseases come from, that is, what diseases actually are; then he applies that explanation to several prominent diseases. The treatise well illustrates the employment of a twofold argument that features first an inductive part starting from observation and yielding two insights: a general nosological axiom ('opposites heal each other', aka the 'allopathic principle')[8] and air (*pneuma*, called *phusa* when within bodies) as the most powerful element in the whole *kosmos*. The combination of the two leads the author to his spectacular claim that it must be air that causes disease, because air is also a precondition of human life, which is where the idea of opposites comes in again. This claim he then defends in a deductive part, which successfully applies the theory to various prominent diseases the etiology of which is contested, such as fevers, problems of digestion, *rheumata*, *rhēgmata*, dropsy, *apoplexia*, and epilepsy.[9] In all of these cases the explanation assumes that air in the body works as a mechanical obstacle that affects vital bodily functions (hence the title *peri phusōn*, 'on air in the body = breaths'). At the end, the treatise remarks that one could explain *all* ailments (*arrhōstēmata*) in the same way. This is certainly a spectacular claim, defended by what we can call a 'systematic' treatment (see Asper 2016, 108-110). One of the central passages of the text is the following (*Flat*. 2.1-3.2 (6.92 f. Littré); my translation, Greek in appendix #2):

> Of all diseases the general way they work (*tropos*) is the same, but their seat (*topos*) varies. The diseases appear to be unlike each other due to the difference and dissimilarity of the seats; there is, however, for all diseases only one and the same abstract concept (*ideē*) and cause. And whatever this (cause) is, I will try to show in my imminent discourse. The bodies of men and of animals in general are nourished by three nourishments. These nourishments have the following names: food, drink, breathed air (*pneuma*). Air within the bodies is called breath (*phusa*), the one outside air (*aēr*). This has the greatest power in all (beings) and of all.

[8] 1.5, 6.92 Littré = 104.11 Jouanna; "CP4" in Hankinson 1998, 450.
[9] 6-8 (96 f. Littré) fevers, digestion problems (9, 104 L.), 10 ῥεύματα (104 L. ff.), 11 ῥήγματα (108 L.), 12 dropsy (108 L.), 13 ἀποπλεξία (110 L. ff.), 14 epilepsy (110 L.): air blocks blood which carries φρόνησις.

This is the spectacular claim: against the evidence, this physician claims that all diseases have one and the same cause; that he knows what it is; and he thus probably implies that he can heal them accordingly. Please note the very strong 'I' in mid-passage: 'I will (better: 'shall') show/demonstrate that cause'. The personal mode of the argument's presentation comes across even more clearly in a passage a little below after the author has shown that air is the most vital constituent of everything (*Flat.* 5.2 (6.96 Littré); my translation, Greek in appendix #3):

> On the subject as a whole what I have said may suffice; after that I shall proceed in my argument to the facts and shall demonstrate that all the diseases are derived and caused by it (i.e., air).

Again, it is remarkable how the author chooses to fashion his argument in a personal style that brings across much of the argument's intentionality and ties its success to the author. Such an extremely reductive claim, although seductive due to its clarity and simple structure, obviously contradicts common sense and common perception and therefore needs very strong support. As things are in Hippocratic medicine, all a physician can do in order to convince his addressees of a strong claim is construct either logically stringent arguments or come up with persuasive analogies (Regenbogen 1930/1961). In this case, as in many other Hippocratic etiological theories, most prominently the explanation of epilepsy in *On the Sacred Disease*, the analogy relies on mechanical models, here of air pressure and fluids: blocked air causes problems by blocking fluids in turn that are conceived of as making the body work properly. In his discussion of *rheumata* ('fluxes') the author explains his mechanical analogy most clearly (*Flat.* 10.1 f. (6.104 f. Littré); my translation, Greek in appendix #4):

> I believe that I can show how these (diseases) are caused by the same, too. When the veins around the head are fully loaded with air, at first the head becomes heavy because the breaths press against it. Then, the blood is shut in and cannot flow through due to the narrowness of the ways. The thinnest part of the blood is pressed through the veins; when this liquid has accumulated, it flows through other passages. Wherever it arrives in the body in a mass, there a disease develops. If it goes to the sight, there will be pain; if it goes to the ears, the disease is there; if it goes into the nose, a head cold develops; if it goes into the chest, it is called hoarseness.

Obviously, the author derives the mechanics of fluids from everyday experience (certainly irrigation in agriculture, perhaps cheese-making, too). The analogy relies on being evident; the causal explanation is perfectly adaptive due to the principle of the *locus affectus*. What appears as different diseases, are simply different places in the body that are affected by the same substance due to the same process.

I hope that it has become clear how the author presents his explanative system. The treatise is presented as an 'axiomatic system' aiming at explanation, that is, essentially deduction.[10] It moves from the most general assumptions to individual diseases. Its deductive operations are built on and embedded in inductive parts. In addition, this system is presented by a strong authorial persona. On both accounts, it differs greatly from the data-collection mode as shown in the *Epidemics*. Just as in *Epidemics*, however, the author is, understandably, tacit about therapeutic measures. Apparently, his ambition is etiological explanation, put in modern terms, research rather than clinical practice. Furthermore, as in several other treatises of the Hippocratic Corpus, an agonistic style prevails that aims at impact, both by making big claims and by flamboyant rhetoric. Completely unlike the collective spirit as exhibited in the *Epidemics*, *On Breaths* displays an individual aiming at reputation through spectacular explanation.

As for the setting of such texts, we usually refer to the concept of *epideixis*,[11] which means a performative public confrontation of experts, one expert challenging his peers. How these public confrontations were arranged for and performed, we do not know exactly: it is clear, however, that the sophists from fifth century BC to imperial times and also many physicians operated in that epideictic mode (we find many examples in the works of Galen, both spontaneous ones and somehow institutionalized ones). The strategy of experts to search out competitors and then try to publicly destroy their reputation by verbal confrontation is present, for example, in Socrates' habit of discussion as described by Plato and Xenophon. Whether such an *epideixis*

[10] Cf. Popper 1994, 31-33, and Asper 2016.
[11] See Demont 1993, van der Eijk 1997.

counts as ‘institution’ or not (the Berger-Luckmann definition (n. 1) does not provide much help), I have to leave open for now.

As a typical setting, however, of how knowledge acquires great social impact for the actors involved, one sees instantly, what the *epideixis* does for the knowledge-structure involved: Since it is essentially rhetorical and performative, it fosters abstract terms and formalized argument, that is, theory, bold claims and poignant style instead of practical knowledge and long-time clinical success. Odd as it may sound at first: at least with respect to the Hippocratic physician and the sophist, the agonistic setting fosters systematicity. There is another aspect to this that points to the same: the experts that competed in the epideictic setting were travelling professionals, like the Greek poets of the archaic age. Thus, knowledge that was apt to feed in such agonistic settings had to be movable, yet explicit. Claim-oriented theory met these two criteria well. Therefore, epideictic confrontation of experts will have added additional zest to an already existent drive towards abstraction, reduction, and explanation that we can observe, for example, in so-called pre-Socratic cosmology.

(2) The ‘School Mode’ and Aristotle: Writing for Agreement

Many scholars have written on Aristotle’s institution (usually they have called it a ‘school’), the precise organizational features of which have, however, remained opaque. The same is true for the puzzle of the form and purpose of Aristotle’s extant writings. Jaeger’s concept of ‘lecture notes’ represents, until today, a common denominator.[12] There are, however, at least two serious problems with this concept: the first is, that the concept of a ‘lecture’ that is prepared and delivered by the lecturer with the help of notes, is almost certainly anachronistic[13] and derives ultimately from late-antique teaching environments as understood by nineteenth-century Prussian university professors. Second, the extant, so-called ‘esoteric’, writings are themselves very diverse. Among them, we find works like the *Nicomachean Ethics* or the *Politics*, which seem to be carefully designed. We have huge treatises such as the *History of*

[12] See, e.g., Jaeger 1923, 335-337 (engl. 1948, 314-316).
[13] In Asper 2015, I have suggested to consider the sophistic *epideixis* as a literary model of at least some Aristotelian writings.

animals, which nobody really can conceive of as a lecture. We have rather short texts such as the *Poetics* or the single books of the *Metaphysics*, which display a rather casual style. Finally, we have handbooks such as the *Rhetoric* or *Parts of Animals* which combine some of these features. Faced with such heterogeneity, we should, I believe, forget about the concept of lecture notes and, rather, think about the function of these texts within the group of Aristotle's addressees. My over-all impression is that Aristotle wishes to construct a consensus as starting-point for further discussion and even research in each of the fields treated and beyond. The concept of the 'starting-point' in discussion is all-pervasive in the dialogues of Plato and in Aristotle's *Organon*. The *Posterior Analytics*, for example, begins by stating that all knowledge is derived from already existing knowledge[14] and then unfolds the concept of axiomatic-deductive argument. Nobody knows how Aristotle and his friends conducted their research in practice; obviously, these practices must have varied by field. No matter what field, however, there must have been a large amount of internal debate. At some point, depending on the field, the need must have emerged to establish a consensus as a new starting-point for further treatment, as a basis for further discussion securely based upon the group's common agreement.

That explains, I think, the strong drive of Aristotelian knowledge-presentation towards charting terms and their relations, towards definition, classification, and taxonomies. Almost every Aristotelian page exhibits that drive, which will be illustrated here only with a few passages. As an example I choose a short remark on opposition from the *Categories* (*Cat*. 10, 11 b18-21; my translation, Greek in appendix #5).

> Things are said to be opposed to one another in four ways: as relatives or as contraries or as privation and possession or as affirmation and negation. Examples of things thus opposed, to give a rough idea, are: as relatives, the double and the half; as contraries, the good and the bad; as privation and possession, blindness and sight; as affirmation and negation 'he is sitting' vs. 'he is not sitting'.

Aristotle presents a neat micro-system of the different forms of opposites, complete with examples, terms and relations. The point of this micro-system is its correctness

[14] Anal. post. I 1, 71a1-3: Πᾶσα διδασκαλία καὶ πᾶσα μάθησις διανοητικὴ ἐκ προυπαρχούσης γίνεται γνώσεως. φανερὸν δὲ τοῦτο θεωροῦσιν ἐπὶ πασῶν.

and exhaustiveness, enhanced by using terms that are well-known to the addressee and by impersonal rhetoric. Aristotle gives examples chosen from fields as widely various as possible. At the same time, the exposition rests upon observed discursive practice ('things are said to ...') and is being kept open to further embellishment ('to give a rough idea ...'). From now on, whenever the group discusses opposition (which plays a central role in early scientific argument, remember the allopathic principle in *On Breaths* as referred to above) or searches for logical faults in an argument, all the Aristotelian has to do is to refer back to that passage which provides an internally agreed-upon starting-point. Taken together with hundreds of such passages from all fields thinkable, dispersed over the 'esoteric writings', the school's communal knowledge emerges, prepared as providing secure ground in order to foster further endeavors.

The form of presentation is clearly geared towards agreement and canonization, but that also applies to the distinctive features of that knowledge itself. Typically, the knowledge presented seems to call for diagrammatic presentation: on paper, one can arrange these four pairs of opposites in an evidence-constructing and aesthetically pleasing way. Sooner or later, most readers of Aristotle find themselves drawing trees or other forms of diagram. Furthermore, actual diagrams, inspired by mathematics, play a rather large and unprecedented role within Aristotelian discussion, for example in zoology (how do animals move? *Inc. anim*. 12-13, 711 a 8 – 712 b 22) or ethics (what is justice? *EN* V 7, 1131 b 9 – 1132 b 20). Making knowledge appear as diagrammatic, a move already present in Plato, seems to be one of the features that depend upon the setting of the school. Certainly, it makes the knowledge concerned more movable.[15]

Another remarkable feature of Aristotelian presentation is a pervasive desire to build in the observer into the system. It may suffice to briefly refer to only two instances: first, the taxonomy of intellectual pursuits in *Metaph*. E 1 (1025 b 18 – 1026 a 32) where Aristotle states that there are three kinds of *epistēmē*, namely theoretical,

[15] On the issue of 'movability' cf. Latour 1990, who calls such epistemic things "immutable mobiles".

practical and poetical *epistēmē*. Aristotle does, however, present that taxonomy not in the context of a general treatment of *epistēmē*, but as a frame for his *Metaphysics*, which is of course theoretical. Similarly, all forms of knowledge practiced and displayed in Aristotle's extant writings would find a place in this taxonomy, so that author and readers are moving along in the system while at the same time illustrating it. Second, in his zoological writings man is not only the addressee, but at the same time always part of the argument, be it explanative or taxonomical.

I would like to conclude my brief discussion of Aristotle with a last epistemic feature, namely doxography, that is, the charting of concepts according to individual predecessors who, grouped together and arranged in sequence, provide a pre-history of Aristotelian research. For example, in the first book of the *Metaphysics* Aristotle gives a history of theoretical thinking on causes which leads from its beginning through 'wonder' (*thauma*) over Egyptian priests through what we call pre-Socratic philosophy, Pythagorean and Platonic systems to himself and his group, which is thus located in a well-constructed history of progress (Frede 2005). This is probably the most elaborate doxography in Aristotle (and one that has informed history-writing of philosophy until today), but doxographical passages are abundant almost everywhere in Aristotle. I quote a brief one (*Gen. & Corr.* I 1, 314a 8-19; my translation, Greek in appendix #6):

> (What 'is' coming-to-be and passing-away?) Of the early (philosophers) one group asserts that the so-called unqualified coming-to-be is alteration, while others maintain that alteration and coming to be are distinct. For those who say that the universe is one thing and who make all things come to be from one thing, must assert that coming-to-be is alteration, and that whatever comes-to-be in the proper sense of the term is altered; but those who make the matter of things more than one must distinguish coming-to-be from alteration. To this latter group belong Empedocles, Anaxagoras, and Leucippus. Yet Anaxagoras failed to understand his own utterance. He says, at all events, that coming-to-be and passing-away are the same as being altered; yet, in common with other thinkers, he affirms that the elements are many. Thus, Empedocles holds that the corporeal elements are four, while all the elements—including those which initiate movement—are six in number; whereas Anaxagoras agrees with Leucippus and Democritus that the elements are infinite.

As in so many other passages, Aristotle here constructs a history of dissent and will later on settle the question in what is the best possible agreement in a theoretically

competitive discussion. Doxography's specific function is to provide the school's consensus with a past, upon which the school's agreement can rest and which it then out-shines. This is the rhetorical benefit of doxography, which has, of course, also epistemic functions, above all the one of providing starting-points for eristic discussion. While Aristotle has certainly not invented doxography (the credit for that goes to the sophists),[16] he has made it a more powerful tool and framework for kicking off discussion. Obviously, the doxographic presentation of predecessors does not aim at historical objectivity but belongs to the eristic field of agonistic discussion.[17]

All these are typical features of the school's knowledge, which is based on a certain form of agreement. In Aristotle's and Theophrastus' case, writing for agreement even acquires certain conventions of style, for example, the notable reluctance to employ a personal authorial stance. All Aristotle ever says is 'we'; the authorial 'I' is consistently reserved for definition throughout the corpus (see Asper 2007).[18] Individuals of the school never show up with their names or any personal *deixis*. Individuality and names are thus reserved for the doxographical targets of disagreement. Aristotle prefers a rhetoric of objectivity. The agreement presented has thus an aura of being independent of time or place and is therefore always close to the recipient. In some of the non-Aristotelian works extant, the structure of communal knowledge becomes evident: I am talking of Peripatetic collections, such as the collection of problems, physical or mechanical, the lost collection of *anatomai*, probably anatomical sketches of animals, collections of medical theories, or the mostly lost collection of the political structures of Greek city-states (only the one of Athens extant).[19] These works were collaborative, that is, several anonymous contributors worked together according to an implicit, pre-conceived, agreed-upon structure of research and display. How this work was organized, we cannot know; comparisons with modern collective research environments, their knowledge forms, epistemic structures, and rhetoric are tempting

[16] Hippias, see Asper 2013 on stories of progress.
[17] Cf. the controversy between Jaap Mansfeld and Leonid Zhmud, e.g. in Philologus 2001.
[18] See Rheinberger 2005, 79 f. for modern science writing.
[19] The interplay between collecting and institutional power has been well researched for modern societies (see, e.g., Rehberg 2014). It would be highly rewarding to discuss Rehberg's claims (389-391) with respect to Aristotelian collections.

(Rheinberger 2003). Aristotle and his group have either adopted or invented these ways (and some more) of making knowledge and knowledge texts apt to become starting-points of further research. That is what I called 'writing for agreement', which originated in a certain setting, the one of the 'school'. This is not the place for a comprehensive discussion of Aristotle's agreement-inducing literary strategies. Let it suffice to place them in the setting of the 'school', where agreement provides the basis upon which the school's activities thrive. I move on to a different setting and thus a rather different form of knowledge-presentation.

(3) The Modes of Mechanics: How to Make Things Work on Paper ('how-to mode' vs. 'analytical mode')

Unlike medical theorizing and philosophical speculation, mechanical knowledge is foremost tacit, practical, and connected with objects rather than with text.[20] In ancient Greece, mechanics is, for a very long time, the domain of experts who unfortunately, due to the socially elitist settings of writing, remain almost completely invisible to us apart from some names and a few, mostly architectural, artifacts. Apparently, a tradition of writing down some such knowledge emerges not earlier than in mid-fourth century. Perhaps there is a connection with the rapid development of siege-engines and the quickly increasing need for them by the Successor kings in the last decades of the fourth century BC. Although catapult-construction provides a fascinating topic, I begin my exposition with a more peaceful one, namely the production of olive-oil.

The following text from Cato's handbook on agriculture, authored in the second century BC in Rome, may suffice as an introductory example (I can leave open the question whether Cato qualifies as 'ancient Greek' in the sense of my paper's title – he himself might shudder at that thought). Cato, after listing the materials needed (12), describes how to put together an efficient press, actually a press-room, that is, a system of several presses. The following excerpt presents approximately a third of the description (*Agric.* 18. 1 f.; transl. A. Dalby, Latin in appendix #7):

[20] Cf. the interesting remarks on "papyrocentricity" in Cooter & Pumphrey 1994, 255. For the following paragraph, see Asper 2017, 29-32, in which I discuss the same texts from a different perspective.

> If you wish to build an olive press-room for four presses, make them face in alternate directions. Arrange them in this way: 'Trees' two feet thick, nine feet high including tenons, with sockets cut out 3 3/4 feet long and 6 fingers wide beginning 1 $^{1}/_{2}$ feet from the ground. 2 feet between the 'trees' and the walls; 1 foot between the two 'trees'. 16 feet at right angle from the 'trees' to the nearest of the posts. Posts 2 feet thick, 10 feet high including tenons. Windlass 9 feet long plus tenons. Press-beam 25 feet long, including tongue 2 $^{1}/_{2}$ feet. (transl. A. Dalby)

This is actually a recipe, that is, a series of precise instructions without any general explanation or description. Cato never bothers to give his reader an explanation of why it is that the prescribed dimensions or materials are the best. Nor does he explain how the machine actually works. Apparently, Cato expects his addressee to already know the mechanical principle of such presses, which is why he can concentrate on dimensions and materials.[21] Modern historians of technology would classify Cato's press as a lever-and-drum press as opposed to various types of screw presses that were invented later.[22] Such abstract terms of classification would instantly supply the reader with the information needed to visualize the machine. Cato's reader, however, knows what machine Cato is talking about and, presumably, knows only one kind of such machine. If pressed for the setting, one could think of rural expert culture, geared towards making things work in larger agricultural estates. I suppose that these experts were migrant specialists who would build such a press for hire. Things work, because experts construct them in the right way, as they have always done. Thus there is no need for alternative options, choices of models, discussion of inventors, etc.

As for presses, this holds in the same way for siege-engines. One example may suffice here: This is how Biton, a second-century BC author of siege-lore whose work poses many challenges,[23] begins his description of Zopyrus' so-called mountain belly-bow (p. 76 Marsden = 65 Wescher; translation Marsden, Greek in appendix #8):

[21] For technical details see Schürmann 1991, 129-132.
[22] According to Pliny, *Nat. hist.* XVIII 317, who distinguishes 'ancient' from more recent 'Greek' presses (Curtis 2008, 382).
[23] See Lewis 1999 on Biton's date and the question of why he does not cover torsion artillery at a time when this technology was the only one used.

> There is a base, A, the length of which is 5 ft., the breadth 3½ ft., the height 1 ft. Above it are the trestles, XX, of which one is smaller, one larger, and the smaller is I, the larger Θ. The height of the smaller one is 3 ft., of the larger one, 5 ft.

As is clear from the letters and as it is also explicitly stated by Biton,[24] there was a diagram illustrating the construction which is now lost. This fact partly accounts for the difficulties modern readers might have with Biton. On the other hand, even with the diagrams imagined, Biton decides not to give any abstract account of the machine, that is, an explanation of how it works, what the principles of its constructions are, etc. We conclude that for the expert mechanic of those times, probably either the name of the machine (*gastraphetēs*, 'belly-bow') or the one of its inventor (Zopyrus of Tarentum) or of the place of its first construction and success (*en Kumēi tēi kat' Italian*, 'in Italian Cyme') implicitly carried some information about such details. I have quoted this passage merely in order to show the parallels with Cato, and thus to illustrate what I call the 'how-to mode', that is, a mode which aims at enabling its reader to successfully construct a specific machine.

The 'how-to mode' is not the only way to describe such machines. About 250 years later, the Alexandrian arch-mechanic Hero describes the very same machine in the following way (Hero, *Mech.* III 13, p. 226 f. Nix & Schmidt; transmitted in Arabic, Greek lost; my translation follows the German of Nix & Schmidt):

> Now agricultural machines (al-ālātu = lit. 'tools'), namely the ones one presses wine and oil with, are quite close to the applications of levers (muḫlun = Gr. *mokhlos*) which we have discussed above [...]. The beam called 'mountain' (ǧabalun = Gr. *oros*) which others call 'press' (ʿuṣṣāratun),[25] is nothing but a lever and its fulcrum (ḥaǧaru llaḏī taḥta l-muḫli = lit. 'the stone that is below the lever' = Gr. *hupomokhlion*).[26]

Unlike Cato, Hero classifies the same press in analytical terms, by which I mean that his approach is to disassemble its parts for the sake of theoretical description and perhaps even teaching and look at them discreetly. Thus, for him such a press is a

[24] Marsden p. 76 = p. 67 Wescher: τὸ δὲ σχῆμα οἷόν ἐστι ὑπογέγραπται. Almost every machine that Biton describes was illustrated by diagrams.
[25] As conjectured by my colleague Oliver Overwien (manuscript reading: ʿuṣṣār).
[26] My English translation is not based on the Arabic, as it should, but on Nix's German. I would like to express my gratefulness to Oliver Overwien who discussed with me Hero's Arabic passage.

complex machine that can be analyzed as put together from well-defined elements that have agreed-upon terms, such as levers, windlass, etc.; parts that he had defined earlier as 'simple machines'. From such a perspective, the press is an application of a lever, perhaps combined with a windlass. Once this analytic step is taken, all there remains is to identify which parts correspond to which element of the simple machine. Matters of size and dimensions, material, etc., do not play a role in this text, which is not about construction but about classification (at least in this passage) and, perhaps, about deductive explanation. Here, things work, when and because one can show that they are put together from agreed-upon basic units, the simple machines. Things work, because one can explain them according to certain norms of analytical or even deductive reasoning. This is the 'analytical mode'.

The setting of Hero's knowledge remains unknown: usually, modern scholars assume a royal institution in Ptolemaic Alexandria, perhaps vaguely similar to the later *arsenale* in Venice, founded already by the Ptolemies with a focus on ship-building and siege-engines. We do not know anything about its internal organization, but we know a series of head-mechanics and a textual tradition that somehow maps the institution.[27] Hero's role within that institution is uncertain, but his œuvre which crosses and combines theoretical and practical aspects of mechanics and even mathematics, probably betrays a focus upon the education of engineers. The drive towards theories of mechanics instead of mechanical how-to knowledge, which of course persists, perhaps should be seen as a side-effect of its institutionalization in the vicinity of royal courts. I admit that the development towards theory already appears in Aristotle's remarks upon mechanics as applied mathematics; but the first mechanical theory, Ps.-Aristotle's *Mechanics*,[28] might well be early Ptolemaic, or at least belong to the environments of post-Alexander Macedonian courts. The same holds *mutatis*

[27] The Ptolemies were certainly interested in experts and, presumably, also in controlling their knowledge. The key passage is Philo, *Belop*. p. 49.13-50.6 Thévenot = p. 106 Marsden. See Schürmann 1991; on the Philo-passage Asper 2013, 414 f.; Keyser 2013. For the topic of controlling 'mechanics', see Shapin & Barnes 1977, esp. 35 ff.

[28] At first glance, the treatise looks rather like a loose, and sometimes even chaotic, collection of problems. Its underlying structure, however, which consists of mathematical proof and some sorts of applications that consistently refer back to that proof, demonstrate that its ambition is theoretical and systematic (see Asper 2007, 74 f.).

mutandis for most of ancient mechanical literature, even the popular treatises on *automata*, which directly point towards patronage and court-culture,[29] and even the later handbook tradition in Vitruvius and Pappus. The fact that mechanical knowledge becomes ever more theoretical and even mathematical, becomes obvious and explicit in Philon and Hero and shows even in the formatting of their texts. While there are perfect mechanical reasons for this development, one should not forget that the texts were also vehicles to either search for or display patronage, which moved the sphere of mechanics to another social level, a level that called, according to traditional Greek views, more for theory than for practice.

(4) The 'Esoteric Mode': Fourth- to Second-century Mathematics

The last in my account is, stylistically, the most remarkable one, a way of writing that I have dubbed the 'esoteric mode', because its setting and focus is the internal (gr. *esōterikos*, 'internal') life of a close-knit and exclusive group, namely theoretical mathematicians. We have come across aspects of that mode already, especially in Aristotle (some of these aspects, e.g. the regulation of how to use grammatical persons, are features of scientific writing that Aristotle must have borrowed from or must have generalized on the basis of his knowledge of pre-Euclidean mathematics). However, the texts introduced now opt more radically for standardization. Unlike practical mathematics which operated either orally or along the recipe formular, Greek theoretical mathematics has developed a highly peculiar style of exposition. While the earliest extant texts written in that form date from the third century BC, the convention to cast mathematical results and argument in that form goes back at least to the late fifth century. As an example, a short proof from Euclid's *Elements* may be appropriate (*Elem*. III 5; my translation; Greek in appendix #9).

[29] Cf. Hero, *Pneum*. I introd., vol. I, p. 2 ἐκπληκτικόν τινα θαυμασμόν. See the brief remarks of v. Hesberg 1987, 55.

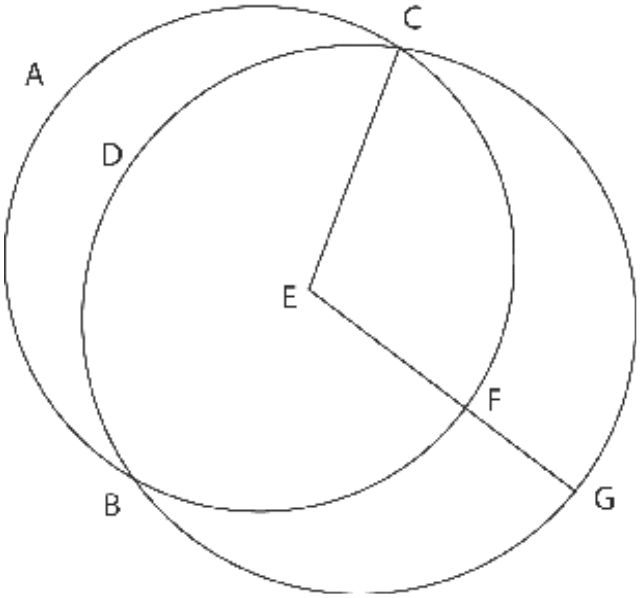

Fig. 1: Illustration of Euclid, *Elem.* III 5 (drawing by Markus Heim)

> *If two circles cut one another, they will not have the same center.*
>
> For let the circles ABC, CDG cut one another at the points B, C. I say that they will not have the same center. For, if possible, let it (i.e., the center) be E, let EC be joined, and let EFG be carried through, as if by chance. And since the point E is the center of the circle ABC, EC is equal to EF. Again, since the point E is the center of the circle CDG, EC is equal to EG. It was shown, however, that EC and EF are equal; and thus EF is equal to EG, the lesser to the greater; which is impossible. Therefore the point E is not the center of the circles ABC, CDG.
>
> Therefore, if two circles cut one another, they do not have the same center. What was to be proved.

The mathematician proves a proposition which is almost evident anyway. In order to do that he assumes the opposite of what he wants to show. Since this leads into paradox and since there are only these two possibilities, he has proved his proposition. The argument is entirely deductive, in that it presupposes definitions, such as the one of a circle in which all radii are of the same length, or axioms such as that the sum must be greater than its parts.

We are all familiar with the rather odd format of mathematical argument. Because Greek mathematics has set such a strong paradigm in early modern Europe, modern mathematics still follows that format to a large extent. In comparison to other traditions of textual mathematics, both ancient and modern, and also in comparison with the way mathematicians actually talk, two features of the esoteric mode emerge

as remarkable: the forced impersonality and the standardized way of exposition, adopted by all proofs in Euclid. It is sufficient to hint only at these rather elaborate imperatives ('let the circles ... cut each other', 'let EC be joined', etc.). In classical Greek these are forms that are reserved for theoretical mathematics; they hardly ever occur outside of that corpus. By using these odd forms, the mathematician rhetorically separates his objects from his own persona as being the actual agent of the proof. The language suggests that circles, lines, etc. are just there, independent from any beholder. Interestingly, the announcement "I say", which seems to break the impersonal style, rather proves the rule, instead: all proofs in Euclid contain that phrase, and always in the same position; plus, it occurs nowhere else. In other words, the seemingly personal statement appears as standardized part of the impersonal proof. Reviel Netz has persuasively argued that the greatest part of the mathematical text consists of what he calls 'formulas' which cover the smallest syntactical unit up to the structure of the largest proof (Netz 1999, 127-167). Apparently, this language was carefully designed to rule out contingency.

Thus, what we read in the Greek mathematicians is the result of rigid and carefully observed norms of how to write mathematics. The question of how these norms are connected to some sort of setting or institutional context remains open. The only nexus I would like to point out is, as already mentioned, how this mode of writing reflects a certain group-spirit among theoretical mathematicians of the time. The mode features the inner life of the group instead of an interest in reaching out or competing with someone else outside that group; which is why I call it 'esoteric'. Because it is an integral part of that mathematical code that the author never mentions himself, except perhaps in an occasional introductory letter (which we have in the case of Archimedes and Apollonius, but not of Euclid's *Elements*), we hardly know anything about the mathematicians themselves. Paradoxically, Euclid, one of the most influential ancient Greeks of all times, is almost completely unknown to us. However, since philosophers became interested in this knowledge and its mode of presentation early on, we have some information or, at least, opinions from them concerning the groups of mathematicians the philosophers were interested in. Eudemus, a friend of Aristotle, was apparently the first to assemble a historical account of mathematics. We have an

excerpt of that account by the late-Platonic commentator Proclus. Proclus gives an essentially chronological account from the beginnings of mathematics down to Euclid, connecting names, some of them otherwise unknown, to mathematical innovations. A short passage will suffice to bring out the specific spirit of that tradition (*In Eucl. I*, p. 67.8-16 Friedlein; my translation, Greek in appendix #10):

> Amyclas of Heraclea, one of the followers of Plato, and Menaechmus who was a disciple of Eudoxus and close to Plato, and his brother Deinostratus made the whole geometry even more accomplished. Theudios from Magnesia had an excellent reputation in mathematics and also in philosophy in general. For, among other things, he put together the elementary theorems in a beautiful way and made many of the definitions more general.

These are just a few lines from a long list of names introduced with only minimal personal information and the position of which within and contribution to the progress of geometry is then protocolled. This story of gradual, linear progress will then, two pages later, end with Euclid in whose *Elements* the telos of that story is fulfilled, 800 years before the second-hand narrator, Proclus, enters the scene. This is a wonderful example of a *grand récit* à la Lyotard constructed to explain and establish modernity (Asper 2013). However, for now I am more interested in a slightly different aspect of that story, and that is the relation of individual and group-achievement. The story conveys, among other information, a sense of mathematics as a whole being constituted and maintained by a collective effort to discover timeless truths. Being a successful mathematician means, within this frame, to be not only brilliant, but a responsible co-worker within a fixed tradition and to put, in the end, the collective achievement before one's own individual reputation. Such a normative concept, which authors such as Proclus and Pappus explicitly convey to their readers,[30] differs remarkably from what we find in some strands of Greek imperial medicine, for example. It seems, now, that this normative concept of 'collectiveness' has informed the traditional way to write mathematics, which I have illustrated with Euclid. The anonymity and the standardized way of expression on all levels seem to be the product and, at the same time, an implicit program, of an esoteric collective achievement, a

[30] For Pappus, see Asper 2013, 416.

kind of monument for the group. This is not to say that there actually was not any struggle among mathematicians for personal reputation, even international competition. But we know of these competitive mathematical practices only from scattered remarks, mostly in personal letters or in ancient secondary literature. The standard way of writing mathematics, however, remains within the limits of that esoteric mode with its implicit ideology of group-coherence. Why exactly mathematicians developed this mode, probably already well before Plato and Aristotle, remains an open question.[31] In Archimedes' times, he and his peers certainly were part of a reading community, scattered far over the Mediterranean. When, however, mathematics became institutionalized as part of the Neoplatonic philosophical institutions, a process that began about 400-500 years after Euclid, mathematical group ideology with its tendency towards self-effacement in writing proved to be perfectly adaptable to the deuteronomic ideology of the commentators.[32]

Conclusion

I have sketched out six modes of ancient Greek science writing (collective, epideictic, school mode, how-to mode, analytical, and esoteric modes). Although I have illustrated them with texts drawn from certain fields of knowledge, it does not seem impossible that the same modes apply to other fields as well (e.g., the how-to mode is found in ancient pharmaceutics, the epideictic mode in rhetoric, the collective mode in astronomy). For each mode I have tried to suggest features of its respective setting that can explain, or at least throw light upon, some typical elements of that mode. Perhaps this list of modes and settings can function as a modest contribution towards a historical narrative about the interplay of institutions and styles of knowledge. For pre-Hellenistic Greece, the transmission of expert knowledge, for example in architecture or calculation, was almost certainly part of internally organized groups, sometimes perhaps simply families,[33] the knowledge of whom never made it into writing. This is

[31] Two competing accounts in Netz 1999 and Asper 2007.
[32] For the term 'deuteronomic' see Netz 1998. For that group ideology, see my remarks on Proclus and 'team spirit' in Asper *forthcoming* 2019.
[33] While it would be highly rewarding to think about families as 'institutions' of knowledge transmission, in ancient Greece, where families are indeed attested in expert culture, e.g., in

because the boundary between oral and written communication with regard to transmitting knowledge, is, at least in pre-Roman Greece, largely determined by social class and it coincides with the fuzzy border between practice and theory. At the same time, due to the provincial character of the Greek polis in archaic and classical times ('provincial' in comparison with Egyptian, Babylonian or Persian large-scale administration), those few people who engaged in science writing did so without a proper pre-existing institutional context. Plato and Aristotle provide well-known illustrations both of the social class of writers engaging in theory as of the fact that individuals with an agenda actually *create* institutions. On the other hand one cannot deny that within the emerging fields the knowledge concerned shows certain characteristics, such as, e.g., a drive towards abstraction, recipe-structures, or deductive arguments. I have chosen the rather vague category of 'mode' in order to provide a concept for a certain style of communication that is influenced both by field and by setting and still more voluble and more easily to re-combine than the features one would associate with genre. Within, say, a letter or some kind of treatise, authors can switch from one mode to another, e.g. from school-mode to epideictic mode. Large works, such as the ones of Galen, can show different stylistic levels, according to different modes, perhaps 'epideictic' here and 'analytical' there.

Such modes seem to transcend mere questions of presentation. Certainly in the field of mathematics, the 'esoteric mode' has usually been taken for a certain way of argument. Even more, some historians of science who were interested in cultural comparisons (Crombie, Hacking, Davidson), have made it one star item in their lists of 'styles of reasoning'.[34] The notion has been prominent already in Ludwik Fleck's and Karl Mannheim's pioneering works in the sociology of knowledge and science in the 20s and 30s, respectively,[35] and, at least for Mannheim, it certainly carries with it

tragedy writing or pottery, we have no evidence of how such knowledge was managed. Families, however, have a function as starting point for ancient stories of progress, such as in Galen, *Anat. Admin*. II 1, 2.280.1-12 ed. Kühn; cf. Asper 2007, 215.

[34] Crombie 1994, xi briefly lists and explains his "six styles" (postulation, the experimental argument, hypothetical modelling, taxonomy, probabilistic analysis, and historical derivation); see the five claims on styles of reasoning in Hacking 1985 as discussed by Davidson 1999, 125 f.

[35] Fleck 1979, 125-144; Mannheim 1964, 323 n. 5.

concepts that seem to be imported from art history, such as a succession of styles.[36] The tentative list of modes given above tries to describe more such modes and at the same time, to caution against identifying them with styles of reasoning. With respect to Greek science, it remains an open question, whether and how one can separate a mode of presentation from a style of reasoning, that is, separate epistemic from rhetorical structures. It is to be doubted that in scientific research and communication, the reasoning is always and necessarily prior to the writing-up. In the course of writing-up, which one can see as a scientific practice in its own right, the style of reasoning might just follow from certain unwritten rules of how to present, that is, of a certain mode. I believe that this is, e.g., the case in what I have called above the 'epideictic mode'. Furthermore, while one would be hesitant to allow for several competing styles of reasoning within one field, say, medicine, one can conveniently imagine different modes of presentation operative side-by-side (as I have tried to illustrate) or as overlapping. Unlike genres, modes can interact more flexibly; they are less field-dependent, as some have argued styles of reasoning are (Furth 2007, 4): for example, the collective mode, the school mode and the esoteric mode share some features, such as impersonality, the desire for objectivity and the tools to construct it. In sum, regarding the rather open question of the interdependence of institutions and epistemic structures, the Greek cases I have presented merely invite us to think about rhetorical presentation and its epistemic rewards.

[36] Crombie 1994, ix.

Appendix: Texts of Passages Quoted

1 Hippocratic Corpus, *Epid*. III 8 (3.56 Littré = 2.221 Kühlewein)

Τὸ μειράκιον ὃ κατέκειτο ἐπὶ ψευδέων ἀγορῇ, πῦρ ἔλαβεν ἐκ κόπων καὶ πόνων καὶ δρόμων παρὰ τὸ ἔθος. τῇ πρώτῃ κοιλίη ταραχώδης χολώδεσι, λεπτοῖσι, πολλοῖσιν, οὖρα λεπτά, ὑπομέλανα, οὔχ ὕπνωσε, διψώδης. δευτέρῃ πάντα παρωξύνθη, διαχωρήματα πλείω, ἀκαιρότερα. οὐχ ὕπνωσε, τὰ τῆς γνώμης ταραχώδεα, σμικρὰ ὑφίδρωσε. τρίτῃ δυσφόρως, διψώδης, ἀσώδης, πολὺς βληστρισμός, ἀπορίη, παρέκρουσεν, ἄκρεα πελιδνὰ καὶ ψυχρά, ὑποχονδρίου ἔντασις ὑπολάπαρος ἐξ ἀμφοτέρων. τετάρτῃ οὐχ ὕπνωσεν· ἐπὶ τὸ χεῖρον. ἑβδόμῃ ἀπέθανεν, ἡλικίην περὶ ἔτεα εἴκοσιν.

2 Hippocratic Corpus, *Flat*. 2.1-3.2 (6.92 f. Littré = 105 f. Jouanna)

Τῶν δὲ δὴ νούσων ἁπασέων ὁ μὲν τρόπος ὁ αὐτὸς, ὁ δὲ τόπος διαφέρει· δοκέει μὲν οὖν τὰ νουσήματα οὐδὲν ἀλλήλοισιν ἐοικέναι διὰ τὴν ἀλλοιότητα καὶ ἀνομοιότητα τῶν τόπων. Ἔστι δὲ μία ἁπασέων νούσων καὶ ἰδέη καὶ αἰτίη ἡ αὐτή· ταύτην δὲ, ἥ τις ἐστὶ, διὰ τοῦ μέλλοντος λόγου φράσαι πειρήσομαι. Τὰ γὰρ σώματα τῶν τε ἀνθρώπων καὶ τῶν ἄλλων ζώων ὑπὸ τρισσέων τροφῶν τρέφεται· ἔστι δὲ τῇσι τροφῇσι ταύτῃσι ταῦτα τὰ οὐνόματα, σῖτα, ποτὰ, πνεύματα. Πνεύματα δὲ τὰ μὲν ἐν τοῖσι σώμασι φῦσαι καλέονται, τὰ δὲ ἔξω τῶν σωμάτων ἀήρ. Οὗτος δὲ μέγιστος ἐν τοῖσι πᾶσι τῶν πάντων δυνάστης ἐστίν ...

3 Hippocratic Corpus, *Flat*. 5.2 (6.96 Littré = 108 f. Jouanna)

Περὶ μὲν οὖν ὅλου τοῦ πρήγματος ἀρκέει μοι ταῦτα· μετὰ δὲ ταῦτα πρὸς αὐτὰ τὰ ἔργα τῷ λόγῳ πορευθεὶς, ἐπιδείξω τὰ νοσήματα τούτου ἀπόγονά τε καὶ ἔκγονα πάντα ἐόντα.

4 Hippocratic Corpus, *Flat*. 10.1 f. (6.104 f. Littré = 116 f. Jouanna)

οἶμαι δὲ καὶ ταῦτα δηλώσειν διὰ τωὐτὸ γινόμενα. Ὅταν αἱ περὶ τὴν κεφαλὴν φλέβες γεμισθῶσιν ἠέρος, πρῶτον μὲν ἡ κεφαλὴ βαρύνεται τῶν φυσέων ἐγκειμένων· ἔπειτα εἰλεῖται τὸ αἷμα, οὐ διαχέειν δυναμένων διὰ τὴν στενότητα τῶν ὁδῶν· τὸ δὲ λεπτότατον τοῦ αἵματος διὰ τῶν φλεβῶν ἐκθλίβεται· τοῦτο δὴ τὸ ὑγρὸν ὅταν

ἀθροισθῇ, ῥεῖ δι' ἄλλων πόρων· ὅποι δ' ἂν ἀθρόον ἀφίκηται τοῦ σώματος, ἐνταῦθα ξυνίσταται ἡ νοῦσος· ἢν μὲν οὖν ἐπὶ τὴν ὄψιν ἔλθῃ, ταύτης ὁ πόνος· ἢν δὲ ἐς τὰς ἀκοὰς, ἐνταῦθ' ἡ νοῦσος· ἢν δὲ ἐς τὰς ῥῖνας, κόρυζα γίνεται· ἢν δὲ ἐς τὰ στέρνα, βράγχος καλέεται.

5 Aristotle, *Cat.* 10, 11 b18-21:

Λέγεται δὲ ἕτερον ἑτέρῳ ἀντικεῖσθαι τετραχῶς, ἢ ὡς τὰ πρός τι, ἢ ὡς τὰ ἐναντία, ἢ ὡς στέρησις καὶ ἕξις, ἢ ὡς κατάφασις καὶ ἀπόφασις. ἀντίκειται δὲ ἕκαστον τῶν τοιούτων, ὡς τύπῳ εἰπεῖν, ὡς μὲν τὰ πρός τι οἷον τὸ διπλάσιον τῷ ἡμίσει, ὡς δὲ τὰ ἐναντία οἷον τὸ κακὸν τῷ ἀγαθῷ, ὡς δὲ κατὰ στέρησιν καὶ ἕξιν οἷον τυφλότης καὶ ὄψις, ὡς δὲ κατάφασις καὶ ἀπόφασις οἷον κάθηται – οὐ κάθηται.

6 Aristotle, *Gen. & Corr.* I 1, 314a 8-19:

Τῶν μὲν οὖν ἀρχαίων οἱ μὲν τὴν καλουμένην ἁπλῆν γένεσιν ἀλλοίωσιν εἶναί φασιν, οἱ δ' ἕτερον ἀλλοίωσιν καὶ γένεσιν. Ὅσοι μὲν γὰρ ἕν τι τὸ πᾶν λέγουσιν εἶναι καὶ πάντα ἐξ ἑνὸς γεννῶσι, τούτοις μὲν ἀνάγκη τὴν γένεσιν ἀλλοίωσιν φάναι καὶ τὸ κυρίως γινόμενον ἀλλοιοῦσθαι. Ὅσοι δὲ πλείω τὴν ὕλην ἑνὸς τιθέασιν, οἷον Ἐμπεδοκλῆς καὶ Ἀναξαγόρας καὶ Λεύκιππος, τούτοις δὲ ἕτερον. Καίτοι Ἀναξαγόρας γε τὴν οἰκείαν φωνὴν ἠγνόησεν· λέγει γοῦν ὡς τὸ γίνεσθαι καὶ ἀπόλλυσθαι ταὐτὸν καθέστηκε τῷ ἀλλοιοῦσθαι, πολλὰ δὲ λέγει τὰ στοιχεῖα, καθάπερ καὶ ἕτεροι. Ἐμπεδοκλῆς μὲν γὰρ τὰ μὲν σωματικὰ τέτταρα, τὰ δὲ πάντα μετὰ τῶν κινούντων ἓξ τὸν ἀριθμόν, Ἀναξαγόρας δὲ ἄπειρα καὶ Λεύκιππος καὶ Δημόκριτος.

7 Cato, *Agric.* 18. 1 f.:

Torcularium si aedificare voles quadrinis vasis, uti contra ora sient, ad hunc modum vasa conponito: arbores crassas P. II, altas P. VIIII cum cardinibus, foramina longa P. III S exculpta digit. VI, ab solo foramen primum P. I S, inter arbores et parietes P. II, inter II arbores P. I, arbores ad stipitem primum derectas P. XVI, stipites crassos P. II, altos cum cardinibus P. X, suculam praeter cardines P. VIIII, prelum longum P. XXV, inibi lingulam P. II S.

8 Biton, *Constructions of War-Engines and Catapults* (*Κατασκευαὶ πολεμικῶν ὀργάνων καὶ καταπαλτικῶν* p. 76 Marsden = p. 65 Wescher):

ἔστιν ἄρα βάσις ἡ Α, ἧς τὸ μῆκος ποδῶν [ι]ε΄, τὸ δὲ πλάτος ποδῶν γσ΄, ὕψος δὲ ποδὸς α΄· ἐπάνω αὐτῆς κιλλίβαντες οἱ ΧΧ, ὧν ὁ μὲν ἐλάσσων, ὁ δὲ μείζων, καὶ ὁ μὲν ἐλάσσων ὁ Ι, ὁ δὲ μείζων ὁ Θ. ἔστι δὲ τοῦ ἐλάσσονος τὸ ὕψος πόδες γ΄, τοῦ δὲ μείζονος πόδες ε΄.

9 Euclid, *Elem*. III 5:

Ἐὰν δύο κύκλοι τέμνωσιν ἀλλήλους, οὐκ ἔσται αὐτῶν τὸ αὐτὸ κέντρον.

Δύο γὰρ κύκλοι οἱ ΑΒΓ, ΓΔΗ τεμνέτωσαν ἀλλήλους κατὰ τὰ Β, Γ σημεῖα. λέγω, ὅτι οὐκ ἔσται αὐτῶν τὸ αὐτὸ κέντρον. Εἰ γὰρ δυνατόν, ἔστω τὸ Ε, καὶ ἐπεζεύχθω ἡ ΕΓ, καὶ διήχθω ἡ ΕΖΗ, ὡς ἔτυχεν. καὶ ἐπεὶ τὸ Ε σημεῖον κέντρον ἐστὶ τοῦ ΑΒΓ κύκλου, ἴση ἐστὶν ἡ ΕΓ τῇ ΕΖ. πάλιν, ἐπεὶ τὸ Ε σημεῖον κέντρον ἐστὶ τοῦ ΓΔΗ κύκλου, ἴση ἐστὶν ἡ ΕΓ τῇ ΕΗ· ἐδείχθη δὲ ἡ ΕΓ καὶ τῇ ΕΖ ἴση· καὶ ἡ ΕΖ ἄρα τῇ ΕΗ ἐστιν ἴση ἡ ἐλάσσων τῇ μείζονι· ὅπερ ἐστὶν ἀδύνατον. οὐκ ἄρα τὸ Ε σημεῖον κέντρον ἐστὶ τῶν ΑΒΓ, ΓΔΗ κύκλων.

Ἐὰν ἄρα δύο κύκλοι τέμνωσιν ἀλλήλους, οὐκ ἔστιν αὐτῶν τὸ αὐτὸ κέντρον· ὅπερ ἔδει δεῖξαι.

10 Proclus, *In Eucl. I*, p. 67.8-16 Friedlein (exc. from Eudemus, 4th cent. BC):

Ἀμύκλας δὲ ὁ Ἡρακλεώτης, εἷς τῶν Πλάτωνος ἑταίρων, καὶ Μέναιχμος ἀκροατὴς ὢν Εὐδόξου καὶ Πλάτωνι δὲ συγγεγονὼς καὶ ὁ ἀδελφὸς αὐτοῦ Δεινόστρατος ἔτι τελεωτέραν ἐποίησαν τὴν ὅλην γεωμετρίαν. Θεύδιος δὲ ὁ Μάγνης ἔν τε τοῖς μαθήμασιν ἔδοξεν εἶναι διαφέρων καὶ κατὰ τὴν ἄλλην φιλοσοφίαν· καὶ γὰρ τὰ στοιχεῖα καλῶς συνέταξεν καὶ πολλὰ τῶν ὁρικῶν (μερικῶν ms.) καθολικώτερα ἐποίησεν.

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